

LONG-TERM TRENDS IN CATCH AND EFFORT IN THE KWAZULU-NATAL NEARSHORE LINEFISHERIES

A. J. PENNEY*, J. B. MANN-LANG†, R. P. VAN DER ELST‡ and C. G. WILKE‡

The boat-based linefishery is the most important marine fishery along the coast of KwaZulu-Natal, producing 40% of the total annual mass of fish landed there. Since 1900, the fishery has supported commercial and recreational sectors that compete for more than 120 species, using similar methods in the same fishing areas. Catch-and-effort data have been collected sporadically from the commercial linefishery since 1910 and the recreational linefishery since 1970. The number of commercial vessels increased from 10 in 1910 to 140 in 1995, and effective commercial effort continues to increase, despite a limit placed on the number of vessels in 1985. Recreational participation escalated from 20 skiboats in 1948 to 2 000 in 1995 and entry to this sector remains unlimited. Introduction of the beach-launched, trailable skiboat in 1945 resulted in a rapid expansion of effort to coastal areas that previously functioned as harvest refugia for resident reef fish. Total catch has declined, despite increased effort, as has catch per unit effort (*cpue*). There have also been substantial changes in catch composition and catches have been sustained by sequential target switching from large endemic reef fish such as seventyfour *Polysteganus undulosus*, red steenbras *Petrus rupestris* and rockcods *Epinephelus* spp., to smaller sparids, such as slinger *Chrysolephus puniceus*, santer *Cheimerius nufar* and blueskin *Polysteganus coeruleopunctatus*, and shoaling migrants, such as king mackerel *Scomberomorus commerson*, geelbek *Atractoscion aequidens* and kobs *Argyrosomus* spp. The linefish resources off KwaZulu-Natal have long been incapable of sustaining the fishing effort in the region and most resident species are now overexploited. Existing linefish management measures have not been successful in limiting fishing mortality to sustainable levels and existing limits on commercial permits and recreational launches will have to be substantially reduced if this is to be achieved. Bag limits may also have to be substantially reduced, particularly for endemic reef fish, to rebuild stocks to sustainable levels. Given the difficulty of implementing such controls, the maintenance of a number of large, suitably sited marine reserves appears to offer one of the few practicable chances of conserving the endemic reef fish stocks of KwaZulu-Natal.

The South African commercial linefishery originated in the Western Cape with the development of Table Bay as a replenishment station for passing ships when the Dutch East India Company plied their trade with the East Indies (Thompson 1913, Muller 1938, Robb 1975). Until the late 19th century, linefishing was conducted from sailing vessels operating out of harbours and off beaches (Pulfrich and Griffiths 1988). At that time, there is no record of boat-based linefishing off KwaZulu-Natal (KZN) and it was only towards the end of the century, after larger steam-powered vessels were introduced to exploit the rich demersal fish resources of the Southern Cape (Lees 1969), that linefishing was first conducted out of Durban harbour. It has been estimated that more than 3 000 people are now active in commercial fisheries in the region, while 300 000 people participate annually in recreational activities that rely on KZN's coastal living marine resource (Van der Elst *et al.* 1996). In all, 17 commercial and 26 recreational marine fisheries have been identified in KZN, ranging from informal subsistence shellfish gathering and artisanal trap fishing to commercial prawn trawling and recreational angling

(Van der Elst *et al.* 1996). Together, these fisheries were worth approximately R65 million to the region in 1992. Their financial value and large number of participants make the fisheries highly important to the region, socio-economically, recreationally and as a source of food.

Of the diverse fishery sectors in KZN, the boat-based nearshore linefishery is the largest in terms of capital investment, accounting for approximately 35% of the total capital value of all fisheries in the province. Hook-and-line-caught species account for about 40% of the total mass landed in KZN (Van der Elst *et al.* 1996). The nearshore linefisheries operate along most of the coast and support commercial and recreational sectors. Fish are caught from recreational boats, charter boats and commercial vessels, and are used for food, sport and financial gain. The commercial and recreational linefishery sectors have therefore competed for the past five decades, using similar vessels and fishing equipment to target on the same species in the same areas, complicating efforts to manage this fishery.

As a result of steadily increasing fishing effort, there

* Pisces Research and Management Consultants cc, 22 Forest Glade, Tokai Road, Tokai 7945, South Africa (formerly Sea Fisheries). E-mail: piscesc@iafrica.com

† Oceanographic Research Institute, P.O. Box 10712, Marine Parade 4056, South Africa. E-mail: seaworld@dbn.lia.net

‡ Marine and Coastal Management (formerly Sea Fisheries), Private Bag X2, Rogge Bay 8012, South Africa

Table I: List of families and species of importance to the KwaZulu-Natal offshore commercial and recreational linefisheries. The accepted common names shown are those from Smith's Sea Fishes (Smith and Heemstra 1986)

Family	Common name	Species
<i>Reef fish</i>		
Dinopercidae	Lampfish	<i>Dinoperca petersi</i>
Lethrinidae	Blue emperor	<i>Lethrinus nebulosus</i>
	Longnose emperor	<i>Lethrinus elongatus</i>
Lutjanidae	Green jobfish	<i>Aprion virescens</i>
	Rosy jobfish	<i>Pristipomoides filamentosus</i>
	Yellowtail fusilier/protea bream	<i>Paracaesio xanthurus</i>
Mullidae	Goatfish	<i>Parupeneus</i> sp.
Pomadasyidae	Lemon fish	<i>Plectorhincus flavomaculatus</i>
	Rubberlip	<i>Plectorhincus</i> sp.
Serranidae	Catface rockcod	<i>Epinephelus andersoni</i>
	Greasy rockcod	<i>Epinephelus tauvina</i>
	Halfmoon rockcod	<i>Epinephelus rivulatus</i>
	Tomato rockcod	<i>Cephalopholis sonnerati</i>
	White-edged rockcod	<i>Epinephelus albomarginatus</i>
	Yellow-edged lyretail	<i>Variola louti</i>
	Yellowbelly rockcod	<i>Epinephelus guaza</i>
Sparidae	Blacktail	<i>Diplodus sargus</i>
	Blue hottentot	<i>Pachymetopon aeneum</i>
	Blueskin/trawl soldier	<i>Polysteganus coeruleopunctatus</i>
	Bronze bream	<i>Pachymetopon grande</i>
	Cape stumpnose	<i>Rhabdosargus holubi</i>
	Dageraad	<i>Chrysoblephus cristiceps</i>
	Dane	<i>Porcostoma dentata</i>
	Englishman	<i>Chrysoblephus anglicus</i>
	German	<i>Polyamblyodon germanum</i>
	King soldier-bream	<i>Argyrops spinifer</i>
	Natal stumpnose	<i>Rhabdosargus sarba</i>
	Poenskop	<i>Cymatoceps nasutus</i>
	Red stumpnose	<i>Chrysoblephus gibbiceps</i>
	Sand soldier	<i>Pagellus natalensis</i>
	Santer	<i>Cheimerius nufar</i>
	Scotsman	<i>Polysteganus praeorbitalis</i>
	Slinger	<i>Chrysoblephus puniceus</i>
	Zebra	<i>Diplodus cervinus</i>
<i>Demersal migrants</i>		
Sciaenidae	Geelbek	<i>Atractoscion aequidens</i>
	Dusky kob	<i>Argyrosomus japonicus</i>
	Snapper kob	<i>Otolithes ruber</i>
	Squaretail kob	<i>Argyrosomus thorpei</i>
Sparidae	Red steenbras	<i>Petrus rupestris</i>
	Seventyfour	<i>Polysteganus undulosus</i>
<i>Pelagic migrants</i>		
Carangidae	Bigeye kingfish	<i>Caranx sexfasciatus</i>
	Blacktip kingfish	<i>Caranx sem</i>
	Giant kingfish	<i>Caranx ignobilis</i>
	Leervis	<i>Lichia amia</i>
	Queenfish	<i>Scomberoides commersonnianus</i>
	Rainbow runner	<i>Elagatis bipinnulata</i>
	Yellowtail	<i>Seriola lalandi</i>
Coryphaenidae	Dolphinfish	<i>Coryphaena hippurus</i>
Istiophoridae	Black marlin	<i>Makaira indica</i>
	Blue marlin	<i>Makaira nigricans</i>
	Sailfish	<i>Istiophorus platypterus</i>
	Striped marlin	<i>Tetrapturus audax</i>

Table I: (continued)

Family	Common name	Species
Pomatomidae	Elf	<i>Pomatomus saltatrix</i>
Rachycentridae	Prodigal son	<i>Rachycentron canadum</i>
Scombridae	Eastern little tuna	<i>Euthynnus affinis</i>
	King mackerel	<i>Scomberomorus commerson</i>
	Queen mackerel	<i>Scomberomorus plurilineatus</i>
	Skipjack	<i>Katsuwonis pelamis</i>
	Striped bonito	<i>Sarda orientalis</i>
	Wahoo	<i>Acanthocybium solandri</i>
Sphyraenidae	Yellowfin tuna	<i>Thunnus albacares</i>
	Barracuda	<i>Sphyraena barracuda</i>
	Pickhandle barracuda	<i>Sphyraena jello</i>

have been growing indications of overexploitation in the KZN nearshore linefisheries over the past two decades. The mean sizes of many resident species have declined sharply, as have catch rates of principal target species. A number of endemic reef fish appear to have been seriously depleted by excessive fishing mortality, and an estimated 35% of the linefish resources exploited off the KZN coast are now considered to be threatened or moderately overexploited, and a further 5% are considered to be critically overexploited (Van der Elst and Adkin 1991). Efforts to improve management of these resources have been hampered by a lack of quantitative information on relative rates of exploitation and status of stocks. Published comparisons of the relative trends in effort, catch, catch per unit effort (*cpue*) and catch composition of the competing commercial and recreational nearshore linefishing sectors has also not been available. The purpose of this paper is therefore to assimilate catch-and-effort data for KZN nearshore linefisheries and to describe, quantify, and compare catch-and-effort trends in the commercial and recreational linefisheries in the region.

DATA SOURCES AND METHODS

Study area

The 564 km coastline of KZN stretches from Ponto do Ouro in the north (20°52'S, 32°55'E) to Port Edward in the south (31°06'S, 30°11'E, see Fig. 1). The continental shelf is narrow (3–11 km wide) north of St Lucia and south of Durban. Between these areas the shelf widens to 45 km opposite the Tugela River (Flemming 1978). The relatively straight coastline has few protected bays and is generally a high energy coast. Shelf circulation varies in close associa-

tion with the topography of the continental shelf. The Agulhas Current transports warm, tropical and subtropical water in a poleward direction along the shelf and has a major influence on the oceanography of the region (Shillington 1993). Where the shelf is narrower, the Agulhas Current tends to be closer inshore, where it flows predominantly to the south-west. Where the shelf widens, the Agulhas Current continues to follow the shelf-break and moves farther offshore. In that region, between Richards Bay and Durban, the inshore waters primarily flow northwards as a result of the Natal gyre (Bang and Pearce 1978).

Two major fishing areas are exploited by the boat-based linefishery off this coast. The first consists of a long zone of scattered reefs that extends along much of the coast, roughly following the 50 m isobath (Fig. 1). The second important fishing area consists of deeper reefs to the south of Durban and to the north of the Tugela River in a depth of 100–200 m (Garratt 1984). A relatively small proportion of the KZN coastal shelf area consists of areas suitable for reef-dwelling species.

