AN ASSESSMENT OF THE SOUTH AFRICAN EAST COAST LINEFISHERY FROM KEI MOUTH TO STIL BAY

Thesis

Submitted in fulfilment of the
requirements for the degree of
Master of Science
of Rhodes University

by

STEPHEN LEONARD BROUWER

SEPTEMBER 1997

A shore fisher at Sundays surf with a prized catch of a 10.3 kg dusky kob, *Argyrosomus japonicus*.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I am extremely grateful to Dr. Colin Buxton for his support and encouragement throughout this study as well as his advice and criticism. My supervisors Prof. Tom Hecht and Dr. Colin Buxton are thanked for thoroughly reviewing earlier drafts of this thesis. Sue Abraham is thanked for drawing the maps. Colin Attwood provided mathematical assistance for the shore fishing effort calculations. Tony Booth, Paul Cowley, Janice Henning and Kerry McPhail gave editorial assistance on various sections of this thesis

A programme such as this one could not be successfully completed without the co-operation of the fishers. I am extremely grateful to them for their willing assistance, for responding so positively to the questionnaires and allowing me to weigh and measure their catch. Bruce Mann, Steve Lamberth, Warwick Sauer, Corne Erasmus and Dr. Colin Buxton assisted in the development of the questionnaires. Prof. Mike McGrath and Charles Horner are thanked for their contribution to the development of the economics questions and assistance with the analysis.

Many people assisted in accommodating, feeding and entertaining me throughout this study: Liz and Pete Thorburn and Jenny and Richard Trow in Komga, Pieter-Jan Schoen in Port Elizabeth, Lee Thorburn and Sandy Roodt in George, Brin Arys in Mossel Bay and Aidan and Mandy Wood in Grahamstown. My thanks go to Justin Lindsay and Cliff Jones for the field assistance in Port Alfred, and Anita Stoll for being a good field assistant and amusing companion. The pilots Etian LeRoux and Niels Anderson are acknowledged for their keen assistance with the aerial surveys.

I would like to take this opportunity to thank my parents for their unending support throughout

the duration of this study.

The FRD is gratefully acknowledged for supplying a bursary. The economics section was funded by the FRD under the Sea and Coast Programme. This study was performed under contract to the Sea Fisheries Research Institute, who are thanked for their financial support through the Sea Fisheries Research Fund.

ABSTRACT

During the period April 1994 and February 1996 as part of an investigation into the national linefishery, the east coast shore fishery and the recreational and commercial ski-boat fisheries were surveyed, at eight sites between Kei Mouth in the East and Stil Bay in the West. Roving creel, access point and aerial surveys were used. A questionnaire was developed for each sector to gather data on catch and effort, fisher demographics, economics, fisher attitudes towards, and knowledge of, the current management regulations and assess the efficacy of the fisheries inspectorate. During the access point survey the catch of 3273 fishers was inspected and 1556 interviews were conducted. Questionnaires were conducted on 118 recreational ski-boaters and the catch of 165 boats was inspected. 96 commercial skippers were interviewed and 230 had their catch inspected. Three aerial surveys of the entire area were conducted during which a total of 1067 shore fishers were counted giving a shore fisher density of 0.39 fishers.km^{-1}.

The majority (99%) of participants in all sectors of the linefishery were male. The greatest number of participants were white, shore fishery 77% recreational ski-boat 98% commercial ski-boat 89%, followed by coloured, asian and black people. To a large extent this reflects the income of various racial groups.

Most fishers supported the current linefish management plan. However, when tested on their knowledge of the size limits, bag limits and closed seasons of their target species many shore fishers (59%) did not know them and a high proportion of fishers in all sectors had disobeyed at least one of the regulations (shore 50%, recreational ski-boat 70%, commercial ski-boat 56%).

When compared to historical data the present catch per unit effort (CPUE) in all sectors has decreased. Most interviewees in the various sectors did not accept responsibility for the decline in CPUE, but attributed it to three principal reasons vis their perceived direct competitors, trawling and pollution.

Analysis of the catch revealed that all sectors were multispecies fisheries, with each sector being characterised by a small number of target species. Catch composition differed significantly between the shore and ski-boat sectors, but there was significant overlap between the two ski-boat sectors. Analysis of the catch in comparison to that reported to the National Marine Linefish System (NMLS) revealed that there was a substantial degree of under-reporting. There was little seasonal difference in effort in the shore fishery while the recreational ski-boat effort was highest in the summer and the commercial ski-boat effort was high in the winter. Effort in the shore and recreational ski-boat fisheries was concentrated over weekends while the commercial ski-boat effort was highest during weekdays. Total effort for the entire area was estimated at 903 186 (±1913) fisher days per annum in the shore fishery, 24 357 (±685) recreational ski-boat fisher days and 64 266 (±1686) commercial ski-boat fisher days per.

Expenditure and capital investment in the various sectors was calculated, as were earnings of the participants in the commercial ski-boat sector. The linefishery in the Eastern Cape was estimated to have a minimum capital investment in excess of R210 million and more than R32 million is spent annually on running costs. The commercial ski-boat fishery directly employed an estimated 3184 people. The economic implications of changes in CPUE for the commercial ski-boat fishery are considered, as are the benefits of a recreational angling licence. Management of the linefishery is discussed in relation to the findings of this study.

CHAPTER 1 - INTRODUCTION

Marine linefishing in South Africa has been the principle cause of changes in the species composition of catches, specifically the decline in the relative proportion of reef associated teleosts (Crawford and Crous 1982; van der Elst and de Freitas 1988; Hecht and Tilney 1989). This has been ascribed to an increase in overall linefishing effort and improvements in fishing equipment since the turn of the century. For example, nylon line has replaced blood line, graphite rods have replaced glass fibre rods which in turn replaced cane rods, all of which allow for improved performance. Global positioning systems (GPS) make it easier to return to fishing "hot spots". Echo sounding equipment and greatly improved boats and boating equipment make it easier to find and catch fish.

In an attempt to ensure sustainable utilisation of linefish resources, active management in the shore fishery has been ongoing since the 1970's. The South African linefishery is currently being managed using bag limits, size limits and closed seasons together with marine protected areas. These regulations were developed mainly from biological and catch data. The regulations are set out in the Sea Fisheries Act No. 58 of 1973, which was modified as new information came to light in 1984 (Government Gazette No. 9543 of 1984), replaced in 1988 (Sea Fisheries act No. 12 of 1988) and further amended in 1992 (Government Gazette No. 14353 of 1992). However, the continuing decline in catches suggests that the current linefish management plan has been ineffective and is in need of revision. It is also important to determine what quantity of fish constitutes a reasonable recreational catch which satisfies the needs and aspirations of the purely recreational fisher (Attwood and Bennett 1995a).

These restrictions were implemented without detailed knowledge of angler attitudes towards such regulations. The luxury of managing fisheries entirely through a 'natural history' approach is long gone (Matlock 1991). Both social and economic data are needed for effective management. Most fisheries' problems result from a failure to understand and manage fishers, therefore the study of people involved in the fishery should be a major part of fisheries research (Hilborn 1985). This is evident in the United States of America where fisheries management objectives have evolved from single species biologically based management plans to a multispecies management plan, which incorporates ecological and social management objectives for optimum yield (Ditton *et al.*1992; Storer 1992; Malvestuto and Hudgins 1996).

In the United States of America prior to the 1950's, marine fisheries research and management efforts were primarily directed toward the commercial fisheries (Deuel 1980). However, growth in recreational fisheries resulted in nationwide surveys of fishing since 1955 (Grambsch and Fisher 1991). These surveys have been important for fisheries management for many years (Phippen and Burgersen 1987; Phippen and Burgersen 1991). Since the mid 1950's the survey techniques have undergone considerable refinement (Malvestuto 1983; van den Avyle 1986; Essig and Holliday 1991; Hoenig *et al.* 1993; Pollock *et al.* 1994). Similar surveys have also been conducted on tropical islands in the western Pacific (Amesbury *et al.* 1991) and the Australian coast (Caputi 1976; Anon 1994).

Most of the research on South African linefish has been conducted on a species directed basis, and few long term studies of catch and effort have been conducted. A fishery is not simply made up of the species caught, but includes the fishers and their associated sociological characteristics. It is therefore essential for fisheries management to also incorporate other data sets such as economics. Therefore the role of science in fisheries management is not simply to provide management with ways in which to manage fish but also to manage fishers. No previous studies have been undertaken in South Africa to assess the attitudes of fishers towards the marine linefish regulations. In South Africa only one study including information on fishers' opinions has been conducted. This relatively small study was carried out in KwaZulu-Natal by Joubert (1981).

The South African linefishery consists of six user groups. There are shore fishers, commercial ski-boats, deck boats, recreational ski-boats, light tackle boats and spearfishers. Each has its own suite of target species with considerable overlap within the offshore sectors and the inshore sectors but with very little overlap between the two. This study focused on the shore fishery and the commercial and recreational ski-boat fisheries. Ski-boats are small craft, usually 4.5-10m long, either single-hulled or of the catamaran type. They may be powered by two outboard motors of between 45 and 200 horse power each, or by an inboard engine with tilting propulsion gear. Each carries a crew of 2-12 fishers. The deck boat fishery (diesel powered decked boats that put to sea for up to 15 days at a time) and the spearfishery were excluded from this study. An attempt was made to sample the spearfishery but not enough data was collected to reach any meaningful conclusions. The deck boats on the other hand catch fish over a wide area and very often outside the Eastern Cape area. It was for this reason that the deck doat fishery was excluded. Light tackle boats (small ski-boats of between 4 and 7 m where the anglers use line with a 2-6 Kg breaking strain) were considered to be part of the recreational ski-boat fishery. Therefore this study focused only on the shore fishery and the commercial and recreational ski-boat fisheries. Both the shore and recreational ski-boat fisheries are open access while access to the commercial ski-boat fishery is controlled by a licencing system. Commercial linefishing boats are licenced as either A- or B-class. In the past the A licences were held by full-time commercial fishers and the B licences were held by part-time fishers (Hecht and Tilney 1989), each with their own set of regulations (Appendix I). However, many B licenced boats now also fish on a full-time commercial basis. The overlapping nature of the different sectors of the linefishery has resulted in conflict which has been difficult to resolve because the fisheries are managed in different ways (Attwood and Bennett 1995a).