Fish fauna

The fish fauna off the east coast of South Africa is largely Indo-Pacific in nature and, although less abundant than the temperate resources of the Benguela upwelling system off the Cape west coast, or on the wide continental shelf south of Cape Agulhas, is diverse in species. Over 120 different fish species are caught in the KZN nearshore linefishery, of which about 60 are regarded as important (Van der Elst and Garratt 1984). These targeted species may be broadly divided into two groups; resident reef fish and seasonal migrants. The migrants can, in turn, be divided into pelagic migrants from the north and south (mainly Carangidae and Scombridae) and demersal migrants

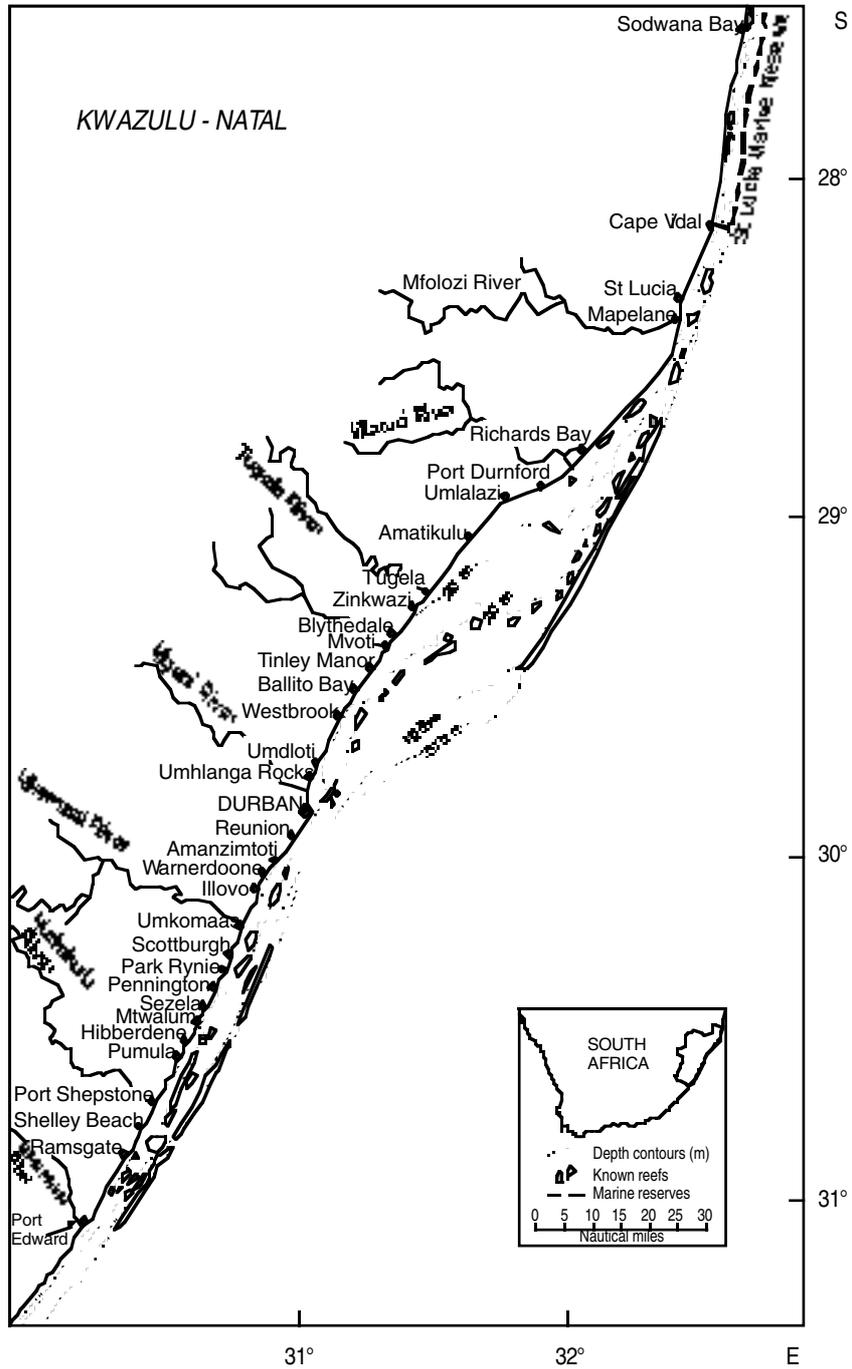


Fig. 1: Map of KwaZulu-Natal showing the main launch sites, linefishing reefs and the St Lucia Marine Reserve

from the south (Sciaenidae and Sparidae, Table I). A number of species of local pelagic gamefish (Scombridae, Carangidae and Istiophoridae) are also targeted, particularly by recreational anglers.

A number of reef fish species caught in the fishery are relatively resident within the limited suitable reef areas (Fig. 1), including the poenskop *Cymatoceps nasutus*, slinger *Chrysoblephus puniceus*, Scotsman *Polysteganus praeorbitalis* and the Englishman *Chrysoblephus anglicus*. Many of them have complex life histories, exhibiting sex-change, late maturity and slow growth, making these species particularly vulnerable to localized overexploitation, resulting in marked changes in abundance and population structure (Buxton 1993).

The availability of migrant species is strongly affected by seasonal oceanographic patterns, particularly changes in current flow, and is usually linked to the migration of prey species, particularly in southern KZN (Baird 1970, 1971). The annual sardine *Sardinops sagax* migration from the Cape waters along the KZN south coast is generally followed by predatory gamefish such as elf (shad) *Pomatomus saltatrix*, yellowtail *Seriola lalandi* and garrick *Lichia amia* (Van der Elst et al. 1978), as well as demersal species such as dusky kob *Argyrosomus japonicus* and geelbek *Atractoscion aequidens* (Griffiths and Hecht 1995, Griffiths 1997). Movement of cooler, inshore water northwards along the southern coast during winter (June and July) appears to enable these fish to extend their ranges to regions that are normally too warm (Van der Elst et al. 1978, Crawford et al. 1990). Temperate reef-associated species such as the seventyfour *Polysteganus undulosus* and red steenbras *Petrus rupestris* also undertake seasonal migrations from the central Agulhas Bank area, being found off southern KZN during winter and spring (Garratt 1988, Smale 1988, Penney and Wilke 1993).

In contrast, tropical species migrate southwards into KZN during summer (November–March). Gamefish such as king mackerel *Scomberomorus commerson*, queen mackerel *S. plurilineatus*, yellowfin tuna *Thunnus albacares*, eastern little tuna *Euthynnus affinis*, skipjack *Katsuwonus pelamis*, dorado *Coryphaena hippurus*, billfish (Istiophoridae) and kingfish (Carangidae) are therefore typically more abundant off KZN during summer.

Sources of catch-and-effort data

Various catch-and-effort data sources are available for the KZN linefisheries, but only those giving substantial coverage of the major sectors of the linefishery in the region were used for this paper.

COMMERCIAL DATA

Catch-and-effort data have been collected from the commercial linefishery along the KZN coast since 1907, but the responsible authority, and the enthusiasm, for collecting such data have changed often. Different data sources were therefore used for different time periods.

1907–1933: Printed reports by Natal Fisheries Officers — A Natal Fisheries Officer was provincially appointed to be responsible for documenting catches made by commercial deckboats operating out of Durban harbour, analogous to the harbour returns currently submitted to the National Marine Linefish System (NMLS) by fisheries officers stationed at fisheries harbours in the Cape. These reports, which were subsequently obtained by the Oceanographic Research Institute (ORI), contain annual summaries of the number of vessels and their annual catches (Natal Fisheries Department 1924).

1940–1950: Hand-written reports by Natal Fisheries Officers — These are similar to the records collected between 1907 and 1933, except that they contain the original, monthly handwritten records of boat numbers and catch. These data were rescued by the then Natal Parks Board (now KwaZulu-Natal Nature Conservation Services) just before they were to be destroyed, and subsequently passed on to the ORI for analysis (Natal Fisheries Department 1940–1946).

1964–1971: Company catch records from Irvin & Johnson — Unfortunately, the position of the Natal Fisheries Officers was discontinued after 1950. However, over this period the bulk of the commercial catch was made by deckboats operating out of Durban Harbour. The fishing company Irvin & Johnson owned a number of these vessels and kept records of their effort and catch. Summaries from these records for the period were available from the ORI (Van der Elst and Garratt 1984).

1976–1977: Catch-and-effort data from commercial linefishing associations — In 1976, the first association of KZN commercial skiboat operators was formed to negotiate improved access to launching sites. This association compiled records of the number of commercial skiboats operating from each launch site, supplemented with records of numbers of crew, days fished and catch per crew member, recorded by commercial fishers active at that time (P. A. Garratt, Two Oceans Aquarium, Cape Town, pers. comm.)

1979–1984: Voluntary monthly returns to Sea Fisheries (now Marine & Coastal Management) — During this

period, Sea Fisheries stationed a technical staff member in KZN to coordinate the collection of data from all KZN commercial fisheries. At that time, first attempts were made to introduce voluntary monthly catch returns to important commercial linefishing areas in the Cape, and this initiative was extended to the commercial linefishing vessels in Natal. Returns from these vessels provided indices of average number of crew, days fished and catch per species over this period.

1985–present: Compulsory monthly returns to the NMLS — As part of the comprehensive linefish management recommendations made by the ministerially appointed National Marine Linefish Committee in 1984, specific permits were first introduced for South African commercial linefishing from 1985 onwards. One of the conditions of these permits is the submission of compulsory monthly catch returns, which are all captured on the NMLS to provide data on number of crew, days fished and catch per species for registered commercial linefishing vessels.

The coverage and accuracy of these data sources has varied over the years, and derivation of annual estimates of total catch since 1907 requires extrapolation of catch-per-vessel indices in some years. Between 1950 and 1985, when data were not collected from all active vessels, total catches were estimated by extrapolating average annual catches per vessel to the total number of active commercial vessels per year. The number of crew on commercial vessels was not recorded during the periods 1907–1912, 1940–1950 and 1964–1971. However, commercial vessels are required to obtain an annual safety certificate issued by the Department of Transport, and these provide a record of the total number of commercial vessels operating each year. Although the maximum permissible number of crew on each registered vessel is also indicated in these records, a maximum crew complement was not always carried, particularly on the larger deckboats. For periods when crew numbers were not recorded, the average number of crew per vessel from data for the previous or subsequent periods was therefore used for the purpose of calculating *cpue*, i.e. catch·fisher⁻¹·year⁻¹. The calculated average number of crew used per vessel was 20 for the period 1907–1912, 10 for the period 1940–1950 and 16 for the period 1964–1971. Actual reported crew numbers were used for data in other periods. The validity of assumptions regarding average number of crew per vessel was confirmed in discussions with commercial fishers active during the periods concerned (P. A. Garratt, pers. comm.)

As an inevitable result of the incomplete nature of records for the KZN linefishery, most estimates of total catch are underestimates. However, information

collected by Natal Fisheries Officers between 1907 and 1950 appears to provide good estimates of catch in central KZN, in the vicinity of Durban. As there was little commercial fishing away from this area at that time, most of the catch is probably reflected in these data. Similarly, although catch-per-species data are not available, estimates of total catch produced by the commercial fishers' association during 1976 and 1977 are considered to be accurate (P. A. Garratt, pers. comm.). Data received from fishing companies between 1964 and 1971 only reflect the activity of those company vessels, and so do not provide total catch estimates, although they do provide accurate *cpue* indices for these vessels.

Although catch returns have been compulsory from registered commercial linefishers since 1985, and various attempts have been made to improve the accuracy of submitted catch data since then, problems with data accuracy remain. Certain species are still grouped on catch returns, particularly many of the smaller sparids, collectively referred to as "reds". Fishers also have difficulty distinguishing between certain species, particularly the kobs *Argyrosomus* spp., breams *Pachymetopon* and *Polyamblyodon* spp. and sharks. More important, in a study comparing commercial returns submitted to the NMLS with scientific observer data, Sauer *et al.* (1997) noted a number of inaccuracies in commercial returns. The most common of these involved under-reporting of catches, including non-reporting of unimportant by-catch species, variable under-reporting of target species and complete failure to submit returns. For important commercial target species, the national mean under-reporting ratio was estimated to be 2.87 (± 0.94) times.

Not all commercial data submitted to the NMLS are inaccurate, however, and sources of bias appear to have been relatively constant over time. In particular, Sea Fisheries technical staff stationed in Durban from 1990 to 1994 determined that compulsory returns submitted by commercial fishers in Natal were substantially more complete than those received from the Cape (Sauer *et al.* 1997). Although data captured on the NMLS may not give accurate estimates of total catch and effort, they do appear to provide reliable estimates of species composition in catches, geographic and sector-specific catch distribution patterns and seasonal and interannual catch trends. These provide acceptable representative indices of catch, effort and species composition trends for the major sectors of the linefishery (Penney *et al.* 1997).

RECREATIONAL DATA

Catch and effort data have been collected from the KZN recreational skiboat fishery since the early

1970s. Prior to this, some information on this sector is available in books, newspapers, minutes of meetings and popular articles. Further information was obtained from personal log books and club records. In particular, detailed club records are available for skiboat clubs in the Durban area from 1961 onwards. Two principal data sources were used in the analyses presented in this paper:

Voluntary catch cards — Since the early 1980s, a substantial quantity of catch-and-effort data from recreational skiboat anglers has been entered onto the NMLS. Most (90%) of the data are in the form of daily catch cards, submitted voluntarily or collected from controlled beach access points or skiboat clubs. On average, 10 700 catch cards have been received annually from the skiboat fishery since the inception of the NMLS in 1985. In some years, up to 60% of these cards were received from access points along the coast controlled by the Natal Parks Board (NPB). As some of these areas are marine reserves where bottom fishing is not permitted, the catches reflected in these data are biased in favour of pelagic gamefish. In other areas, the coverage by voluntary catch cards has varied considerably between clubs as a result of changing club committee attitudes to the collection of data. This has resulted in fewer data for the KZN south coast, further biasing catch estimates in favour of North Coast gamefish catches. Data from the Durban area have been patchy, but the availability of the former Natal Parks Board inspection data and independent surveys (Hall 1995) provided additional information on the Durban-based fishery. Data on numbers of active recreational vessels were obtained from the Natal Deep-Sea Angling Association and the Department of Transport registration figures, whereas estimates of the number of launches were obtained from skiboat clubs along the coast.

NPB skiboat inspection records — Skiboat inspections by the NPB were initiated in 1986 and have been regularly conducted at major landing sites along the coast since then. These skiboat inspections have provided reliable, angler-independent catch-and-effort information, used to provide both an independent index of recreational skiboat catch and effort and to validate data submitted on skiboat catch cards. Catch card and inspection data show similar trends, indicating that either data source could be used to analyse trends in this sector. Since the inspection data are only available from 1986 onwards, data on trends in catches, *cpue* and species composition were obtained principally from catch cards. However, recent catch composition data were obtained from skiboat inspections, because of better regional coverage by these

data.

Various other catch-and-effort data sources are available for KZN nearshore recreational fishing, particularly skiboat competition returns captured on the NMLS. However, although these returns provide an accurate record of catches during competitions, they are strongly biased by competitive angler ability, competition rules and altered targeting during competitions. They are therefore of limited use when analysing trends in the general, non-competitive, recreational skiboat fishery, and were not used in this study. Mann-Lang (1996) identified 13 different types of bias or inaccuracy in data collected for the KZN recreational fisheries, a number of which have serious effects on data quality. Like commercial returns, voluntary recreational data typically contain numerous errors, including incorrect species identification, incorrect weights, exaggeration or under-reporting (Mann-Lang 1996). Recreational anglers also tend to target preferred fish groups, particularly gamefish, reef fish and billfish, resulting in biased estimates of comparative species abundance. Low or non-existent catches of a particular species may therefore reflect target preferences rather than reduced abundance of the species concerned. Any imposition of catch restrictions alienates anglers, resulting in reductions in both quantity and accuracy of data. Notwithstanding these various sources of inaccuracy, these are the only data available for the recreational skiboat fishery, and they do provide indices of the major trends in this sector over the years.

RESULTS AND DISCUSSION

Characteristics of the linefishery sectors

Participants in the KZN linefishery have traditionally been divided into commercial and recreational sectors. Within these sectors, there is substantial variation in fishing effort and the extent to which income is derived from linefishing. In the “commercial” sector, some fishers, who registered their vessels in the past in order to sell catches legally, essentially operate as recreational fishers, and derive little income from fishing. Conversely, a number of unregistered “recreational” participants exert considerable fishing effort on commercially profitable species and sell their catches illegally. There are also close similarities between the vessels and equipment used, areas fished and species caught. Many of the “commercial” and “recreational” participants are therefore virtually indistinguishable from one another and it is more correct to say that there is a gradation in the KZN boat-fishing sector from full-time commercial fishers, who derive the

greater part of their income from linefishing, to sport fishers who fish solely for sport and recreation and derive no income from the fishery. In recent years, a charter-boat sector has also developed, with essentially commercial fishers taking recreational anglers out on charter fishing trips. The monitoring and management measures for these commercial and recreational sectors differ markedly (see Table II) and the sector characteristics need to be specifically considered when evaluating their influence on trends in the fishery.

COMMERCIAL SECTOR

Commercial linefishing started off KZN shortly after 1900, using steam-powered deckboats operating out of Durban harbour. These carried up to 20 crew and initially fished the shallower reefs along the central KZN coast (Fig. 1). Between 1900 and 1940, commercial fishing vessels and methods remained essentially unchanged, although effort increasingly extended southwards towards the then Transkei coast as initially high catch rates in the central region declined. In contrast with the Cape, where development of numerous fisheries harbours allowed the linefishery to expand rapidly over this period (Pulfrich and Griffiths 1988, Sauer *et al.* 1997), the absence of any suitable harbour other than Durban limited development, and the number of active vessels remained relatively constant. Most fishing operations ceased from 1940 to 1945, during the Second World War.

A number of factors contributed to marked changes in the nature of the commercial linefishing sector in KZN after 1945. The most important of these was the development of the "skiboat", a compact, affordable, trailable, beach-launched vessel 4–6 m long, powered by twin outboard engines. Although the first wooden skiboats were underpowered and limited to nearshore waters, they freed fishers from constraints imposed by the lack of harbours, allowing effort to be deployed from beaches and river mouths along the coast (Impey 1961, Van der Elst and Garratt 1984). This facilitated a rapid expansion of effort and, although there are still a few deckboats operating out of Durban harbour, the commercial linefishery in the region has relied primarily on these small craft to this day.

Concomitant with the development of the skiboat was the introduction of rods, reels, nylon line and eyed hooks to replace the natural fibre handlines originally used throughout the South African linefishery (Pulfrich and Griffiths 1988). These contributed to effort increases, making it easier to deploy and retrieve increasing numbers of hooks on deeper fishing reefs from small craft. Underwater sonar technology developed during the war was adapted to produce the first commercial echo-sounders shortly thereafter, and these were increasingly used by commercial linefishing

vessels to search for new reefs situated farther from launch sites. Technological developments have continued to contribute to increasing effective effort in this sector, particularly the development of colour echo-sounders and electronic navigation systems, such as the Global Positioning System (GPS), in the 1990s.

In contrast with changes in vessels and fishing equipment, fish processing and marketing methods have remained largely unchanged throughout the history of the KZN linefishery. Fish are gutted at sea, kept unchilled on small vessels or on ice in larger deck-boats and generally marketed whole, at least at time of first sale. Fish are distributed rapidly through a comprehensive network of small, formal and informal fish buyers and outlets to a virtually insatiable local fresh fish market. There has therefore been no need to export fish to other markets. In fact, local demand is so considerable that KZN now absorbs substantial quantities of linefish caught in the Eastern and Southern Capes.

CHARTER-BOAT SECTOR

In South Africa, the charter-boat fishery is largely unique to KZN, where it functions as an overlap between the commercial and recreational sectors. Charter-boat fishing started when anglers chartered tugs from Durban harbour for daily fishing trips in Durban Bay (see the description of the recreational sector), providing anglers unable to afford their own vessels with the opportunity to fish nearshore. Charter trips ceased during the First World War but resumed in 1923, when the charter-boat fishery began developing as a distinct sector. Encouraged by the popularity of the early charter trips from Durban harbour, commercial linefishing entrepreneurs began operating a couple of charter vessels. These originally remained registered as commercial linefishing boats but, as catch rates in the Durban area declined and operating costs (particularly fuel costs) increased, charter trips offered better profits and these vessels became dedicated charter vessels.

Until the early 1980s, only 1–4 charter boats operated, with the number of trips fluctuating in response to local or tourist angler demand. Although the KZN charter-boat sector is still considerably smaller than the well-established charter-boat fisheries operating in areas such as the southern coasts of the USA (Brusher and Palko 1987), or even the relatively new charter-boat fishery off Taiwan (Liao *et al.* 1995), it has become an increasingly important recreational fishing activity in the Durban area. As a result of increases in tourism to the region, the number of charter vessels and the number of charter trips conducted annually has been increasing (T. Simms, charter-boat operator, pers. comm.). As a result, the charter-boat sector is

Table II: Summary of management regulations applicable to the South African offshore linefisheries up until 1998 (from Chief Director Sea Fisheries 1996)

Sector	Species group					
	Critical	Restricted	Exploitable	Recreational	Bait	Minimum size limits†
	Brindle bass* Potato bass* White shark* Natal wrasse* Poenskop Seventyfour Red steenbras Sawfishes*	Bludger Blue hottentot Dageraad Dane Elf Englishman Red stumpnose Rockcods# Roman Scotsman Slinger West coast steenbras Zebra	Blueskin Cape gurnard Carpenter Dorado Elasmobranchs# (excluding those on other lists) Geelbek Hake Hottentot Javelin grunter King mackerel Kob Panga Queen mackerel Red tjør-tjør Santer Snapper kob Snoek Squartail kob Tunas# White stumpnose Yellowtail Plus all other species not listed in the critical, restricted, exploitable, recreational and bait lists	Baardman Banded galjoen Billfish# Blacktail Bronze bream Cape knifejaw Cape stumpnose Galjoen Leervis Janbruin Kingfish# (excluding bludger and horse mackerel) Large-spot pompano Musselcracker Natal knifejaw Natal stumpnose River bream River snapper Southern pompano Springer Spotted grunter Stonebream Swordfish White steenbras	Anchovy# Fransmadam Garfish# Glassies# Halfbeaks# Horse mackerel Chub mackerel Mullet# Pinky Sardine# Sauries# Scad# Steenjie Strepie Cutlassfish Wolfherring	15 cm: Strepie 20 cm: Cape stumpnose Blacktail 22 cm: Hottentot 25 cm: Carpenter Natal stumpnose River bream Slinger White stumpnose 30 cm: Bronze bream Dageraad Elf Roman Santer Scotsman Red stumpnose Zebra 35 cm: Galjoen Squartail kob 40 cm: Catface, white-edged & yellow-belly rockcod Kob Red steenbras Seventyfour Spotted grunter Squartail kob 50 cm: Poenskop 60 cm: Geelbek Musselcracker Snoek White steenbras 70 cm: Leervis
Recreational	*No catch, 2/person/day	5/person/day	10/person/day	10/person/day, max. 5/species	Unlimited	
Semi-commercial	*No catch, 2/person/day	10/person/day	Unlimited	10/person/day, max. 5/species	Unlimited	Applicable to all sectors
Commercial	*No catch, 2/person/day	Unlimited, except 5 elf/person in KZN	Unlimited	10/person/day, max. 5/species	Unlimited	

Applies to all species in the group. Minimum size limits are expressed in total length

expanding and becoming formally organized. An increasing number of commercial A (full-time), B (part-time) and T (tuna) permit-holders are also conducting fishing charters during peak holiday periods, as this is more profitable than fishing.

RECREATIONAL SECTOR

Recreational boat-based linefishing began off KZN in the early 1900s when anglers, tempted by the success of Durban-based commercial deckboats, began to charter harbour tugs for fishing trips from Durban harbour. Anglers were limited to fishing off these

chartered vessels, or small recreational dinghies in sheltered areas such as Durban Bay, until after the second World War. The development of the skiboat after 1945 had a dramatic effect on the recreational fishery, providing anglers with their first affordable means of participating in the nearshore linefishery (Mara 1986). By 1961, the Durban Skiboat Club had more than 60 registered members. This was the first organized skiboat club in KZN, and Durban remains the centre of the KZN recreational skiboat fishery to this day. However, recreational fishing spread rapidly to the north and south of Durban, and in 1972 the Natal Skiboat Association (now the Natal Deep-Sea

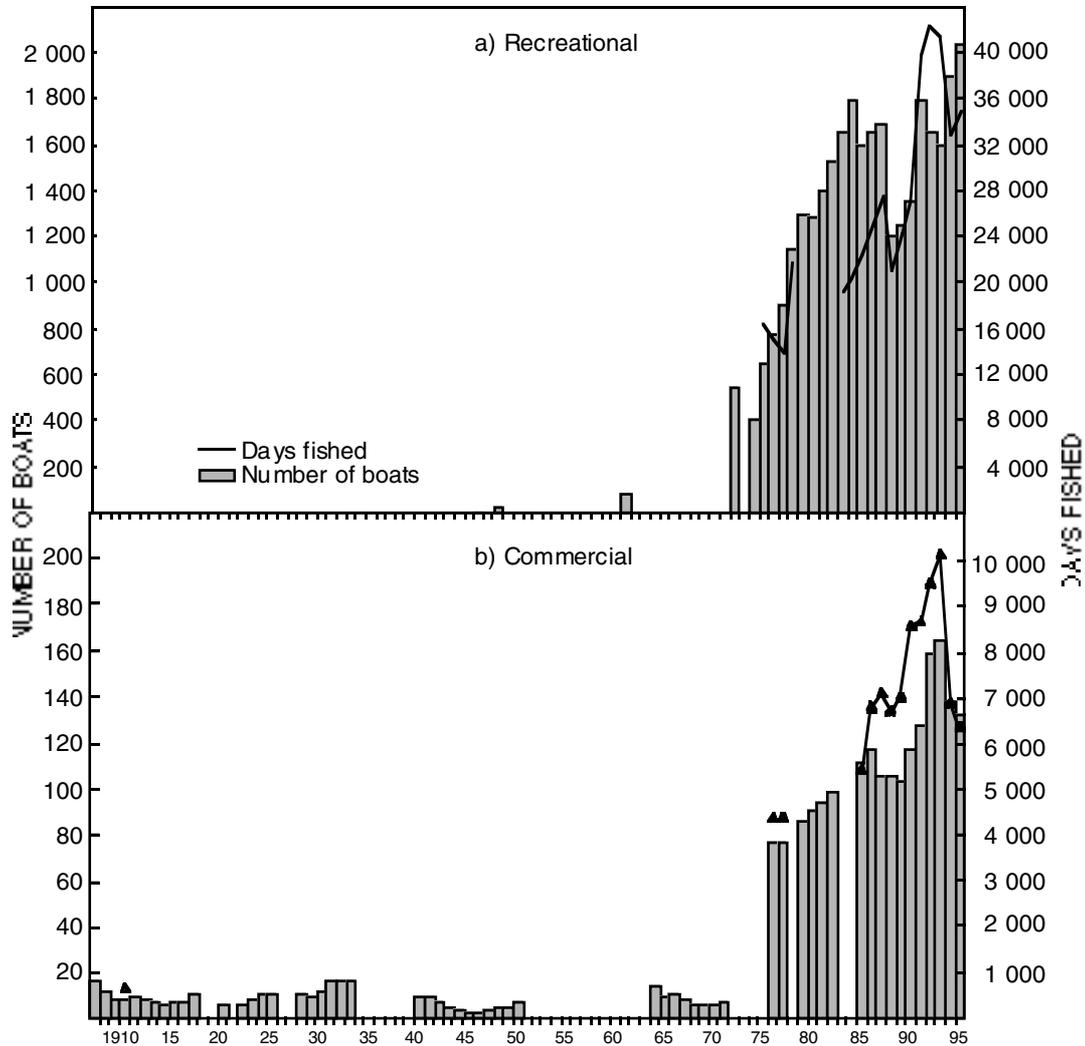


Fig. 2: Annual fishing effort (in number of boats and days fished) by (a) recreational and (b) commercial linefishing vessels operating off the KwaZulu-Natal coast for the period 1910–1995. Blanks indicate missing data

Angling Association [NDSAA]) was formed by the association of 10 skiboat clubs. Entry into the recreational fishery remains unlimited and by 1995, the NDSAA included 38 affiliated clubs with more than 4 000 members and 2 000 affiliated boats.