Studies which have been conducted in South Africa on the linefishery include those by Smale and Buxton (1985), who assessed the economics and the catch and effort of the recreational ski-boat fishers in Port Elizabeth. Hecht and Tilney (1989) collected similar data for the Port Alfred commercial ski-boat fishery. Shore angling CPUE data has been analysed in the Western Cape (Bennett 1991; Bennett *et al.* 1994) and in the Eastern Cape (Coetzee and Baird 1981; Coetzee *et al.* 1989). Opportunistic shore patrol data from KwaZulu-Natal have also been analysed (Hughes 1989, Joubert 1981) and a roving creel survey was conducted in Port Elizabeth (Clarke and Buxton 1989).

This study formed part of a nationwide investigation into the South African linefishery which was co-ordinated by the Sea Fisheries Research Institute (SFRI). The work along the KwaZulu-Natal coast was conducted by the Oceanographic Research Institute (ORI). Rhodes University studied the Eastern Cape (this study), excluding the Transkei area. The University of Cape Town (UCT) studied the fishery along the Southwestern Cape and the SFRI investigated the linefishery along the West Coast.

The aims of this study were:

1) To estimate total effort, total retained catch and CPUE in the shore fishery, recreational and commercial ski-boat fishing sectors of the Eastern Cape.

2) To gather fisher information from these sectors including fisher demographics, economic indicators, and to determine the attitudes of fishers towards, and their knowledge of, the current regulations.

3) To determine the efficacy of the fisheries inspectorate and in the light of these findings to consider the current linefish management plan.

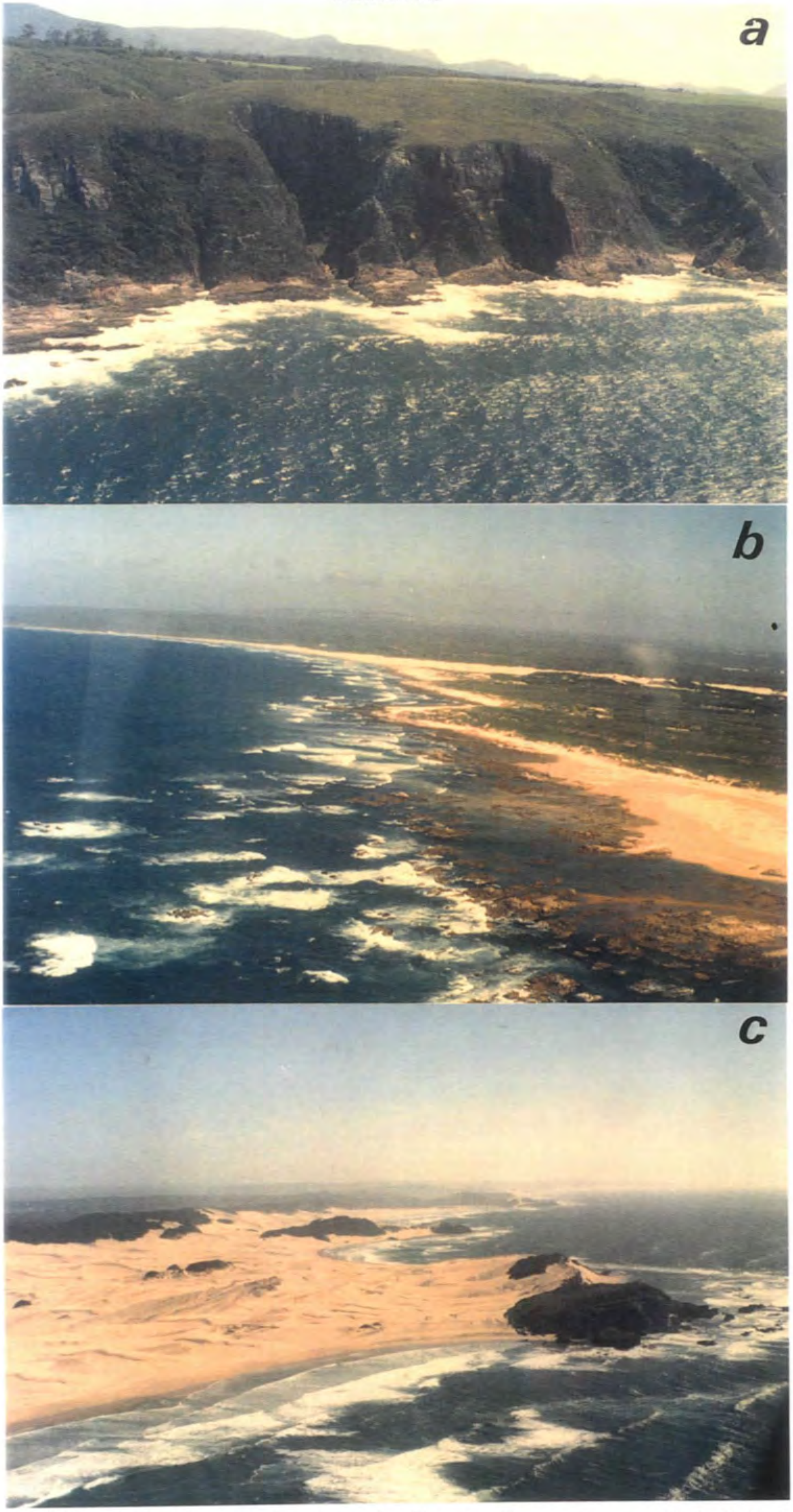
CHAPTER 2 - STUDY AREA AND METHODS

STUDY AREA

The study area extended from Stil Bay (21°20'S,34°25'E) to Kei Mouth (32° 41'S,28° 23'E) covering a distance of 982 km along the southeast coast of South Africa (Figure 2.1). The coastline and its associated topography are highly variable (Plate 1) but a general description is given below.

The coastline between Stil Bay and Knysna is dominated by sandy beaches interspersed with rocky outcrops and cliffs. Rocky outcrops entering the sea at a low gradient are particularly common in the Gouritz River mouth area. From Knysna to Plettenberg Bay the shoreline topography typically consists of high rocky cliffs interspersed with sandy beaches, with the first 12km east of Plettenberg Bay being generally sandy. Thereafter, the coast extends for approximately 133km in an easterly direction to Cape St Francis. The first half of this section, the Tsitsikamma coastline, consists of high rock cliffs intersected by deep ravines at the mouths of rivers. The second half is generally rocky with occasional sandy bays. From Cape St Francis to Woody Cape there are a series of east-facing half-heart bays. Rocky headlands protrude into the sea in the western and eastern regions of these bays, sand accumulates along the northern and eastern sections (Lubke *et al.* 1988). Between Woody Cape and the Keiskamma river the coast is characterised by sandy beaches and scattered rocky outcrops. North of Keiskamma river the coastline is much straighter than the southern section due to the uniform nature of the lithology (Illgner 1996). Long sandy beaches become less frequent as one approaches Kei Mouth where doleritic headlands and rocky erosive shores are common.

PLATE 1



Examples of the varying topography along the Eastern Cape coast, a = high cliffs, b = low gradient rock and sand, c = sandy beaches separated by rocky outcrops.