Recreational skiboats in current use range in size from 3.8 to 8 m long, powered by twin 50–150 hp outboard engines and crewed by 2–8 anglers. The development of small, relatively cheap inflatable and semi-rigid craft (known locally as “rubber ducks”)

during the 1990s brought nearshore linefishing within financial reach of an increased number of anglers, resulting in a further increase in recreational participation and fishing effort. These smaller (3–5 m long) craft are easier to transport than skiboats, and may be launched off practically any beach. They tend to be used in shallower, nearshore areas by anglers and spearfishers, focusing increased effort on already heavily exploited nearshore reefs.

The fishing gear used on skiboats is fairly standard

throughout the KZN fishery and recreational anglers adopted the same rods, reels and nylon fishing line as commercial fishers, although usually with fewer hooks per reef-fishing trace. As a result of the higher degree of recreational targeting on gamefish, the recreational sector tends to make more use of trolling techniques, using larger gamefishing reels and artificial lures. In particular, increased use of Rapala® lures during the 1980s and 1990s greatly increased the efficiency of fishing for gamefish. During the early 1970s, relatively few recreational skiboats carried echo-sounders. However, from then onwards, recreational anglers increasingly adopted echo-sounders (including colour sounders) and GPS (as occurred in the commercial sector), contributing to increased effective recreational angling effort.

Effort trends

From the inception of the fishery in about 1905 until 1945, the number of commercial linefishing vessels fluctuated from 6 to 16, each carrying from 15 to 20 crew, fishing for a combined 500–1 000 boat-days-year⁻¹ (see Fig. 2). Following the introduction of the trailable, beach-launched skiboat in 1945, the number of commercial vessels increased rapidly. The earlier part of this increase is not well documented in the available data sources, but by 1975 there were 90 registered commercial linefishing vessels, mostly skiboats carrying from 6 to 8 crew, fishing for more than 4 000 boat-days-year⁻¹. By 1985, when commercial linefish permits were first introduced, there were 110 commercial vessels operating off KZN, fishing for more than 5 000 boat-days-year⁻¹.

Although the number of commercial linefishing vessels was not limited by any fisheries management measures prior to the introduction of commercial linefish permits in 1985, there were two factors, largely unique to the region, which did limit the extent to which fishers chose to become commercially registered in KZN. The first was a direct result of the delegation of coastal control to KZN when the Sea Fisheries Act was promulgated in 1940. The Natal Provincial Administration, in turn, delegated authority for control over activities on beaches to the various coastal municipalities. As recreational participation in the linefishery increased and skiboat clubs proliferated along the coast, these municipalities, in turn, delegated control over launching of skiboats from beaches to these skiboat clubs. Most of these clubs discouraged, or even expressly prohibited, their members from participating in commercial fishing. Indeed, the largest and most influential club, the Durban Skiboat Club, was established on land leased from the Durban port authorities

under the condition that no commercial fishing was conducted by club members. At a time when most fishers in the Cape were registering their vessels as commercial in order to qualify for use of the increasing number of fisheries harbours, and to sell their catches, most fishers in KZN therefore chose rather to retain “recreational” status in order to retain access to club-controlled launch sites.

The second factor which discouraged commercial registration in KZN stemmed from the safety requirements of the Department of Transport, which introduced a compulsory safety certificate for all vessels participating in commercial fishing after promulgation of the Sea Fisheries Act. Although such certificates were a national requirement, specific details were tailored to suit local conditions by Chief Inspectors in the various regions. In the Cape, there were no minimum size requirements for commercial fishing vessels, and most vessels from the many 3 m, two-man dinghies upwards were registered. However, in KZN, 18 feet (5.5 m) was considered to be the minimum safe length for a skiboat launching through the surf. Although the first skiboats were typically this length, fibreglass construction methods and improved outboard engine technology resulted in cheaper 4.9 m (16 ft) skiboats becoming increasingly popular. Fishers operating these smaller skiboats could not obtain safety certificates, and so could not register their vessels as commercial, even if permitted to do so by their clubs. As a result of a combination of these two factors, the number of commercially registered linefishing vessels in KZN increased slowly in comparison with the situation in the Cape.

After commercial linefish permits were introduced, and the total number of permits capped, in 1985, KZN skiboat clubs rescinded their prohibition on commercial activities and many participants in the “recreational-commercial” sector in KZN requested permission to register their vessels. Although these requests were not granted, linefish permits could be freely traded and there was a steady movement of permits from the Cape to KZN from 1985 to 1993 as a result of the purchase of permits from previously inactive vessels in the Cape. The number of active commercial vessels in KZN thus increased to a maximum of 165 skiboats fishing for up to 10 000 boat-days in 1993 (Fig. 2). After 1994, further transfer of permits from the Cape to KZN was prohibited, resulting in a slight decrease in numbers of active vessels (Fig. 2), but transfer of licences within KZN continues. High fishing effort is sustained as repeated cycles of new entrants attempt to recoup the costs of their newly purchased permits. Spurred on by high market prices for fresh fish, new entrants continue to exert heavy pressure on dwindling linefish resources

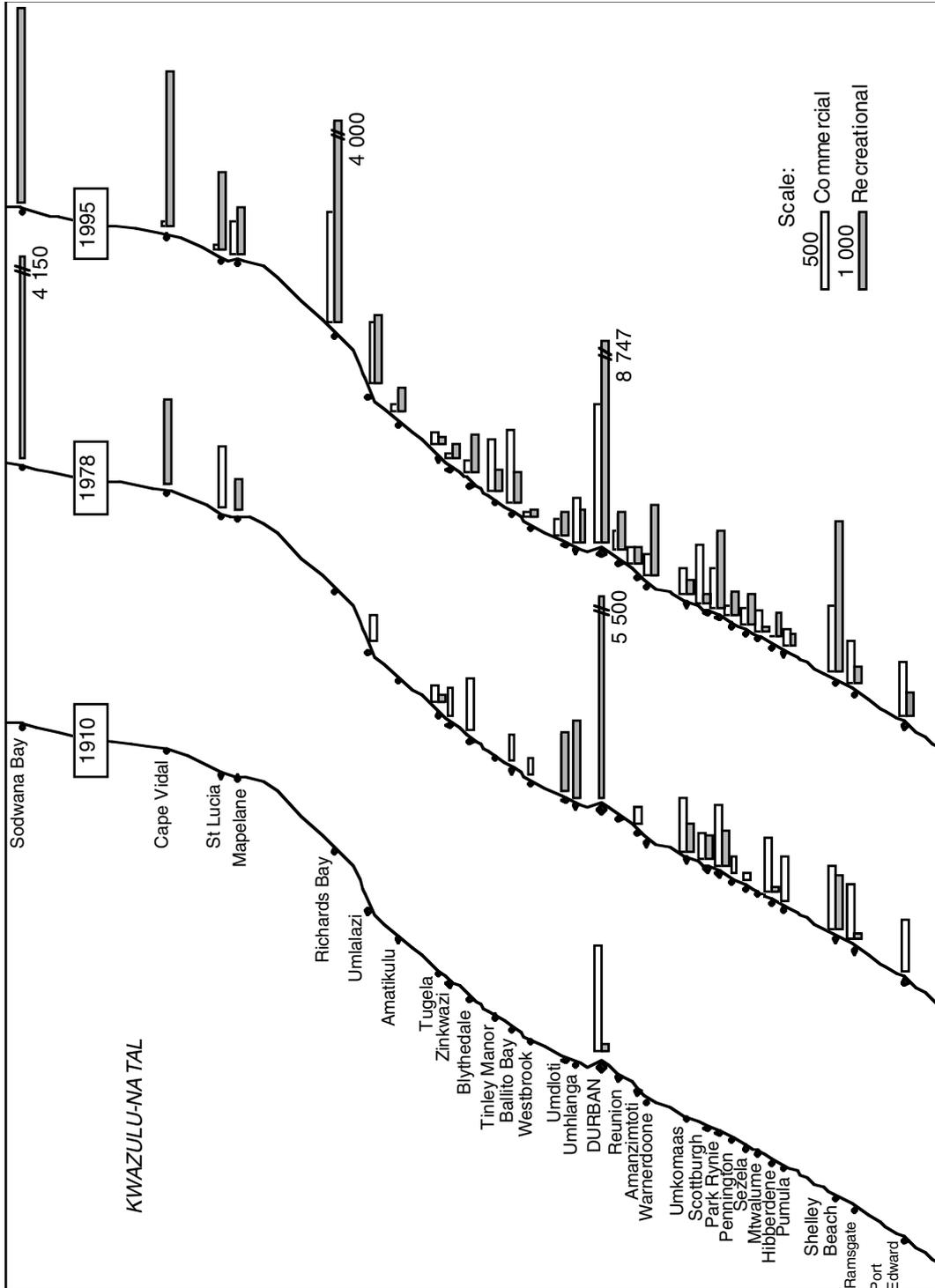


Fig. 3: Coastal maps showing the geographic spread of launch sites and commercial and recreational linefishing effort (in days fished) along the KwaZulu-Natal coast in 1910, 1978 and 1995. Note that recreational effort is expressed at half the scale of commercial effort

in the region, despite unprofitably low catch rates.

Apart from the limited number of charter trips conducted out of Durban harbour between 1910 and 1945, the recreational linefishery off KZN lacks the initial deckboat phase of the commercial fishery. However, the recreational sector expanded far more rapidly than the commercial sector after introduction of the skiboat. From about 80 skiboats in 1961, this sector expanded to some 1 600 boats carrying 4–6 crew and fishing for 28 000 boat-days·year⁻¹ by the time linefish permits were introduced in 1985 (Fig. 2). Numbers of vessels and fishing effort continued to increase after 1985, reaching a recorded maximum of some 2 000 local recreational vessels, fishing for about 35 000 boat-days in 1995. Prevented from registering commercially, an appreciable number of the “recreational” skiboat club members in KZN nonetheless sold their fish, leading to intense competition between “commercial” and “recreational” sectors, and causing ongoing controversy over sale of fish by recreational fishers in the region.

In addition to the craft registered in KZN, hundreds of up-country skiboats operated along the KZN coast during the midyear and end-of-year tourist seasons. Political factors also appear to have influenced the number of vessels operating along the KZN coast. The decline in launches noted after 1992 can, in part, be attributed to the widespread violence in KZN at that time. Similarly, since the cessation of hostilities in Moçambique, there has been a movement of recreational effort from KZN to that region, once a popular fishing destination for South African skiboat fishers (Van der Elst *et al.* 1996). Up-country skiboat fishers have certainly turned their attention to Moçambique recently, reducing the number of visitors to KwaZulu-Natal and contributing to the decrease in the number of launches observed during 1994 and 1995 (Fig. 2).

Although the number of recreational skiboats active off KZN appears to have stabilized or declined in recent years, the introduction of inflatable craft in this sector has contributed to increasing recreational effort in the region over the past few years. To date, no limit has been placed on the number of recreational vessels registered in the province, although attempts have been made recently by local municipalities to limit the number of daily launches at specific launch sites (Natal Town and Regional Planning Commission 1987).

Effort distribution

As a result of the increase in total effort, there has been a steady spread in the geographic distribution of linefishing effort along the KZN coast since the incep-

tion of the fishery. In the early 1900s, deckboats used by commercial fishermen required a substantial harbour and these vessels all operated out of Durban, the only harbour in the region at that time. During 1910, there were 670 commercial boat-days recorded, all out of Durban harbour (Fig. 3). These deckboats could range along most of the KZN coast, but were not equipped with freezers, and had limited hold capacity. Although they did occasionally fish as far south as the Transkei coast, particularly when shoaling species such as seventyfour or red steenbras were seasonally abundant there, effort decreased rapidly with distance from Durban. Effort was particularly focused on few major, well-known reefs, such as the Aliwal Shoal and Illovo Banks, and many of the reefs distant from Durban, particularly the deeper reefs off the North Coast (Fig. 1), were unknown to fishers at the time.