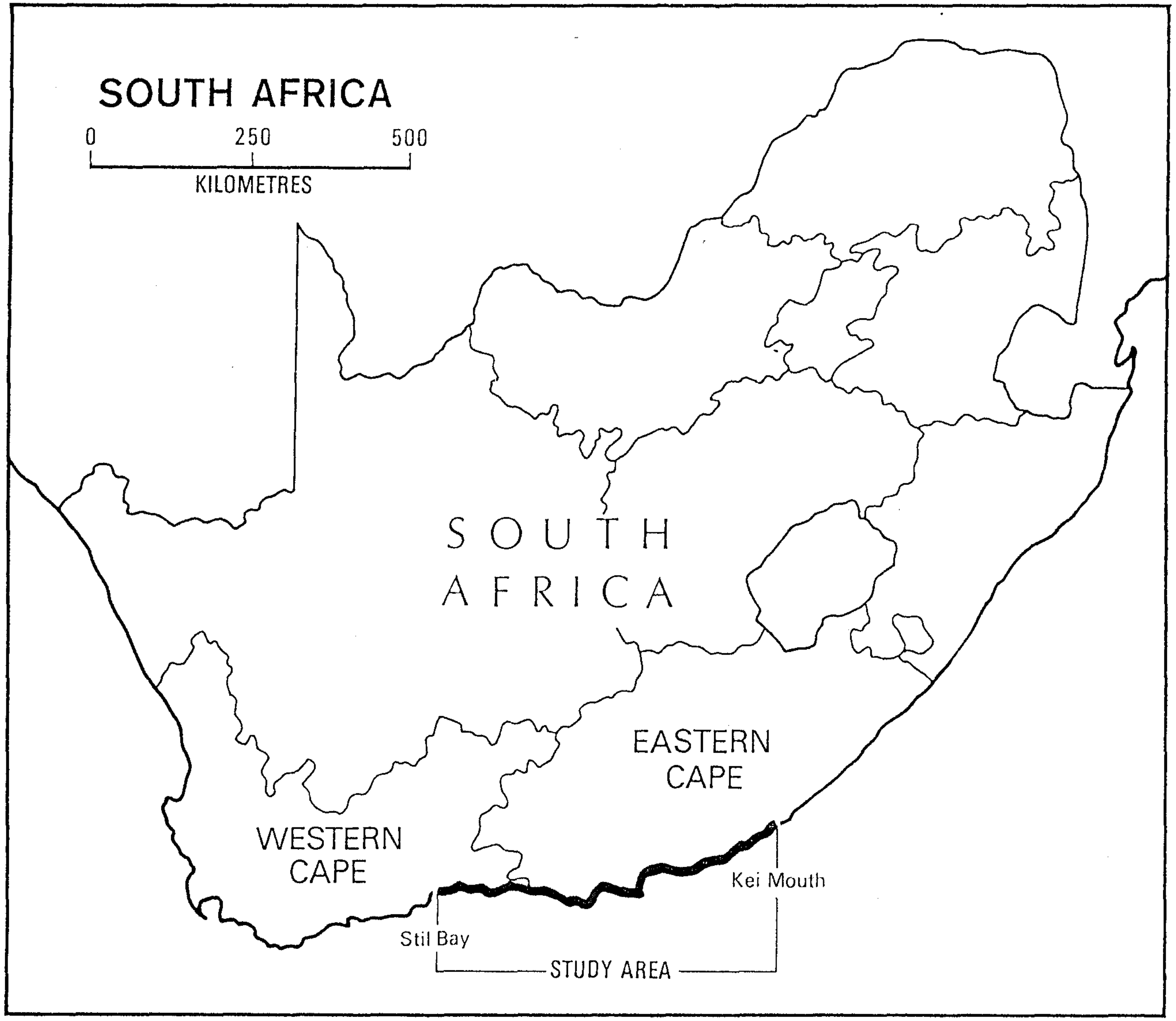


Figure 2.1: Map of South Africa showing the study area

Throughout the area most of the rocky areas are highly exposed to vigorous wave action. The mean tidal height along the coastline ranges from 0.25 to 2m between the low and high spring tides (Anon 1997).

The continental shelf along the eastern seaboard of Africa is narrow, extending to less than 15 km offshore in certain areas such as Port St. Johns (Beckley and van Ballegooyen 1992). The shelf moves offshore between East London and Port Elizabeth, becoming increasingly wider towards the Agulhas Bank region.

The Agulhas Current, which flows along the east coast of South Africa carrying warm tropical waters southwestwards, is the most prominent oceanographic feature of the region (Beckley and van Ballegooyen 1992). It moves offshore in the East London area and its influence on the Cape south coast is considered to be minimal (Schumann *et al.* 1982). Water surface temperature in the core of the current averages around 22°C in August and 27°C in March (Illgner 1996). The current follows the edge of the continental shelf and is closest to the shore where the continental shelf is narrow, such as at Cape Morgan near Kei Mouth. Inshore of the Agulhas current the temperature is lower than in the core of the current, averaging 17.9°C (Greenwood and Clarke 1994), and the water movements are characterised by circulations and counter currents (Hutchings 1994). Wind has a strong effect on the inshore oceanography of the region. Frequent wind-induced upwelling events are recorded in summer, during which the water temperature changes by 10°C or more (Schumann *et al.* 1988). Large thermocline displacements can occur within hours of the onset of a strong wind with an easterly component. However, once established, the upwelling may take several days to dissipate (Schumann *et al.* 1982). Winds with an easterly component are more common in summer, while westerly and southwesterly winds, which form the greatest portion of the annual wind force are particularly strong in winter (Ross 1988). Upwelling in the area is also caused by divergence of the Agulhas current between East London and Port Elizabeth (Hutchings 1994).

METHODS

An overview of different survey methods

Surveys are used to gather information on a particular subject directly from the public. Various fishery survey methods are available, each appropriate for the specific setting for which they are designed. Fishing surveys can be conducted by mail (Deuel 1980), known and random telephone surveys, door-to-door (Deuel 1980), motor boat (Weithman and Haverland 1991), kayak (Rohrer 1986), catch cards, logbooks (Claytor and O'Neil 1991), angler diary (Anderson and Thompson 1991), fishery patrol officers (Hughes 1989; Claytor and O'Neil 1991) roving creel surveys (Malvestuto 1983), access point surveys (Malvestuto 1983) and aerial surveys (McNeish and Trial 1991). Three survey techniques were used in this study. They were a roving creel survey, an access point survey and aerial surveys. A creel survey is a technique used to assess the amount of fishing effort taking place in time and space and can be used to gather concomitant information on fishing (such as fisher attitudes), catch and effort and economic data (Hayne 1991). Creel surveys alone cannot provide estimates of total effort in a fishery but if combined with other survey types total effort can be estimated. A roving creel survey is conducted by travelling through the fishery interviewing fishers in the act of fishing. This differs from an access point survey, in which fishers are approached at the end of a fishing trip at a single point, such as a slipway or beach access point.

Although different information on fishing can be collected more effectively using other survey methods several of the other methods mentioned (above) were not considered appropriate for this study. Mail and telephone surveys were inappropriate because a high proportion (70%) of the black population in the study area were illiterate (Shindler 1994) and many lack access to a telephone. The results would therefore have been biased towards the more affluent members of society, as would data obtained from logbooks and catch cards. Door-to-door surveys were also not considered appropriate as the area was too large and the hit rate (the rate at which fishers are encountered) would be extremely low. Fishery officer patrol records were not used because they are non random (Claytor and O'Niel 1991). Fisheries can also be assessed by analysing data from competitions (Ebbers 1987) and club records (Bennett *et al.* 1994). However, there are large associated biases in these sampling methods. For example, the selection of large fish by tournament fishers, and the correct identification of species (Santucci and Wahl 1991). At the South African national Light Tackle boat competition in 1995, 72% of the carcharhinid sharks were identified incorrectly (personal observations), but the common teleosts were always correctly identified. Similarly in Washington State in the United States of America, fishers were found to incorrectly identify common fish species 52% of the time (Essig and Holliday 1991). In an assessment of various survey methods Essig and Holliday (1991) noted that roving creel and access point survey methods had the lowest sources of potential error. For these reasons access point and roving creel surveys were chosen as the sampling techniques for this study.

Roving creel surveys were used to sample the shore fishery, while the access point survey method was used to assess catch, effort and conduct questionnaires in the recreational and commercial ski-boat fisheries. Fishers were not required to recall any information on their catch, nor were they required to identify their fish. They were requested to answer a set of questions and I identified weighed and measured their catch.

Assumptions

In order to estimate CPUE, four assumptions were made while conducting the roving creel and access point surveys.

1) If a fishers catch is sampled at any time during their outing the CPUE data so collected is an unbiased indicator of overall CPUE. Malvestuto *et al.* (1978), Phippen and Bergersen (1991) and MacKenzie (1991) found no significant differences in CPUE estimates from completed and incomplete trips.

2) Fishing success was identical for short and long trips. It has been suggested that fishing success is not dependent on trip length (Heggenes 1987; Phippen and Bergersen 1991). Generally, sampling error is a function of both sampling intensity and the consistency of the fishing pattern. Therefore, by increasing sampling intensity, errors associated with the fishing pattern will decrease (Heggenes 1987). In this study the sampling intensity was similar to Malvestuto *et al.* (1978) who found that approximately 180 days per annum were adequate for their sample area, which had a shore line of about 845km, an area similar in size to that of the present study.

3) A relationship exists between CPUE and fish population size (Ricker 1975; Ebbers 1987).

4) Respondents to the questionnaire answered the questions truthfully.

Survey methods used in this study

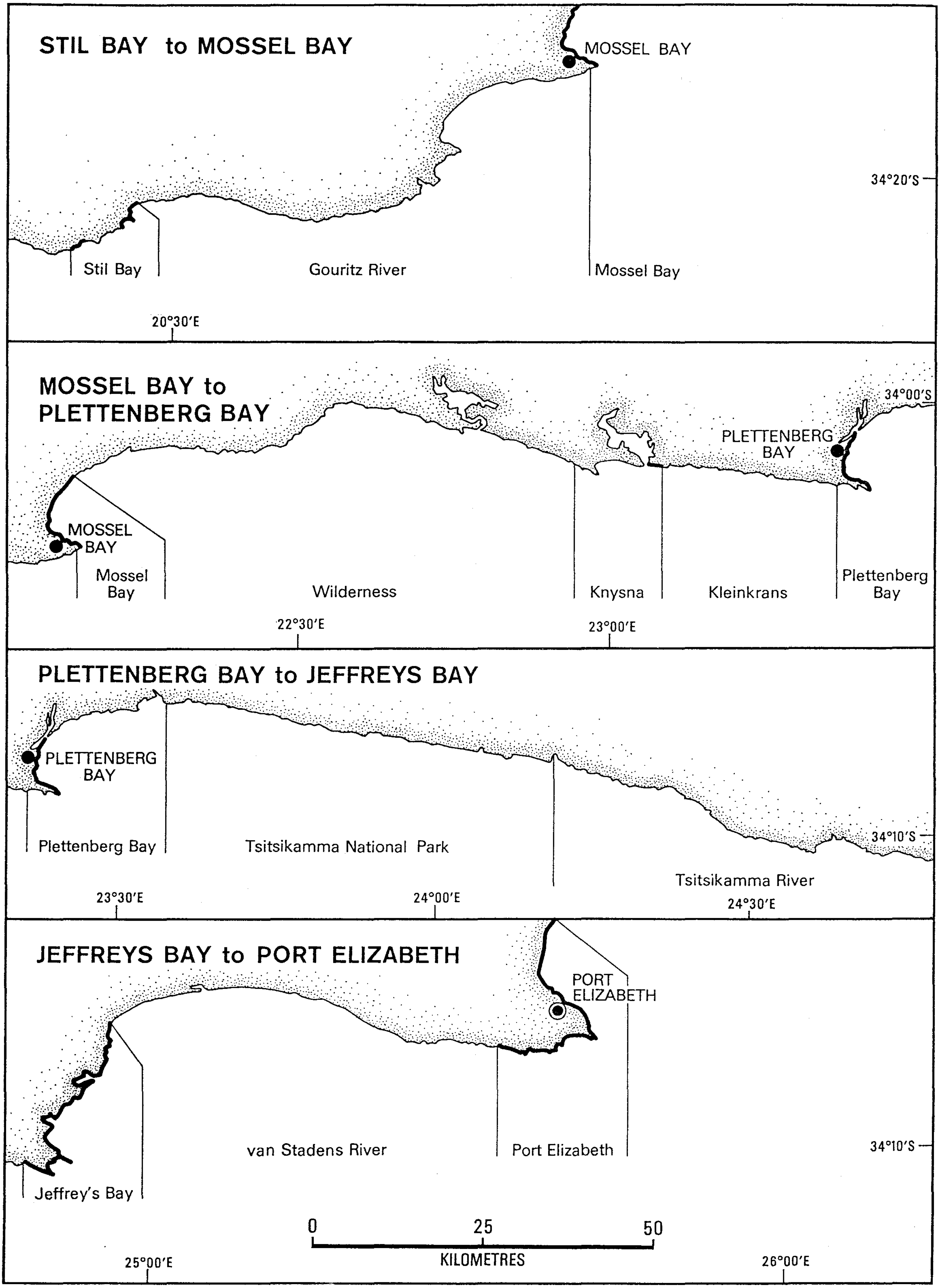
Questionnaires were developed for each sector of the fishery (Appendix II), each of which was divided into four sections. Section A dealt with catch and effort data, including hours fished, bait used and species targeted. Section B dealt with fisher information, including demographics, experience and regular fishing areas. Section C covered the economic information, including trip expenditure and investment in fishing equipment. Section D dealt with fisher attitudes towards fishery regulations: their understanding and acceptance of the regulations, their opinion on possible alternative regulations, their opinion of the status of the fishery, tag reporting and other fishing practices. The questionnaire was designed so that the respondent could give the shortest possible answer, with most questions requiring yes/no answers. The economic section required more detailed answers about the mode of transport and the value of equipment. The economic questions were developed with the assistance of the Department of Economics at the University of Natal, Pietermaritzburg. All the data was captured on Microsoft Excel version 5.0. Specific statistical analyses are discussed in the methods section of the various chapters.

The roving creel and access point surveys were conducted between April 1994 and February 1996. Each fisher or boat skipper was interviewed once. On subsequent encounters only catch and effort information was collected. For the shore fishers all of the fish were identified, weighed and measured. If fish had been gutted, mass was estimated from standard length/weight regression equations (van der Elst and Adkin 1991). In the ski-boat fisheries, when it was not possible to sample the entire catch, a random sub sample (minimum 30%) was measured and the total catch was estimated. Fish that had been cut up for bait were identified to the lowest taxonomic level and counted. If the rate at which fishers were encountered exceeded the interview capacity, interviewees were chosen in a systematic manner. For example, every third fisher/boat skipper was interviewed. However all fishers/boats were counted for that particular day.

As mentioned in the introduction to this chapter the study area was extensive (982 km) and therefore could not be covered effectively. Thus, eight representative sampling areas were selected. They were Stil Bay, Mossel Bay, Plettenberg Bay, Jeffreys Bay, Port Elizabeth, Port Alfred, East London and Kei Mouth (Figure 2.2). During the period April 1994 to February 1996 each area was sampled on nine occasions. Each sampling occasion had a duration of seven days. Sampling in Mossel Bay and Stil Bay were combined as was sampling in Kei Mouth and East London (Table 2.1). In all areas, weekend and weekday sampling was chosen randomly so that each area was sampled on all days of the week. Aerial surveys were conducted to effectively cover the whole area and to quantify the proportion of fishing effort in the shore fishery that was omitted during the ground survey.

Table 2.1: The distribution of sampling effort during the survey conducted between Kei Mouth and Stil Bay.

Area	Number of days sampled
East London	45
Kei Mouth	18
Port Alfred	64
Port Elizabeth	63
Jeffreys Bay	31
Plettenberg Bay	31
Mossel Bay	45
Stil Bay	18


STIL BAY to MOSSEL BAY
MOSSEL BAY
34°20'S
Stil Bay
Gouritz River
Mossel Bay
20°30'E
MOSSEL BAY to PLETTENBERG BAY
34°00'S
PLETTENBERG BAY
MOSSEL BAY
Mossel Bay
Wilderness
Knysna
Kleinkrans
Plettenberg Bay
22°30'E
23°00'E
PLETTENBERG BAY to JEFFREYS BAY
PLETTENBERG BAY
34°10'S
Plettenberg Bay
Tsitsikamma National Park
Tsitsikamma River
23°30'E
24°00'E
24°30'E
JEFFREYS BAY to PORT ELIZABETH
PORT ELIZABETH
34°10'S
van Stadens River
Port Elizabeth
Jeffrey's Bay
0
25
50
KILOMETRES
25°00'E
26°00'E

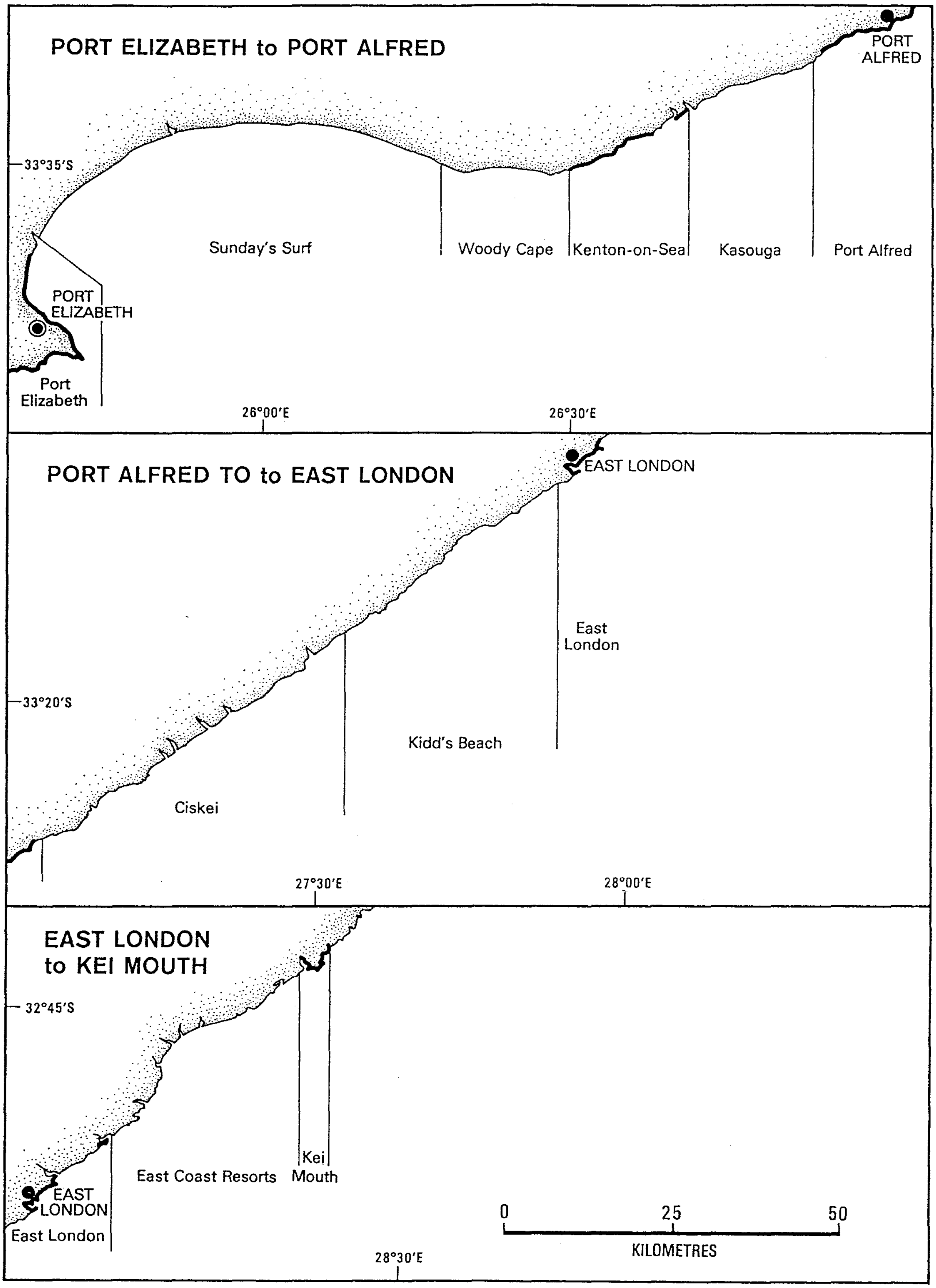


Figure 2.2: The study area showing the areas of regular sampling (bold) and places mentioned in the text.