Increasing skiboat effort after 1945 initially spread to suitable beach launch sites on the South Coast, where suitable fishing reefs were better known and closer to shore (Fig. 1). The South Coast had a well-developed infrastructure, including roads, parking facilities, water, fuel and boat-retrieval winches, as a result of the substantial tourist trade in southern KZN. In contrast, expansion to the north was hampered by slower development and an associated lack of suitable roads. By 1978, only one-third of the total recorded 4 370 commercial boat-days were fished along the North Coast, at some seven launch sites from Westbrook to St Lucia (Fig. 3). Most of the effort was deployed from 11 major launch sites between Amanzimtoti and Port Edward on the South Coast.

The development of Richards Bay harbour in the mid 1970s opened the North Coast to linefishing. Primarily developed for the export of coal, the harbour is also equipped with mooring and slipway facilities for fishing vessels. This has facilitated deployment of skiboats and larger vessels in the area, including newly constructed, 10–15 m catamaran-hulled vessels carrying 10 or more crew, initially developed for use in the South-Eastern Cape squid fishery. These boats can remain at sea for extended periods, are relatively fast and have freezing facilities. This has resulted in a rapid increase in effort on previously unfished reefs along the northern KZN coast. By 1995, the total reported 6 360 commercial boat-days were evenly distributed between the North and South coasts, with commercial skiboats operating from 28 principal launch sites north and south of Durban (Fig. 3). Using GPS navigation systems and colour sounders, fishers have now essentially mapped all the major reefs along the KZN coast, including the deeper reefs along the edge of the Tugela Bank from Tinley Manor to north of Richards Bay (Fig. 1).

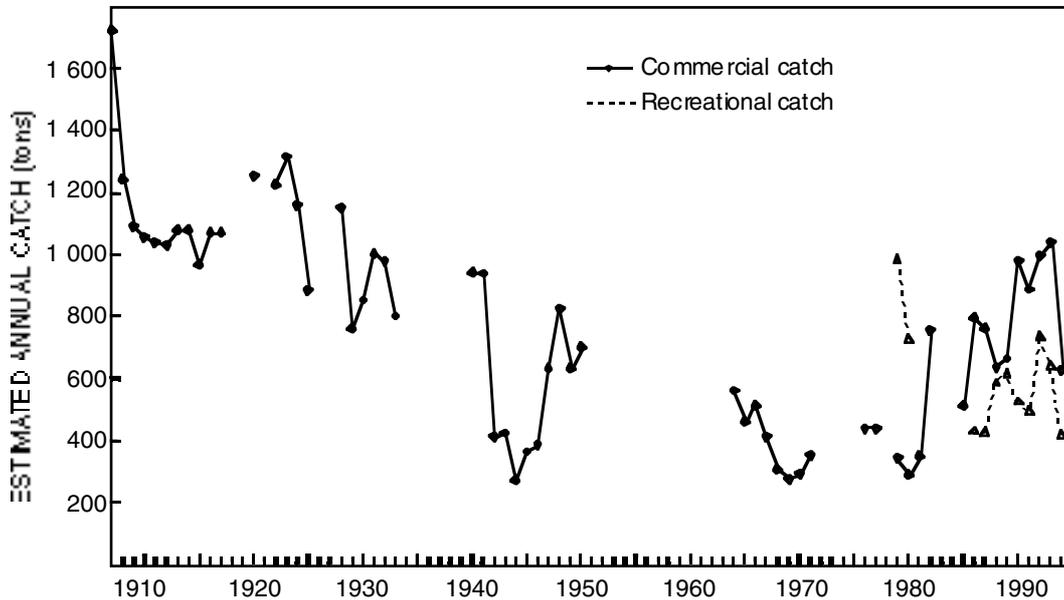


Fig. 4: Estimated annual catch by commercial and recreational linefishing vessels operating off the KwaZulu-Natal coast for the period 1910–1995. Blanks indicate missing data

Distribution of recreational linefishing effort along the KZN coast shows similar, but more dramatic, trends to those of commercial vessels. In 1910, the only recorded recreational boat fishing effort was 65 boat-days fished off chartered tugboats operating out of Durban harbour (Fig. 3). However, recreational skiboats proliferated more rapidly than commercial craft after 1945, encouraged by the control of beach launch sites by skiboat clubs. Recreational skiboats were initially deployed in Durban, where the influential Durban Skiboat Club was established, and along the South Coast. By 1978, annual recreational effort had increased to some 14 900 boat-days, more than three times the commercial effort level at that time, although recreational skiboats operated with fewer (3–4) crew.

These recreational launches took place at nine launch sites between Umdloti, just north of Durban, and Ramsgate, near the Transkei border, with Durban remaining the principal launch site. Another trend in effort distribution, unique to the recreational sector in KZN, also became evident then. Mozambique had become a popular tourist destination for skiboats from the inland province of the Transvaal during the early 1970s. However, with the closure of that area to South Africans in 1975, Sodwana Bay and Cape Vidal became favoured launch sites for these visitors. More than 5 000 of the recreational launches recorded

during 1978 took place at Sodwana Bay and Cape Vidal, in the newly established St Lucia Marine Reserve, which stretches northwards from Cape Vidal (Fig. 1). Although commercial fishing was prohibited in that reserve, recreational fishing was permitted for migratory pelagic gamefish species only. Abundance of species such as king mackerel, sailfish, black marlin, blue marlin and certain kingfish species (see Table I) attracted a substantial amount of recreational skiboating effort to the far North Coast.

Recreational skiboat effort continued to increase rapidly (Fig. 2) and, by 1987, some 49 launch sites, spread between Port Edward in the south to Sodwana Bay in the north, had been recognized by the Natal Town and Regional Planning Commission (1987). In 1995, some 30 000 recreational launches were recorded, more than 4.5 times the commercial effort at that time, distributed along the entire KZN coastline. In addition to their traditional North Coast launch sites at Sodwana Bay, Cape Vidal, St Lucia and Mapelane, recreational fishers also took advantage of the facilities offered by the new Richards Bay harbour, which recorded the second highest number of launches after Durban in 1995. However, Durban has remained the most important single recreational launch site, recording a remarkable 8 747 launches during 1995, an average of 24 per day.

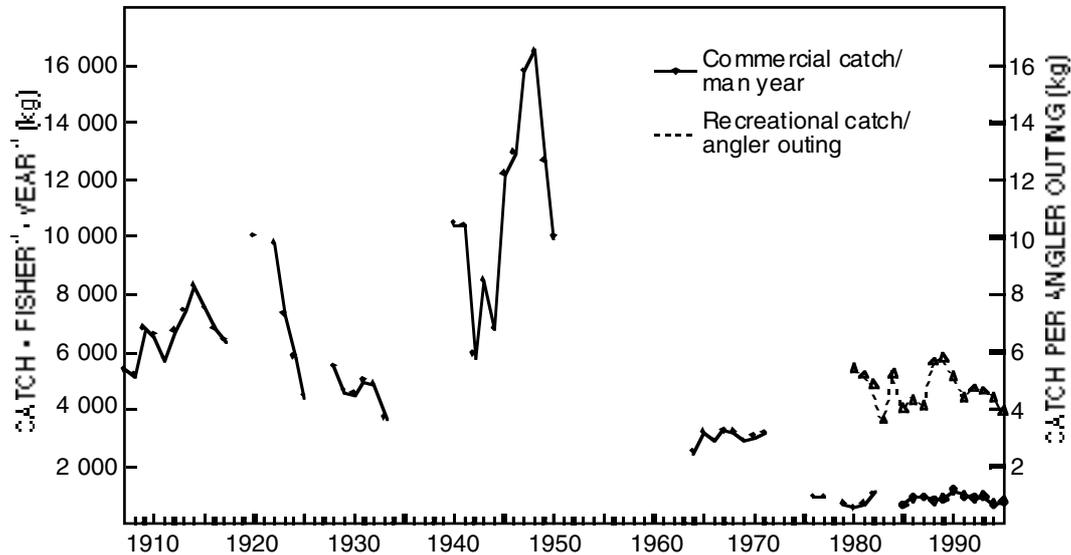


Fig. 5: Estimated annual *cpue* by commercial and recreational linefishing vessels operating off the KwaZulu-Natal coast for the period 1910–1995. Blanks indicate missing data

Total catch and *cpue* trends

COMMERCIAL CATCHES

Earliest estimates of total commercial catches are uncertain. However, it appears from information collected by Natal Fisheries Officers that initial total catches were the highest ever recorded in this fishery. Total annual linefish catches then were estimated to have been somewhere between 1 500 and 2 000 tons, available data indicating approximately 1 700 (Fig. 4). Certainly, annual catches between 1910 and 1920 exceeded 1 000 tons. The first suggestions of declining catches are evident in data from this early period, and catches appear to have declined gradually from some 1 200 tons to just under 1 000 tons by 1940. Understandably, commercial catches were low during the Second World War, but they climbed rapidly again to more than 800 tons in 1948.

Despite the introduction of the skiboat in 1945, and the resultant increase and geographic spread of effort, total commercial catches initially remained at about 800 tons, and then gradually declined to about 500 tons by the late 1970s (Fig. 4). Unexpectedly, the implementation of specific commercial linefish permits in 1985, and the capping of the national total number of permits at that time, resulted in a substantial increase in reported catches in KZN over the next eight years, with total reported catches exceeding

1 000 tons in 1993 for the first time in more than 60 years. This increase closely reflects the increase in the number of commercial vessels operating off KZN over that period, and is clearly a result of the influx of permits into the KZN region. However, with one or two exceptions, these were not actually new entrants to the fishery, but were existing KZN “recreational” fishers, who had refrained from registering their craft as commercial in the past, but who purchased linefish permits from the Cape after promulgation of the new linefish management measures in 1985. Despite this increase in registered commercial effort, total annual commercial linefish catches reported since 1993 again declined to around 600 tons (Fig. 4).

As a result of the switch in the type of vessel in the KZN commercial linefishery, with associated changes in vessel power factor, *cpue* trends by vessel for this sector are difficult to relate to trends in total catch. *Cpue* data for the commercial sector have therefore been expressed in terms of catch·fisher⁻¹·year⁻¹ to remove the effect of vessel type (or, more correctly, crew number). Commercial *cpue* appears to have remained relatively constant during the first 20 years of the fishery, fluctuating between 6 000 and 8 000 kg·fisher⁻¹·year⁻¹ (Fig. 5). Catch rates reached about 10 000 kg·fisher⁻¹·year⁻¹ in 1920, probably as knowledge of the reefs and fish distribution patterns around Durban improved, but then declined steadily to <5 000 kg·fisher⁻¹·year⁻¹ by 1935. However, following the introduction of skiboats and

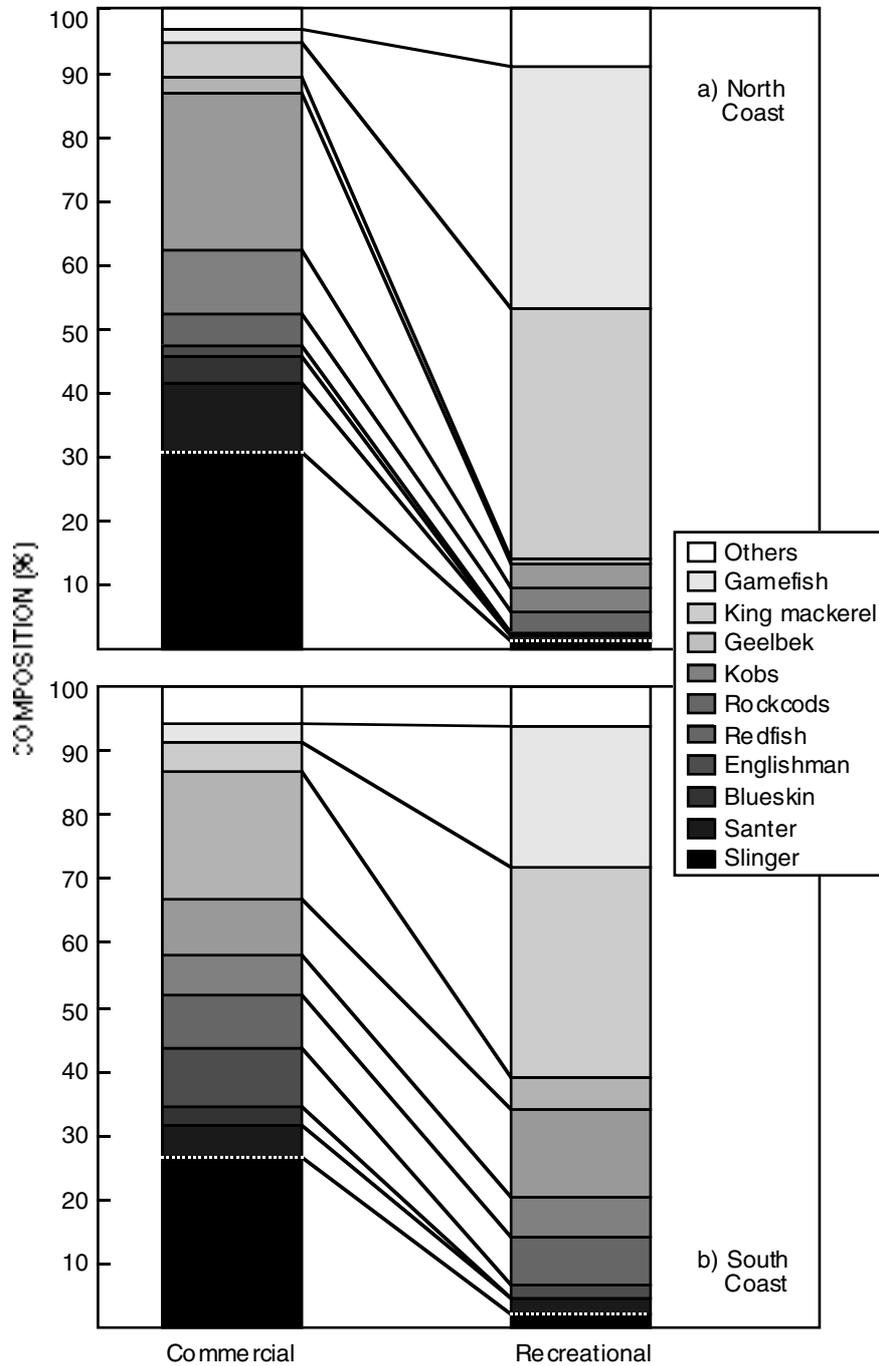


Fig. 6: Species composition of total reported catches by commercial and recreational linefishers fishing off the KwaZulu-Natal (a) north and (b) south coasts between 1986 and 1995

echo-sounders after 1945, individual catch rates increased rapidly to the highest recorded levels of 16 000 kg·fisher⁻¹·year⁻¹ by 1948.