At each location a specific area was sampled using both roving creel and access point surveys daily to sample the shore and ski-boat fisheries respectively. For the shore fishery, the sample areas were not equidistant, but were based on the proportion of coast that could be covered in a five hour period. The starting time (06:00, 11:00 or 16:00), place and direction of travel were chosen randomly on the previous day. Each site was therefore visited over all hours of angling by the end of the sampling period. Due to safety concerns shore sampling at night was only conducted sporadically, and not in all areas. After completing the roving creel survey, ski-boats were sampled at an access point until the last boat landed (usually between 18:00 and 21:00). If the starting time of the shore survey was 16:00, then the ski-boats were sampled first.

Most of the studies conducted on the South African linefishery have used hours as a measure of effort. However, Attwood and Bennett (1995a) believe fisher days were a more accurate measurement of CPUE. This study used fisher days as a measure of effort as the values from the roving creel survey could be directly compared to fisher counts from the aerial surveys. This would not be possible if hourly effort were used. Fisher hours were only used as a measure of effort for comparison with other local studies. Claytor and O'Niel (1991) noted that estimates of released fish vary between 56% and 152% of the true catch. For this reason fish reported to have been released by the fishers were not included in the CPUE database, it is therefore assumed that released fish survived and would not effect total fishing mortality.

A total of 1770 questionnaire interviews were conducted (1556 in the shore fishery, and 118 and 96 in the recreational and commercial ski-boat fisheries, respectively). During these interviews catch and effort information was obtained from 3668 fishers (3273 shore fishers, 172 recreational ski-boat fishers and 223 commercial ski-boat fishers).

Aerial survey

Three aerial surveys were conducted using a small fixed wing aircraft (Sicata Raley 325). The sample day and direction of travel was chosen randomly, but due to financial constraints the starting place could not be chosen randomly. The survey started at either Stil Bay or Kei Mouth. The surveys were initiated at 07:00 on each occasion and were completed by between 15:30 and 16:30. The entire area from Stil Bay to Kei Mouth was covered during each flight, with a stopover in George for re-fuelling. The aeroplane was flown at speeds of between 90 and 110 knots at a height of 50 to 300 feet, depending on the wind and shore line topography. All fishers were counted and an attempt was made to count boat trailers at the launching sites in order to determine the number of ski-boat that launched from a particular site on that day. The data obtained during the aerial surveys and two roving creel surveys, that covered the entire sampling area, were used to estimate the proportion of fishing effort missed during regular sampling trips.

CHAPTER 3 - FISHER DEMOGRAPHICS AND ATTITUDES

INTRODUCTION

Fisheries management is complex, and now involves managing biological aspects of the fishery as well as the human dimension (Matlock *et al.* 1991). In the United States of America management goals have shifted from the purely biological objectives of maximum sustainable yield to the social objectives of optimum sustainable yield, and, more recently, towards fisher satisfaction (Spencer and Spangler 1992). Differences between what managers recognise as a satisfactory fishery and what fishers expect from a fishing experience have resulted in conflict between management and users of the resource (Spencer and Spangler 1992).

The South African linefish management plan, which was implemented in 1984, was designed to control catch and effort using size limits, bag limits and closed seasons. The linefish management plan did not take into account the opinions of fishers. By comparison fisher opinion surveys are conducted regularly in the United States of America as part of a five yearly national census of fishing and hunting, initiated in 1955 (Grambsch and Fisher 1991). This information is screened and, where possible, the opinions of fishers are considered when amending the regulations.

If fisher satisfaction is an indicator of perceived effectiveness of management regulations then examining those variables that influence fisher satisfaction, including motivations and fishing success, becomes important (Spencer 1993). Fishing success strongly influences fisher satisfaction and therefore sustainable utilisation (that is limiting total fishing pressure in order to maintain acceptable yields indefinitely) should be a management goal, however, if additional participants enter the fishery which is managed to limit total fishing mortality, then the success of individual participants will have to be reduced in order to achieve this goal. But bag limits help to equalise the numbers of fish caught by individuals. Compliance with the regulations will improve if the users of the resource understand and agree to regulations prior to their introduction. Therefore it stands to reason that fishers should play a role in the development of a management plan (Spencer 1993).

METHODS

A detailed description of the survey design is given in Chapter 2, but a short description of the way in which the questionnaire was undertaken is given here. The responses from sections B and D (Appendix IIA and IIB) are discussed in this chapter. The questions in section B were designed to determine the demographic distribution of a sample of the Eastern Cape fishing public, their affiliation to clubs, their experience and the area they normally fish. Section D was developed to determine the fishers' attitudes towards, knowledge of and willingness to obey the regulations. Most of the questions required yes/no answers, although some were left up to the respondent. For example, "what has caused the decline in the fishery?" Respondents were also asked whether they would support alternative management options such as a recreational angling licence, a maximum size limit and sector specific species lists (a limited access system). Two questions relating to the National Tag and Release Programme (managed by the Oceanographic Research Institute in Durban) were included to determine the proportion of fishers that do not report tagged fish. A question was also developed to determine the extent to which fishers are familiar with the regulations. This involved interviewees being asked to give the size limit, bag limit and the closed season for the three most common fish in their catch or their three principle target species.

Inspection rates by fisheries patrol officers were also assessed. The questionnaire data was analysed using Kruskal-Wallis One Way Analysis of Variance on Ranks and Chi-square analysis.

RESULTS

The age distribution of fishers in all sectors is normally distributed (Figure 3.1), the widest distribution of age groups was found in the shore fishery (Table 1). Sex ratios in all sectors were strongly skewed in favour of males. Most (97%) of the shore fishers were males and all of the ski-boat skippers interviewed in both sectors were male. Some female skippers are known to operate in both ski-boat sectors but they were not sampled due to the random nature of the sampling design. No age or sex data was collected on the ski-boat crew.

Along the Eastern Cape coastline, the majority of shore fishers were white (77%) with coloureds being the second most abundant population group (17%), followed by blacks (4%) and asians (2%). The situation in the ski-boat fishery was even more skewed towards the white population group. 98% of recreational ski-boat skippers were white and 2% coloured. In the commercial sector 89% of the skippers were white and 11% coloured.

Table 3.1: The age distribution of the fishers in the various sectors along the east coast of South Africa between Kei Mouth and Stil Bay.

Sector	n	Mean age	SD	Range
Shore fishers	1556	38	15.09	6-87
Recreational ski-boat skipper	118	46	11.06	24-70
Commercial ski-boat skipper	96	42	13.4	16-71

A total of 21% of the shore fishers, 76% of recreational ski-boat skippers and 28% of the commercial ski-boat skippers interviewed belonged to an organised recreational angling club. No information was obtained on the number of commercial ski-boaters who belong to the commercial fisheries association.

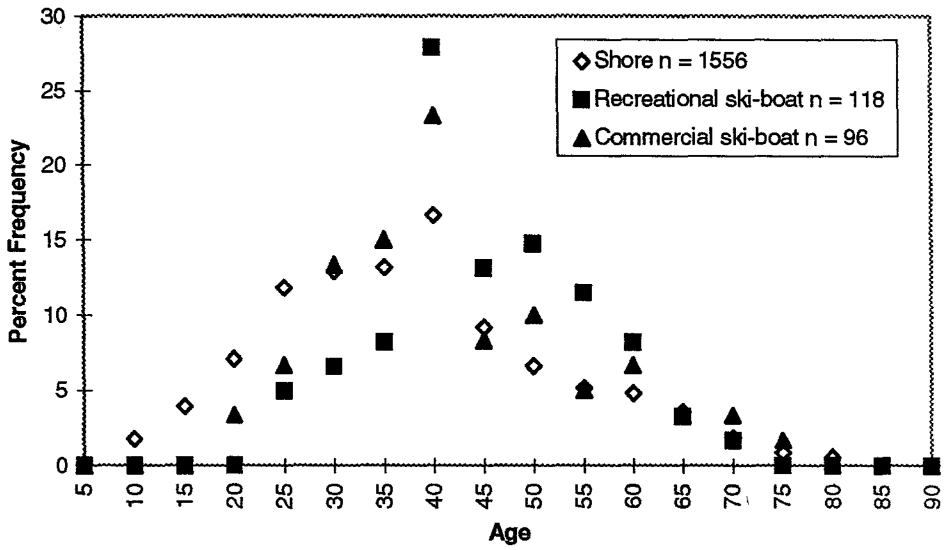


Figure 3.1: The age distribution of fishers from three sectors of the Eastern Cape linefishery sampled between Kei Mouth and Stil Bay.

Commercial ski-boat fishers were fishing solely for financial gain. On the other hand shore fishers had a wide variety of reasons to fish, of which catching fish was not always the main motivation for angling. Recreation (53%) followed by food (24%) and competitions (19%) were the most commonly cited reasons motivating shore fishers. Only 3% of shore anglers cited livelihood as their primary motivation for fishing. A very small percentage (0.2%) of the shore fishers interviewed said they were fishing for other reasons (such as to catch aquarium fish). Recreational ski-boat fishers fished mostly for recreation (41%) and competitions (33%) but also for food (15%) and financial gain (10%) (which is illegal).

Most of the respondents in all sectors believed that the current regulations were effective at controlling the fishery (Figure 3.2). Using a Kruskal-Wallis One Way ANOVA to test for the difference between regulations, the bag limit regulation was significantly different from the other regulations and was seen as the least tolerable management measure for all sectors (shore $P < 0.0001$; recreational ski-boat $P < 0.0001$; commercial ski-boat $P < 0.05$).