These high catch rates were short-lived and, by 1965, commercial *cpue* declined to record low levels of about 3 000 kg·fisher⁻¹·year⁻¹ (Fig. 5). Although catch rates remained fairly constant between 1964 and 1971, total catches declined throughout that period (Fig. 4), as participants left the fishery in response to the “low” catch rates. Catch rates continued to decline dramatically during the 1980s, despite increases in participation and total catch over this latter period. In particular, whereas participation in the commercial fishery increased rapidly after the introduction of linefish permits in 1985, individual catch rates remained at all-time low levels of <1 000 kg·fisher⁻¹·year⁻¹. By 1970, catch rates had declined to less than half those at the inception of the fishery, and <20% of the highest catch rates recorded in the late 1940s. Despite continued improvements in vessel efficiency, current catch rates of only 700–800 kg·fisher⁻¹·year⁻¹ are 10% of those at the start of the fishery, and only 5% of the post-war catch rates. In the face of these low catch rates, it is only the high and steadily increasing market prices for fresh linefish that have sustained the commercial linefishery off KZN.

RECREATIONAL CATCHES

In comparison with the commercial sector, time-series of catch-and-effort data for the recreational linefishery off KZN are short, only starting in the late 1970s. As a result of the voluntary nature of most of the recreational skiboat data sources in the region, estimates of total catch are difficult to obtain and must be extrapolated from information on catch rates per vessel and the number of launches. Inevitably, there is uncertainty associated with this extrapolation process and, despite steady improvements in data coverage as voluntary returns have been replaced by Natal Parks Board surveys of landing sites, it is still not possible to estimate confidently total annual effort by recreational skiboats or anglers. Catch rates of recreational anglers have therefore been expressed in terms of catch per angler outing (catch·angler⁻¹·day⁻¹) rather than catch·angler⁻¹·year⁻¹. Estimates of number of recreational outings per year may be used to raise these to allow some comparison with commercial *cpue* data, if necessary.

Anecdotal evidence suggests that recreational catch trends during the 1950s paralleled those of the commercial sector, although at a substantially lower total catch level. By 1909, press reports were noting increases in both the number and duration of charter fishing trips, predicting that such effort would not be

locally sustainable (Anon. 1909). Indeed, by 1950 it was reported that the reefs directly off Durban had been “fished out” (Mara 1986). KZN recreational anglers adopted skiboats at the same time as the commercial sector, and recreational effort and catch escalated rapidly thereafter (Leslie 1963, Mara 1986). Available data from the late 1970s onwards shows a period of high recreational catch during the late 1970s, with estimated annual catches of 800–1 000 tons, apparently exceeding commercial catches at the time. Thereafter, recreational catches declined to below commercial catch levels, fluctuating between 400 and 600 tons per year between 1985 and 1995 (Fig. 4). To some extent, this decline in recreational catches must reflect the purchase of commercial linefish permits by some of the more active “recreational-commercial” participants in that sector.

Recreational catch rates appear to have remained fairly constant since 1980, fluctuating between 4 and 6 kg·angler-outing⁻¹ (Fig. 5). If the data obtained in recent years are more reliable, then there are indications of a slow decline in recreational *cpue* from 6 kg·angler-outing⁻¹ in 1989 to 4 kg·angler-outing⁻¹ in 1995. Whereas accurate estimates of the number of outings per year are difficult to obtain, data on the number of skiboats and number of launches obtained from skiboat clubs suggest that these skiboat anglers fish for an average of 10–20 days per year. Using 20 outings per year as an illustrative value, the estimated recreational catch·angler⁻¹·year⁻¹ would be some 80 kg, which is approximately 10% of the current average commercial catch·angler⁻¹·year⁻¹.

Trends in catch composition

COMMERCIAL CATCHES

Dramatic changes in species composition of KZN commercial linefish catches have caused concern regarding the state of the fishery and has prompted calls for revision of linefish management measures in the region, particularly for reef-dwelling sparids. Although general declines in overall catch rates have contributed, it is specifically the dramatic declines in species such as the seventyfour that have provoked demands for more effective management.

Since the start of the KZN linefishery, commercial fishers have targeted primarily reef-dwelling species endemic to the region, particularly sparids and serranids. This remains the case, and slinger was the most important species in catches made between 1986 and 1995, contributing about 30% of the annual catch along the North and South coasts (Fig. 6). If santer *Cheimerus nufar*, blueskin *Polysteganus coeruleopunc-*

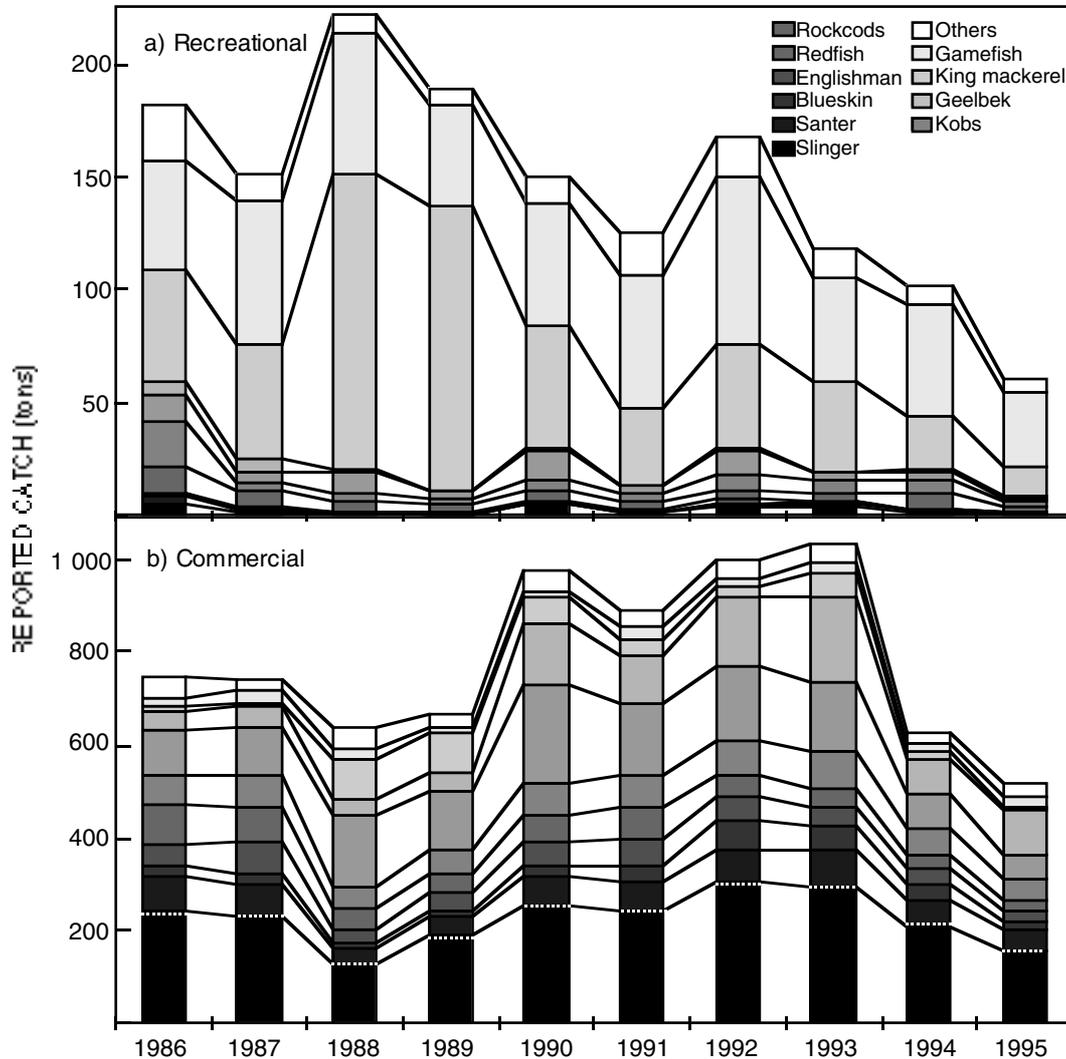


Fig. 7: Interannual trends in species composition (a) recreational and (b) commercial linefisheries off the KwaZulu-Natal coast between 1986 and 1995

tatus, Englishman and unspecified redfish are added, the total contribution by sparids amounts to more than 50% of the catch. The next major contributor to commercial catches are the sciaenids, primarily the squaretail kob *Argyrosomus thorpei*, dusky kob and geelbek. Together, these sciaenids have contributed some 30% of recent catches, North Coast sciaenid catches consisting primarily of squaretail kob, and dusky kob and geelbek being more prevalent in the south. Mixed rockcods (*Epinephelus* spp.) currently

contribute about 10% of catches on the North Coast and slightly more than 5% on the South Coast. Gamefish, primarily king mackerel, also make a moderate contribution (<10%) in both areas.

Interannual trends in commercial linefish catches over the past 10 years (Fig. 7) confirm the consistent dominance of sparids, particularly slinger, throughout that period. In most years, this species group has contributed more than half of the catch, contributing up to 60% of the catch in 1986 and 1987. Catches of

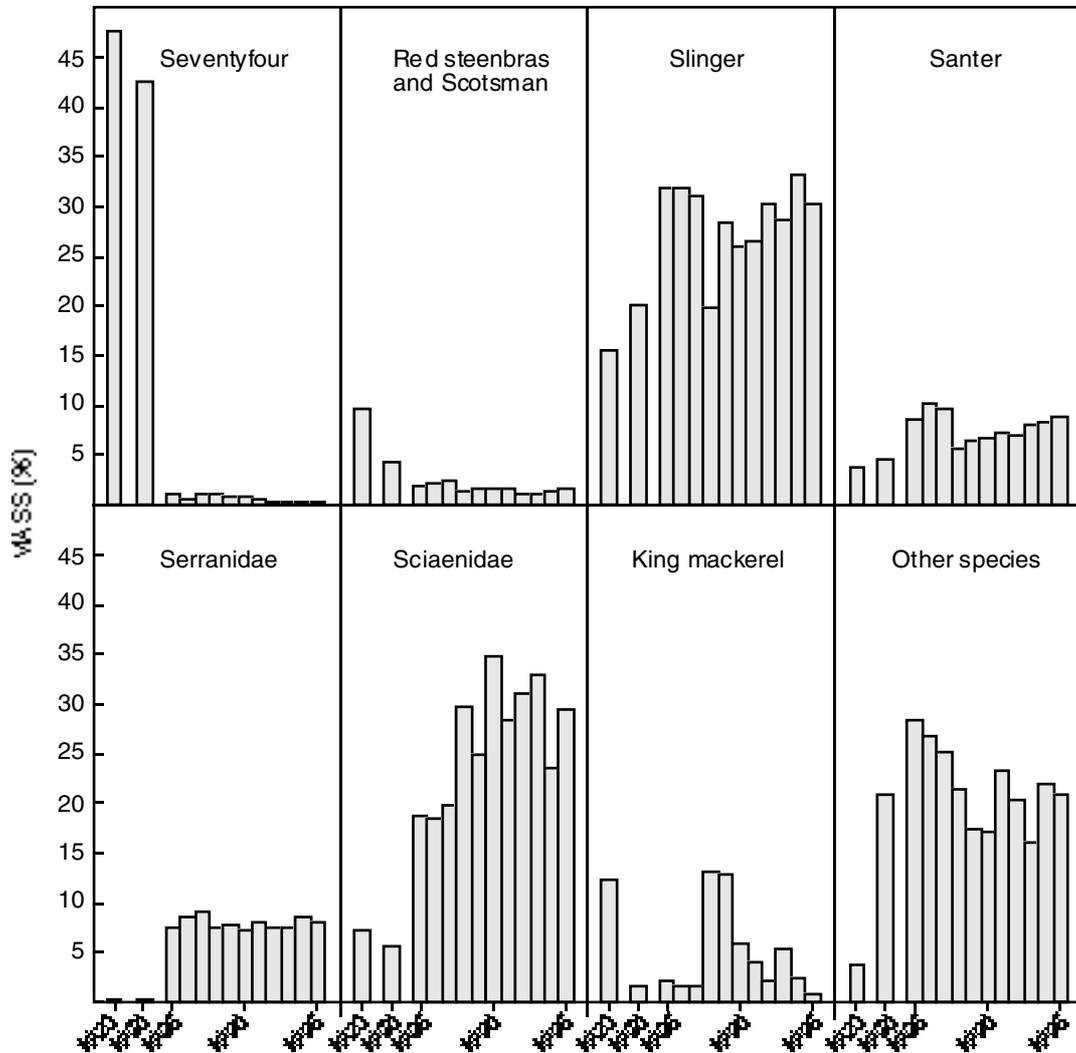


Fig. 8: Trends in catches of the principal target species or species groups in the commercial linefishery off the KwaZulu-Natal coast for the period 1923–1995. Blanks indicate missing data

rockcods have remained fairly constant over that period, but contributions by the sciaenids and gamefish have fluctuated markedly as a result of variable seasonal migration of these species into southern KZN from the Cape and into the northern area from Moçambique. As a result, years of good catches, such as the period from 1990 to 1993, are characterized by strong migrations of these species, rather than increased catches of reef fish.

Analysis of KZN commercial catch composition

data for the past decade provides a false picture of relative stability in catch composition, and comparison with data from earlier years shows that changes in the past have been substantially more dramatic than those observed recently. Historic commercial catch composition data are available for 1923, when only a few deckboats participated in the fishery, and 1950, shortly after the introduction of skiboats. The most striking difference between early and recent catches (Fig. 8) is the complete disappearance from recent

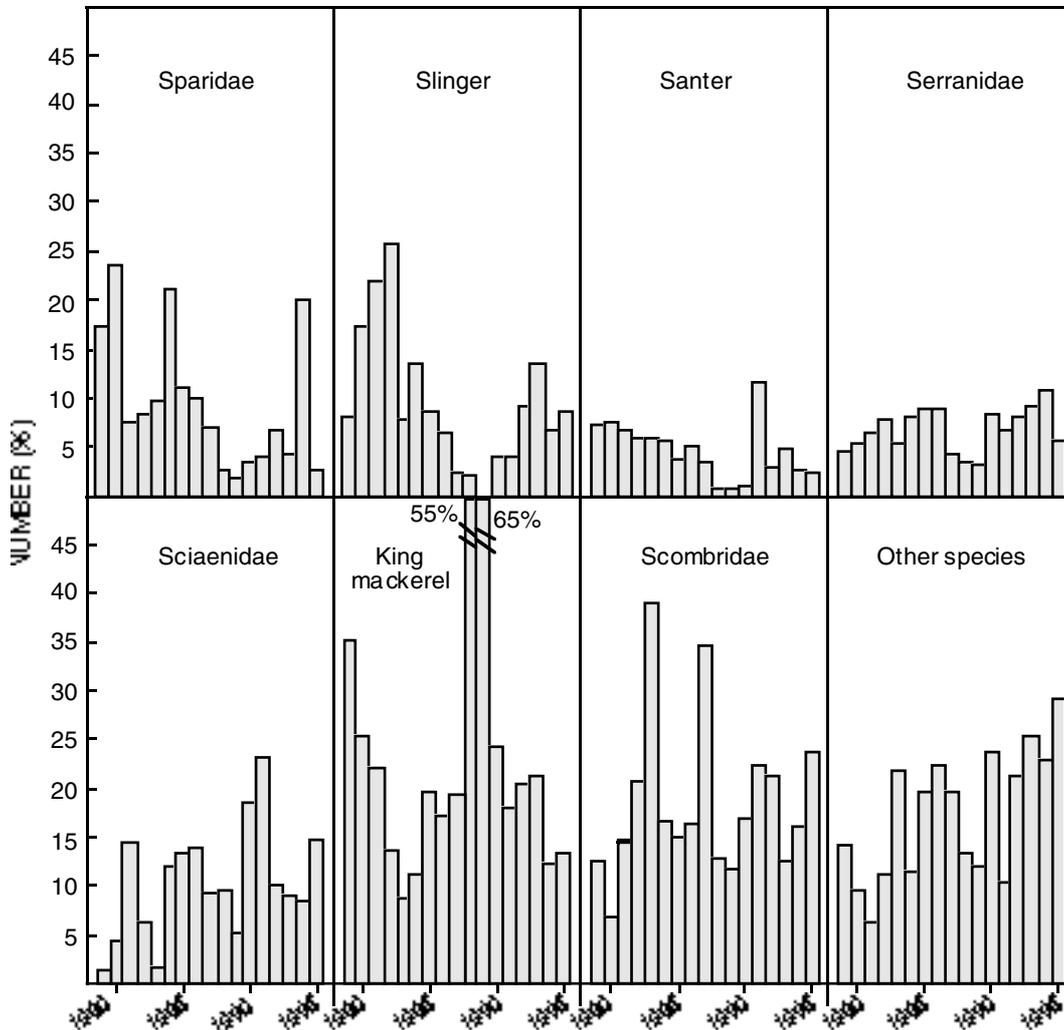


Fig. 9: Trends in catches of the principal target species or species groups in the recreational linefishery off the KwaZulu-Natal coast for the period 1979–1995

catches of large sparids, particularly seventyfour, which formed the main target species in the early years of the fishery. Until the late 1950s, seventyfour contributed almost half of the annual commercial catch, with red steenbras (in the south) and Scotsman contributing a further 10%. Adult shoals of these large, slow-growing sparids migrate seasonally into KZN to aggregate on inshore reefs to spawn. During that time, they feed aggressively and are easily caught, particularly the seventyfour, which used to shoal densely on the Illovo Banks on the South Coast. As a

result, the species were rapidly overexploited, almost totally disappearing from the catches by the early 1960s (Ahrens 1964, Van der Elst and Garratt 1984).

In the early years of the fishery, slinger made up much of the remainder of the commercial catch, after seventyfour (Fig. 8). The slinger caught were large and, as this species is a protogynous hermaphrodite, were primarily adult males (Garratt 1993). With the decline in seventyfour, the contribution by slinger increased steadily, and they now contribute one-third of the commercial catch. However, the mean size of

the slinger caught has decreased steadily, and small fish, primarily females, now make up much of the catch (Garratt 1993). There has also been an increase in catches of santer, another shoaling sparid, and commercial fishermen have recently supplemented catches with smaller species such as blueskin as effort has shifted to deeper reefs, where these occur. Rockcods, initially unimportant to the fishery, have made a fairly constant contribution in recent years (Fig. 8). However, most of the rockcods are highly resident and subject to rapid localized depletion, and it appears that these catches have been sustained by a steady shift of effort onto previously unfished reefs.

In addition to the shift in effort to smaller sparids, KZN commercial fishers have increasingly resorted to fishing at night, targeting on sciaenids, and landings of kobs and geelbek have increased from <10% in early years to one-third of the catch at present. Like king mackerel, which contributes considerably to catches in certain years (Fig. 8), these sciaenids are migratory and KZN linefishers have increasingly come to rely on good runs of these seasonal migrants to sustain catches. There has also been increased reliance on a variety of other species, including reef fish such as small emperors (Lethrinidae), which were previously discarded as unmarketable. To a large extent, overall catch rates have been sustained by a sequential and repeated switching of targeting to alternate species as initially preferred target species became depleted.

Reliable catch composition data are not available for the KZN recreational fishery prior to about 1980, and recreational catch composition trends during the early years of the fishery have not been well documented. However, press reports and anecdotal evidence indicate similar trends in recreational catches to those observed in the commercial fishery. In particular, recreational fishers reported early declines in the abundance of species such as seventyfour, red steenbras and Scotsman, and a resultant switch in targeting to smaller species such as slinger and santer. Recreational linefish catches on the KZN north coast are dominated by king mackerel, which contributed about 40% of the catch during the past 10 years (Fig. 6). Other gamefish, primarily large species such as black marlin *Makaira indica*, blue marlin *M. nigricans*, sailfish *Istiophorus platypterus*, wahoo *Acanthocybium solandri*, barracuda *Sphyraena barracuda* and certain kingfish (*Caranx* spp.), make up a further 40% of the catch. In North Coast areas outside the St Lucia Marine Reserve, squaretail kob, rockcods and redfish (particularly slinger, santer and Lethrinidae) are relatively important, contributing some 5% each to the catch. Gamefish are less dominant in recreational catches on the South Coast, but they still contribute almost 60% of the catch. King mackerel is also the main species caught

on the South Coast, queen mackerel being the other main contributor. Offsetting these smaller gamefish catches on the South Coast are larger catches of sciaenids, serranids and sparids. The relative contribution by geelbek is lower than in commercial catches, but kobs (primarily dusky kob) make up 15% of the recreational catch. Rockcods and redfish contribute a similar percentage to recreational and commercial catches, whereas recreational catches of slinger, santer and blueskin are comparatively low.

Reported recreational catches show higher inter-annual variation in species composition during the past decade than commercial catches (Fig. 7). These variations result primarily from interannual variations in the magnitude of seasonal migratory runs of king mackerel, geelbek and kobs. However, because of the greater importance of those species in recreational catches, the effect on recreational catch composition is stronger. In particular, years of good catches, such as 1988 and 1989, are characterized by large catches of king mackerel. Increased abundance of other gamefish species (notably queen mackerel) also contributes to good catch years, such as 1990–1992. Although the effect is less marked, stronger runs of kob were apparent in 1986, 1988, 1990 and 1992.

Species composition of catches by recreational fishers along the KZN North and South coasts between 1986 and 1995 differed substantially from those of commercial linefishers (Fig. 8). Whereas commercial catches were strongly dominated by reef fish, those by recreational fishers consisted primarily of gamefish, particularly king mackerel. To some extent, this is a true reflection of preferential targeting on gamefish by recreational linefishers. However, this difference also results from prohibitions on the catching of reef fish species, and on any commercial fishing, in the St Lucia Marine Reserve. This has resulted in the focusing of recreational fishing effort, particularly by inland visitors, on gamefish species on the KZN North Coast. Furthermore, whereas the coverage of South Coast catches by voluntary skiboat catch cards is incomplete and sporadic, catches in the St Lucia Marine Reserve are closely monitored by the Kwazulu-Natal Nature Conservation Services, so there are more data available for the North Coast gamefish catches. Even when efforts have been made to monitor recreational catches on the South Coast, fishing for species such as kob and geelbek is often conducted at night when patrol officers are not present to monitor landings. Although it is known that recreational fishers target runs of these species, their catches are under-represented in available data and this fact must be considered when interpreting recreational catch composition data.

Catches of the principal recreational target species between 1979 and 1995 (Fig. 9) show substantial inter-

annual variation, rather than consistent long-term trends. The importance of king mackerel, which contributed up to 65% of the reported catch in 1989, is clearly shown, as is the marked interannual variation in catches of the migratory king mackerel, queen mackerel and Sciaenidae. Recreational catches of the reef-dwelling sparids and serranids fluctuate in opposition to the abundance of the seasonal migrants, increasing substantially in years of poor catches of king mackerel and kob, and decreasing during good runs of these species. As has occurred in the commercial sector, KZN recreational linefishers have also resorted to catching increasing proportions of previously less-favoured species, such as small sparids and lethrinids, as availability of preferred species has declined in recent years.

MANAGEMENT OF THE FISHERY

Past management measures

Prior to the formation of the Union of South Africa in 1910, all aspects of coastal and fisheries management were handled independently by the coastal colonies of the Cape and Natal. During that time, regulations controlling the harvesting of marine organisms were promulgated in Natal, culminating in the Coast Fisheries Act of 1906 (Van der Elst and Garratt 1984). The Act focused on control of harvesting of coastal organisms, particularly shellfish. Following formation of the Union, Natal chose to retain control over coastal resource management, and the Coast Fisheries Act was superseded by the more comprehensive Natal Fisheries Ordinance of 1916. Although expanded to include catch restrictions and minimum sizes for coastal resources, it still did not include any management provisions for nearshore fisheries. Indeed, similar legislation introduced in the Cape in 1911 also contained no legislation controlling nearshore fisheries. However, the development of large-scale trawl, purse-seine and rock lobster fisheries in the Cape between the two World Wars (Thompson 1913, Lees 1969) rapidly led to a need for effective fisheries legislation for these nearshore fisheries, resulting in the promulgation of the Sea Fisheries Act of 1940.