The response to three alternative management measures was assessed. They were the imposition of a maximum size limit, fishing licences and a limited access system. The opinions expressed are reflected in Figure 3.3, and were compared using a Kruskal-Wallis One Way ANOVA on Ranks. Within all sectors the responses to these questions were significantly different (shore $P < 0.0001$; recreational ski-boat $P < 0.005$; commercial ski-boat $P < 0.001$). All sectors believed that a recreational angling licence should be imposed and there was no significant difference between them (Chi-square test $P > 0.5$). The majority of shore fishers (54%) agreed that a shore fishing licence should be imposed. The average licence fee that fishers were willing to pay was R46.70 (range R2-R750). Two completely unrealistic figures of R1500 and R2000 were excluded when calculating the mean. Recreational ski-boaters were willing to pay an average price of R85.75

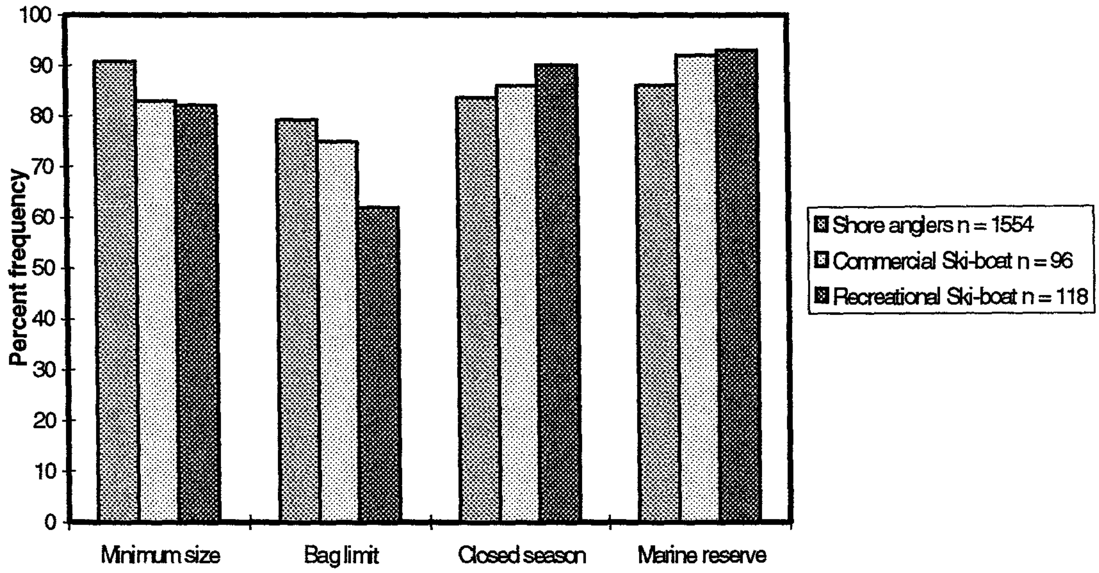


Figure 3.2: The percent frequency of fishers interviewed between Kei Mouth and Stil Bay that were in agreement with the current linefishery regulations.

(range R20-R480) for a licence. Most commercial ski-boat fishers (53%) were of the opinion that recreational ski-boaters should pay a suggested average price of R300 (range R100-R500) for an angling licence.

There was no significant difference between the two recreational fisheries in their responses to a maximum size limit (Chi-square test P > 0.25). However, the commercial fishers responses were significantly different from the other two groups (Chi-square test P > 0.005). Most shore fishers (58%) were of the opinion that a maximum size limit would be a feasible means to manage the fishery. Only 46% of the recreational ski-boat fishers and a third (33%) of the commercial ski-boaters thought that a maximum size limit would be an effective management strategy.

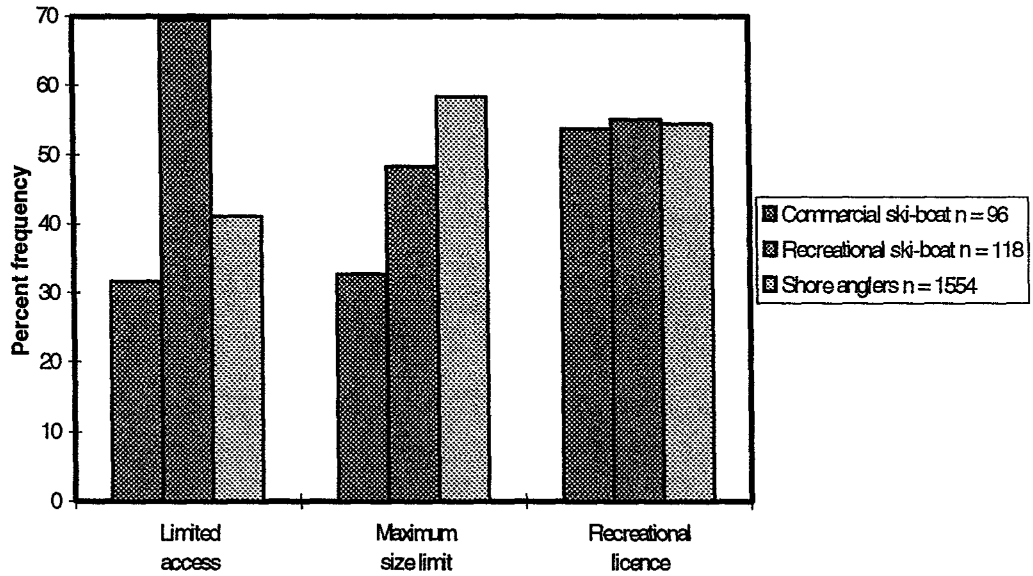


Figure 3.3: The percentage frequency of fishers interviewed between Kei Mouth and Stil Bay who were in agreement with some alternative methods to regulate the South African linefishery.

The response to a limited access system varied between sectors. Only 41% of the shore fishers believed that a limited access system was a good way to manage the fishery, whereas 69% of the recreational ski-boat fishers thought that a limited access system would improve the fishery. This differs from the views of the commercial sector where only 32% of respondents agreed with a limited access system.

The responses to questions assessing the level of compliance with the existing regulations were interesting (Figure 3.4). On average it would appear that fishers in all sectors complied with the regulations applying to Marine Reserves. Many fishers (50% in the shore fishery and over 50% in the ski-boat fisheries) admitted to keeping undersized fish. Forty-five percent of recreational ski-boat fishers have exceeded the bag limits at one time or another and almost 60% of the recreational ski-boat fishers admitted to selling their fish.

Knowledge of the current regulations amongst interviewees in the shore fishery ranged from 0-100%(mean 41%, SD±32%). In the ski-boat sectors test scores averaged at 67% (SD±29%, range 0-100%) for recreationals and 87% (SD±18%, range 33-100%) for commercial fishers. In both sectors of the ski-boat fishery there was almost no difference in the test scores between specialist (club members who target specific fish) and generalist fishers (non-club members who were not targeting any species specifically) ($P > 0.5$). In the shore angling sector, however, club and non-club members' knowledge of the regulations differed significantly ($P < 0.001$). Club fishers scored an average of 56%, while the test score for non-club fishers only averaged at 30%.

A high percentage of fishers in all sectors (81% of shore fishers, 91%of recreational ski-boaters, 80% of commercial ski-boaters) were of the opinion that there had been a decline in the fishery. This opinion was generally based on the perception that there has been a decline in the catch rate

(60% shore fishers; 46% recreational ski-boat fishers; 47% commercial fishers). A small percent of interviewees in all of the sectors responded that the average size of fish had declined (19% shore fishers; 17% recreational ski-boat fishers; 11% commercial fishers). Very few fishers were of the opinion that there had been a significant change in the composition of their catch (5% shore fishers; 7% recreational ski-boat fishers; 11% commercial fishers) with less valuable fish, such as ariids and elasmobranchs, becoming more prevalent in their catch. Respondents in all sectors attributed the decline in catch to a variety of reasons, particularly trawlers (Figure 3.5) and those

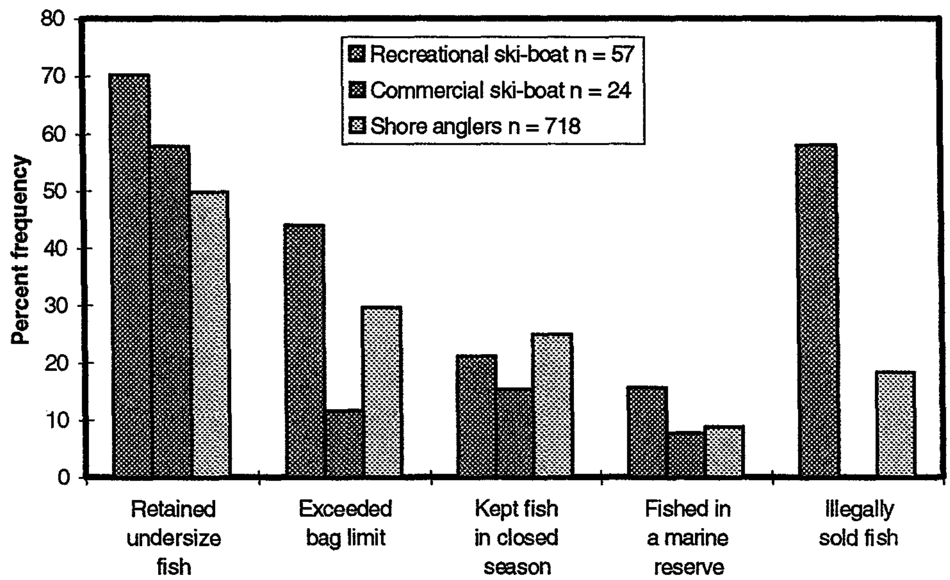


Figure 3.4: The proportion of fishers interviewed between Kei Mouth and Stil Bay who admitted to violating the present linefish regulations.

fishers in sectors conceived to be their immediate competitors. In the commercial ski-boat sector the most commonly cited reason for the decline in the fishery, after trawlers, was recreational ski-boaters. Recreational ski-boat fishers, on the other hand, cited the commercial ski-boat fishers as one of the main reasons for declining catches. The shore fishers mostly blamed trawlers for the decline in the fishery, with commercial ski-boats and pollution as other commonly cited reasons. The shore fishers cited the widest variety of reasons for the apparent decline in fish stocks: from increasing seal and dolphin populations, people along the Transkei coast removing the intertidal rock life and, the noise from beach vehicles frightening fish, to divine influences punishing humanity.

When responding to questions regarding the importance of angling as a recreational pursuit, and participation in other angling disciplines, 60% of the shore fishers and 67% of the recreational ski-

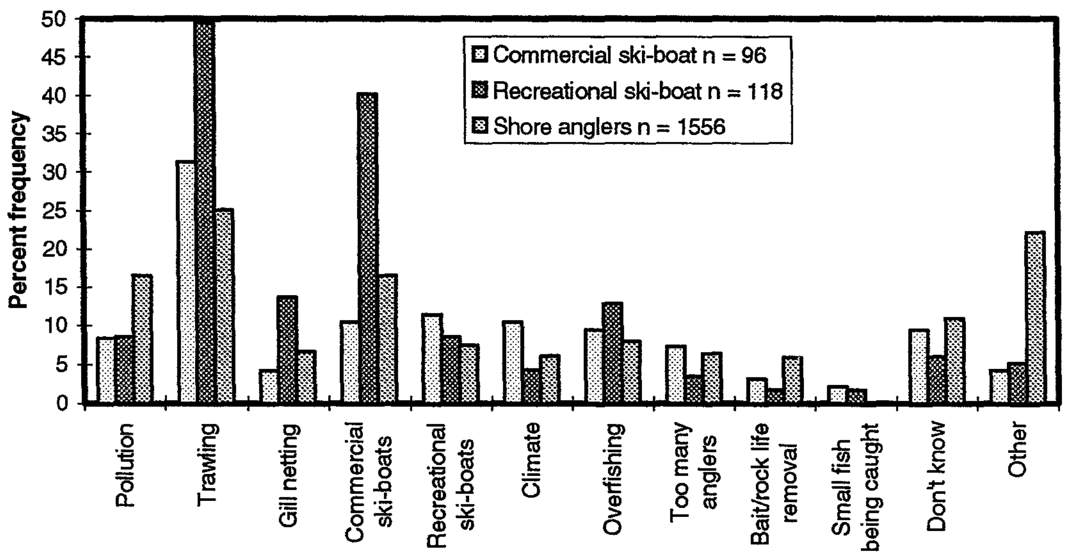


Figure 3.5: The reasons given for the decline in the fisheries along the Eastern Cape coast between Kei Mouth and Stil Bay.

boat fishers responded that angling was their major sport. Angling was the major sport for 58% of commercial fishers who fished for sport. 43% of the shore anglers interviewed participated in other angling activities. Of these, 25% fished in freshwater, 13% from a ski-boat, 10% in estuaries, 5% of respondents were involved in marine fly fishing and only 1% spearfished. A high proportion (48%) of fishers in the commercial ski-boat fishery did not take part in any other type of angling, but of those that did, shore angling (38%) was the most popular, followed by freshwater (7%) and estuarine angling (7%), and spearfishing (2%). The majority of recreational ski-boaters took part in other angling disciplines with only 28% saying that they only fished from a ski-boat. Shore angling was the most common pastime for recreational ski-boaters when not fishing from their boat (34%) 22% fished in freshwater, 14% fished in estuaries and only 2% took part in spearfishing.

In response to questions on the National Tag and Release Programme, only 14% of the shore fishers said that they had tagged a fish, while 30% of the recreational ski-boat fishers and 21% of the commercial fishers had tagged fish. Fourteen percent of the respondents in the shore fishery had caught tagged fish, of which 36% sent a full report of the recapture to the ORI and 20% gave a partial report that is they gave the tag to a friend, an angling club or a fishing tackle shop who they thought may report it. Not one of the fishers who gave the tag to a second party received a tag return report from the ORI. It is therefore unlikely that any of these recaptures were actually reported. A high proportion of interviewees in the shore fishery (44%) admitted to not reporting the recaptures at all, most saying that they threw the tag away. A similar response was obtained from the commercial ski-boat sector. Only 38% of them had caught a tagged fish and sent a full report to the ORI, 24% had sent a partial report and 38% had not reported the recapture at all. The recreational ski-boat fishers were the most dedicated in reporting tagged fish. 54% of them reported the recapture to the ORI, 23% made a partial report and only 23% did not report the recapture.

The frequency of inspections by fisheries inspectors varied between sectors. The fishers in the shore fishery were inspected the least. Only 49% of the respondents had ever been inspected, 28% were inspected within the last 12 months, 10% were inspected one year ago, and 11% were inspected more than one year ago. Commercial ski-boat fishers were inspected most frequently, with only 15% of the respondents never having been inspected before. The majority (69%) had been inspected within the last year, 11% were inspected one year ago and only 5% had been inspected more than 1 year ago. Inspection frequency in the recreational ski-boat fishery was also low. 31% of fishers have never had their catch inspected, 40% had been inspected within the last year, 11% one year ago and 16% more than one year ago.

DISCUSSION

Understanding the diverse nature of the angling public is a major challenge facing recreational fisheries managers (Chipman and Helfrich 1988). All of the sectors covered in this study were dominated by males, from young boys to retired folk, with most being middle-aged. The age and sex ratios in the South African fisheries were similar to those found in the United States of America (Gigliotti and Peyton 1993).

The majority of anglers throughout South Africa are white but the racial proportions vary along the coast. KwaZulu-Natal has the lowest proportion of white fishers. Asian fishers were estimated to be more abundant in this region, accounting for 41% of the KwaZulu-Natal angling population (Brouwer *et al.* in pres). The ethnic structure of the fishing populations outside of KwaZulu-Natal is similar to that of the Eastern Cape, being dominated by whites with coloured, black and asian people being less abundant (Brouwer *et al.* in pres). Historically disadvantaged population groups were found to account for a very small percentage of fishers in all sectors, especially in the two ski-boat sectors. Black and coloured people have been excluded from deep sea angling clubs in the past and were thus denied access to some slipways. Most recreational ski-boaters were white (98%) and only one of the non-white recreational ski-boaters belonged to an angling club. Economic forces and political inequalities probably played a major role in this regard. As both the shore and recreational ski-boat linefisheries are open access in nature the number of new fishers from historically disadvantaged population groups can be expected to increase. This trend is already evident in the offshore fishery. The proportion of fishers from historically disadvantaged population groups who have been fishing for less than five years (27%) was higher than for the white fishers (17%). The average number of years people had fished was also greater in the white (21 years±15.8) than in the historically disadvantaged population groups (17 years±13.3). One reason for the increase in new fishers entering the fishery from historically disadvantaged population groups could be the increasing affluence within these population groups. The commercial fishery is not expected to increase in size as the issuing of new licences has been stopped, but a shift in demographics could be expected as the industry becomes open to all population groups.

Nationally, 17% of shore fishers belong to angling clubs. This is slightly lower than the average for the Eastern Cape region where 21% belonged to angling clubs. On the other hand, the recreational ski-boat sector had a high proportion (76%) of club affiliation. The reason for this high proportion of club members in the recreational ski-boat fishery is due to the fact that access to many slipways is only available to club members. This also explains why some commercial ski-boaters (28%) belong to clubs.

Attitudes of fishers towards a resource are directly related to the level of communication from the management agencies (Spencer and Spangler 1992). While fisher attitudes are important, fisher motivations determine why they fish. Most of the shore anglers fishing for recreation stated that catching of fish was not the only motivation for going on a fishing trip. Environment related motives were also important and respondents often mentioned that they were fishing "to get away from it all" and to be with friends and family. Although this aspect was not quantified in this study, the trends were similar to studies conducted in Australia and the United States of America (Henry and Virgona 1984; Loomis and Ditton 1987; Fedler and Ditton 1994; O'Malley and Crawford 1995).

Spencer and Spangler (1992) noted that one source of fisher dissatisfaction was the failure of fishers to recognise changes in catch rates and fish size over time. South African fishers are concerned about, and well aware of, changes in the fishery, and many believe that the linefishery has declined. It is not surprising to note that fishers blamed other angling sectors for the decline in catch, with trawlers being blamed by the majority of fishers in all sectors. Commercial and recreational ski-boaters are generally antagonistic towards one another, as they perceive each other to be favoured by the current regulations, and largely responsible for the decline in the fishery. Be it a lack of understanding or a lack of willingness to accept responsibility for the decline, these attitudes demonstrate the need for angler education. Education of fishers is necessary as biological data has shown that high fisher effort combined with slow growth and residency of many of the target species are the major factors contributing to the decline in the fish stocks (Buxton 1993; Bennett *et al.* 1994).