Although this Act, the subsequent revised Sea Fisheries Act of 1973 and the recent Marine Living Resources Act of 1998 were nationally applicable to nearshore fisheries, control over the coastal fisheries of Natal was delegated to the Natal Fisheries Ordinance. A dichotomy in control over harvesting of KZN marine resources resulted, with the KZN provincial authorities being responsible for management of organisms caught in estuaries and on or from the shore,

whereas the Sea Fisheries authorities in Cape Town were responsible for control of boat-based, nearshore fisheries. Sea Fisheries understandably focused on the large commercial trawl and purse-seine fisheries in the Cape, paying little attention to linefishing in either the Cape or KZN. So, whereas the shore fisheries of KZN received considerable local management attention, management of the nearshore fisheries was largely neglected. In fact, up until 1985, the only national management measures applicable to linefish were minimum size limits for a few species.

Rapid expansion of the KZN nearshore linefishery, following the introduction of skiboats in 1945, increasingly drew the attention of KZN authorities to the need for proactive management of the nearshore fishery. Declining catch rates and decreasing mean fish sizes prompted calls for management of the linefishery, particularly after the virtual collapse of the seventyfour stock (previously the principal contributor to KZN linefish catches) during the 1960s (Ahrens 1964, Van der Elst and Garratt 1984). However, implementation of linefish management measures for KZN was complicated by dual authority over fisheries in the region. For example, national minimum size limits imposed under the Sea Fisheries Act conflicted with minimum size limits enforced under the Natal Fisheries Ordinance. In 1984, the Linefish Steering Committee of the South African National Committee for Oceanographic Research (SANCOR) initiated a process to standardize minimum size limits based on sizes at 50% sexual maturity (Penney *et al.* 1997). This prompted proposals to the SANCOR Linefish Steering Committee for a broader review of linefish management measures, including fairly comprehensive draft management proposals for the KZN deep-reef fishery by Van der Elst and Garratt (1984).

In response to increasing national concern at the state of linefish resources, the Minister of Environment Affairs appointed a National Marine Linefish Committee (NMLC) in 1984 to develop management proposals for the entire South African linefishery. The draft management proposals for the KZN fishery were submitted to the NMLC, and was formed the nucleus of a comprehensive suite of linefish management measures, promulgated in December 1984. These management measures, (summarized in Table II), have formed the basis for management of South African linefish resources to date. The principal control measure for commercial linefishing was the introduction of a two-tiered permit system for commercial linefishing, with provision for "full-time" (A-permit) and "part-time" (B-permit) vessels, and the capping of the number of permits at the number of commercial vessels registered in January 1985. Linefish species were divided into management categories based on perceived exploitation status, with associated category-

specific bag limits for the various linefishery sectors. Commercial linefishing is therefore primarily controlled by limiting the number of participants, with unlimited catches of "exploitable" species (see Table II), whereas recreational fishing is controlled by means of individual bag limits, with no limitation on effort. Standardized minimum size limits, based on sizes at 50% maturity, were introduced for many species, and closed seasons were established for certain species considered to be over-exploited. Finally, a prohibition was placed on the sale of any fish by recreational fishers, and on the sale of those species designated as "recreational" (Table II) by any sector.

Although representatives from commercial and recreational linefishery sectors participated in the NMLC, these management measures generated widespread and ongoing controversy, because of the perceived disparity between controls placed on commercial and recreational linefishermen. On dissolution of the NMLC in 1985, the participants agreed to establish the independent South African Marine Linefish Management Association (SAMLMA), to provide a continued representative negotiating forum for review of linefish management measures. The SAMLMA was formally established in 1990 and includes representatives from scientific institutions, conservation agencies, recreational angling clubs and commercial fishing associations. SAMLMA was recognized in terms of the Sea Fisheries Act as the official "interest group" representing the South African linefishery, and it provides a forum for discussion of the promotion, protection and sustained utilization of the marine linefish resources off South Africa (Brunt 1993).

The SAMLMA has proposed amendments to the linefish management measures on a number of occasions in response to improved information on the status of particular linefish species, or motivations from one of the represented sectors. Although most of the management recommendations made by the SAMLMA have been implemented, there is no guarantee that all will be implemented. Inevitably, even those recommendations that are implemented are a compromise between conflicting views of the represented sectors. There are also certain linefishing sectors, notably the non-club recreational anglers and the true subsistence fishers, who are not represented at the SAMLMA. As a result, there continues to be widespread dissatisfaction among fishers from all linefishing sectors concerning the existing linefish management measures.

Management recommendations

The linefish management measures promulgated in 1985 were developed by negotiated consensus management advisory groups, particularly the NMLC and

the SAMLMA. As a result of the high degree of competition, and even open conflict, between the KZN linefishery sectors represented at such fora, these negotiated control measures have usually been uncomfortable compromises between sector demands, rather than stock-assessment management recommendations (in the experience of the first author). As a result, they have not been successful in limiting fishing mortality to sustainable levels.

Long-term catch and *cpue* trends in the fishery clearly indicate that commercial and recreational fishing effort in KZN greatly exceeds a level that can be sustained by the endemic reef fish. The available effort also appears to exceed the sustainable capacity of most of the fish that migrate seasonally into the area. Even the stocks of dusky kob, until recently considered to be moderately exploited and capable of sustaining the existing fisheries, have now been shown to be heavily overexploited (Griffiths 1997). Essentially, the commercial fishery has, for many years, been sustained by rapidly escalating prices and the fact that many commercial fishers own another business in addition to their commercial fishing operation. Subsidization of uneconomical fishing effort also occurs in the recreational sector, where a proportion of recreational anglers sell their catches. The prime management objective should therefore be to implement effective ways of substantially reducing effective effort in both the commercial and recreational sectors, and to focus remaining effort on those species capable of sustaining catches. Considering the level of overexploitation evident in the KZN linefishery, these effort reductions will have to be substantial if there is to be any hope of rebuilding reef-fish resources to sustainable levels.

Progress has been made with the limitation of commercial linefishing effort within KZN with the recent prohibition on movement of vessels from the Cape into the region. However, prevention of immigration of effort has not been adequate to reduce fishing mortality. KZN fishers have therefore become increasingly dependent on migrations of shoaling species from the Cape, and so on the success of management efforts outside of KZN waters. It will therefore also be necessary to reduce local KZN commercial effort levels, either by the withdrawal of commercial permits, or by substantial reduction in the catch limits available to commercial fishers. In the recreational fishery, effort continues to increase without limitation. It is clear that bag limits have also been inadequate to limit fishing mortality by this sector and substantial curtailment of either effort or individual catches will be required to reduce recreational fishing mortality to sustainable levels. If bag limits continue to be the principal management measure for recreational fishers, they may have to be reduced to unpopularly low levels of perhaps one or two fish per person. Alternately,

current attempts to limit daily numbers of launches will have to be widely and stringently implemented in order to achieve an sizeable reduction in effort.

Given the wide diversity of species exploited by KZN linefishers, management approaches will also have to be tailored towards particular species groups. In particular, different approaches will be required for local, endemic reef fish and for shoaling migrants from adjacent areas. Effective management measures for local reef fish should be developed and implemented with involvement of local research organizations, management agencies and fishery sectors. Effective implementation of management measures will also require increased jurisdiction of local management agencies over the nearshore marine resources. Management measures for endemic reef fish will have to incorporate limits on deployment of effort on over-exploited reefs, particularly from outside KZN. In contrast, management of the shoaling migrants will require close cooperation with authorities in the Cape and Moçambique.

Finally, one of the most important characteristics of the KZN linefishery is the extent to which catches, particularly of reef fish, were sustained in the past by proclaimed and implicit refuges from fishing effort. These marine harvest refugia played a vital role in maintaining sustainable catches in certain areas, particularly on the KZN north coast where the large St Lucia and Maputaland Marine Reserves were established formally. In contrast, the absence of refuges on the KZN south coast is clearly reflected in the over-exploitation of reef fish there, and the rapidity with which migrating shoals of reef fish such as red steenbras are depleted when they arrive. On a wider geographic scale, recent increases in fishing effort on the reef fish of Moçambique are likely to be reflected in further reductions in *cpue* and mean size of these species in northern KZN. Progress has been made with input to the development of a comprehensive marine protected areas policy for South Africa (Attwood *et al.* 1997, Hockey and Branch 1997, Marine Reserves Task Group 1997), and relevant aspects of this policy could be implemented effectively in KZN. Management efforts for the linefisheries in KZN must recognize the essential nature of substantial marine protected areas: existing areas must be accorded the protection status required to protect reef fish and such areas must be incorporated into long-term management plans for the region. Given the problems of slow growth rate in sparids, sex change, barotrauma, strong inter-sector competition, difficulty in achieving substantial reductions in effort and ineffectiveness of the current bag limits, it is likely that the maintenance of a number of adequately large, suitably situated marine reserves offers one of the few practicable chances of conserving the endemic reef fish stocks of KZN.

CONCLUSIONS

- Since inception, the KZN nearshore linefishery has been characterized by continually increasing effort. Effort continues to increase, despite efforts to curb numbers of vessels, as a result of activation of previously inactive vessels, influx of permits from other regions, or transfer of permits within KZN. Increasing market prices have encouraged these effort increases, despite declining individual catch rates, and continual sequential transfer of vessels continues to compel new owners to fish in an effort to recoup permit and vessel purchase costs. Even where efforts have been made to limit nominal effort, effective effort continues to increase as a result of technological improvements. Catch and *cpue* declines indicate that the fishing effort in the region has exceeded the sustainable capacity of the resource, and there is now substantial excess line-fishing effort capacity in the region. The magnitude of this excess effort is indicated by the speed with which shoals of preferred target species are rapidly detected and fished out, usually within a matter of days. This has occurred both with migrating sci-aenids, particularly dusky kob, and with migrating shoals of red steenbras, which are rapidly depleted shortly after their appearance on the KZN south coast.
- Linefishing off KZN has also spread rapidly from the central Durban Harbour region to the entire coast, penetrating extensively into the neighbouring territories of Moçambique and Transkei. This geographic spread in effort has resulted from sequential development of launch sites along the North and South coasts, implementation of trailable skiboats and, most recently, the development of the Richards Bay Harbour. This new harbour has facilitated the deployment of large, fast, catamaran-hulled vessels along the North Coast, where launch sites for skiboats are widely separated. Throughout the fishery, improvements in skipper experience, vessel seaworthiness and echo-sounder technology have contributed to steady expansion of effort from in-shore areas to deeper, offshore reefs.
- As a result of this relentless spread in effort, areas off the KZN coast that previously served as implicit refuges from fishing effort have been sequentially exploited. This was illustrated by the rapid depletion of previously unexploited large, endemic sparids, serranids and lethrinids from nearshore reefs in the vicinity of Richards Bay, following the opening of the harbour. Instances of fishing out of newly located reefs off KZN have been documented throughout the history of the fishery (Mara 1986),

and the consistent *cpue* declines after the widespread implementation of echo-sounders after 1945 bear testimony to the rapidity with which previously unfished reefs were located. This phenomenon has been noted in studies on reef fisheries in other parts of the world. For example, 80% of the biomass of snowy grouper *Epinephelus niveatus* was removed within a year of discovery of a new reef off Carolina, USA (Epperly and Doderill 1995). In Australia, stocks of another serranid, *Plectropomus leopardus*, were reduced by 25% within two weeks of the opening of a previously closed area (Beinssen 1989, Roberts and Polunin 1991).

- Because of the increase and spread in fishing effort, declines in KZN total catch and *cpue* have been evident, particularly in the commercial sector, for at least the past 30 years. Although the total catch decline has been less dramatic than declines in *cpue* of principal target species, total catches have been sustained primarily by repeated switching of target species. Steady depletion of many of the endemic reef fish has had significant effects on the population structure of certain species, particularly those which exhibit protogynous hermaphroditism, with the larger males being depleted first. Sex ratios (M:F) for slinger differ substantially between unexploited (1:2.3 in Moçambique), lightly exploited (1:4.6 in the St Lucia Reserve) and exploited areas (1:18.8 along the KZN south coast – Garratt (1993). Similar changes in population structure have also been noted in Scotsman in KZN (Garratt 1994), whereas the difference in mean size of red steenbras in exploited and unexploited areas in the Eastern Cape has been found to be considerable (Buxton and Smale 1989). Two rockcod species, *Epinephelus marginatus* and *E. albomarginatus*, have also shown evidence of alterations in population structure, with the mean size of individuals in the catch decreasing (Fennessy 1994).
- The only areas of the KZN coast that are not exploited by linefishers are essentially now limited to the marine reserves along the North Coast. Most of the reef fish outside these reserves are overexploited and are not capable of sustaining the current commercial fishery, let alone providing optimal sustainable yields. The shift to smaller species has also resulted in general acceptance of smaller fish on the market, and many of the fish now sold are below their sizes at 50% maturity (NMLS, unpublished data). Parent stocks in the neighbouring areas of Moçambique and Transkei are being increasingly exploited and, as yet, management efforts have failed to reduce effective effort in KZN. Available effort capacity now greatly exceeds the sustainable effort level and, unless effective management

measures are rapidly and effectively implemented, it appears that catches and catch rates of linefish off KZN will continue to decline until the fishery becomes commercially and recreationally extinct.

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