Although the effects of some of the South African linefish regulations have been assessed by Bennett *et al.* (1994), the opinions of fishers towards these regulations have never been taken into account. It is essential that managers determine the extent to which fishers in all sectors of the linefishery support the regulations, since the success of any regulation requires fisher compliance (Glass and Maughan 1984). One would expect popular regulations to be obeyed more readily than unpopular ones. Marine reserves and size limits are considered by the majority of the angling public as effective ways to manage the fishery. Few fishers in all sectors admitted to fishing in a marine reserve but many respondents admitted to breaking the size limit, particularly the recreational ski-boat fishers, as many of the species they catch suffer from barotrauma. Fishers in both of the recreational sectors frequently admitted to breaking the bag limits. Therefore, taking compliance to the fishery regulations into account, it would appear that marine reserves and closed seasons are the most effective fishery control measures. Of the recreational ski-boat fishers who claimed that they did not sell their fish, only 16% admitted to exceeding their bag limits, whereas 64% of the fishers who sell their fish exceed their bag limits regularly. This suggests that the sale of fish provides the incentive to catch more. This must strengthen the stand taken by managers to prevent the sale of fish by recreational fishers. To compound the problem, 73% of the fishers who have sold fish have kept undersized fish. The sale of fish by recreational ski-boat fishers was a common practice at many ski-boat clubs in the Eastern Cape.

Several questions were asked to gauge the reactions of respondents towards alternative methods of controlling catch and effort. The results presented show that fishers in all sectors did not strongly support the concepts of these alternative management methods. On the strength of this, it appears that, with the possible exception of a recreational licence, these laws would be difficult to implement. Commercial fishers would be the most resistant to a maximum size/slot limit because of the market price difference between large and small fish of the same species. Larger fish fetch higher prices per kilogram. Since most commercial fishers depend on their catch as a sole source of income, there would be immediate resistance to maximum size limits within this sector. Maximum size/slot limits may, however, be a viable means to manage the recreational fishery, especially the shore fishery, where fish do not suffer from barotrauma. Most respondents who stated that maximum size limits would be acceptable, remarked that this could not be done for all species, as they would still like the opportunity to catch and retain a large fish. Possible scenarios for future management could include some of these alternative management measures but they would have to be implemented with an intensive and convincing advertising/education programme to demonstrate the necessity and effectiveness of the regulation.

Knowledge of the regulations was poor amongst the recreational fishers. Increasing awareness could be achieved in two ways. Firstly, inspectors could explain to fishers what the laws are, rather than waiting for people to break the law and then fining them after they have committed an offence or already killed the fish. Having a fisheries officer at popular angling spots is often enough to stop fishers transgressing the law. Secondly, easy to follow copies of the regulations should be readily availably and possibly posted on notice boards at popular angling sites. Part of the proceeds from angling licences could be used to cover the costs of education programmes.

There was a clear correlation between knowledge of the regulations and the frequency of inspection. The inspection rates in KwaZulu-Natal (11%) were higher than those in the Eastern and Western Cape (0.75% and 0.63% respectively) and the level of fisher knowledge was greater in KwaZulu-Natal (62%) in comparison to Eastern and Western Cape (38% and 40% respectively) (Brouwer *et al.* in pres). It stands to reason therefore that the frequency of inspection should be increased, this could be combined with a . This should be combined with an angler education programme aimed at improving their understanding of the regulations and why the regulations have been formulated.

National tagging studies rely on fisher participation in tagging and reporting recaptured tagged fish (Haas 1990; Zale and Bain 1994). In South Africa the ORI has a National Tag and Release Programme in which 3350 anglers and seven research institutes are participating (Govender *et al.* 1995). To date 99016 fish, belonging to 305 species, have been tagged and 5060 recaptures have been reported (Govender *et al.* 1995). Considering the high rates of non-reporting recorded in this study and others elsewhere (Eder 1990; Haas 1990; Zale and Bain 1994), studies that rely on tag reporting must take non-reporting into account during the analysis of the results. The results from this study revealed that over 60% of recaptures in the shore and commercial ski-boat fisheries went un-reported and more than 45% of the recaptures caught by recreational ski-boaters were not reported.

CHAPTER 4 - CATCH AND EFFORT

INTRODUCTION

Historically, linefish catches in South Africa have not been considered to be of great importance as they represent only 8% of the total commercial landings (van de Boonstra 1995). However with the emerging realisation, globally, of the importance of recreational fisheries (Schmied 1980), linefish stocks have assumed a new significance. This fact and declining catches have resulted in a greater concern for the future well being of the stocks and has generated much needed research. In the past, South African linefish research has focused on life-histories of the most important species (Nepgen 1977; Buxton and Clarke 1986; Garratt 1986; Smale 1988; Buxton 1989; Buxton and Clarke 1991; Walter and Ebert 1991; van der Elst and Adkin 1991; Griffiths and Heemstra, 1995). The biology of many species has been thoroughly researched in the Eastern Cape, but few studies examining catch and effort have been conducted. Studies that have been conducted in the Eastern Cape have all been confined to an individual fishing sector within a small section of the coast (Coetzee and Baird 1981; Smale and Buxton 1985; Hecht and Tilney 1989; Coetzee *et al.* 1989; Clarke and Buxton 1989). No attempt has been made to study catch and effort in both the commercial and recreational sectors of the linefishery along the entire coastline.

Historical studies such as those by Smale and Buxton (1985), Hecht and Tilney (1989), and Clarke and Buxton (1989) are a good reference point for comparison to the current situation in the recreational ski-boat, commercial ski-boat and shore fisheries, respectively. CPUE data is important for fisheries management because long term trends in catch and effort provide an indication of possible over exploitation in a fishery (Hughes 1989). Using historical reference points for comparison to the present is useful to examine changes in CPUE and species composition of the catch.

It has been suggested that catches by shore fishers along the South African coast are declining primarily as a result of overfishing (Bennett 1991). Similar trends have been identified in the recreational and commercial ski-boat fisheries (van der Elst and de Freitas 1988; Hecht and Tilney 1989, Garratt 1993; Pilfold and Pampallis 1993). Increasing demand for access to fisheries and increased fishing effort will undoubtedly place more pressure on the linefish stocks in the future. This study attempted to characterise catch and effort in the three sectors of the linefishery in the Eastern Cape as a contribution towards providing a comprehensive reference point and to assess the current status of the stocks.

METHODS

A general description of the methods used in this study was given in Chapter 2, but a more detailed description of the methods used to estimate catch and effort are given below.

The total annual fishing effort for the entire Eastern Cape shore fishery was calculated using a modified version of the equation developed by Pollock *et al.* (1994):

$$E_{total} = \left(\frac{\sum_{i=1}^{n} (a_i/d_i)}{n} \right) \times l \times t \qquad (1)$$

where a_i is the number of fishers counted on the *i*th sampling day, d_i is the number of kilometres patrolled on the *i*th sampling day, *n* is the number of fishers, *l* is the total distance of the sample area and *t* is the potential number of days in the sampling period. The total effort estimate was then multiplied by a factor of 2.48 to account for daily effort (C. Attwood unpublished, Appendix IV).

Variance was calculated after Hoening *et al.* (1993):

$$V(E_{total}) = \frac{N^2 S^2}{n} \qquad (2)$$

where *N* is the number of days in the season and S^2 is the estimated variance of the daily estimates of effort:

$$S^2 = \frac{\sum_{i=1}^{n} (f_i - f)^2}{n-1} \qquad (3)$$

where *f* is the arithmetic mean of the *n* daily estimates of fishing effort and f_i is the estimate of fishing effort in the *i*th day sampled.

Total effort in the ski-boat fishery was calculated using a method developed by Pollock *et al.* 1994:

$$E_{total}=E_{w1}+E_{w2} \quad (4)$$

E_{w1} and E_{w2} were weekend and weekday estimates of effort calculated by:

$$E_w=\frac{\sum_{i=1}^{n} e_i}{(d/p)} \quad (5)$$

Where e_i is the number of anglers per kilometre on the ith day, d is the number of days sampled, p is the potential number of sample days.

The catch per unit effort (CPUE) was calculated as follows:

$$CPUE=\frac{\sum_{i=1}^{n} (C_i/E_i)}{n} \quad (6)$$

where C_i is the number or kilograms of fish retained and E_i is the effort expended by the ith fisher.

Total catch for a specific area was estimated by simply multiplying total effort by the CPUE as follows:

$$C_{total}=CPUE\times E_{total} \quad (7)$$

Total ski-boat effort was calculated in boat days. A boat day is defined as a day on which a boat puts to sea to fish. The time spent at sea varies as does the number of people fishing. To calculate total effort in terms of fisher days E_{total} was multiplied by the average number of crew in the respective fisheries before being used in equation 7.

An independent estimate of ski-boat effort was obtained using records from the port control office in East London. These numbers were compared to the values obtained from equation 4.

RESULTS

Fishing effort

Fishing effort along the Eastern Cape coast in the shore fishery was consistent throughout the year but was slightly higher in late summer and during the Easter holiday period (Figure 4.1). The recreational ski-boat fishery had distinct peaks in fishing effort during April and October. The commercial ski-boat effort showed peaks in winter when fishing was good. Fishers in the shore and recreational ski-boat fishery fish more over weekends, whereas the commercial fishers fish mostly during the week (Figure 4.2).

Shore fishing trips were initiated at all times of the day but some trends were evident. There is an early morning peak (06:00-08:00) followed by others at 10:00, 15:00 and 17:00 to 18:00 (Figure 4.3). At the time of the interview, people who started their fishing trip late at night or early in the morning had fished for longer periods than those interviewed between 08:00 and 18:00 (Figure 4.4). When shore fishers were interviewed they had already fished an average of

2h:30min±2.48. On average they fished for 5 hours per day and 63 ±72.28 $days.year^{-1}$. Shore fishers who were considered to be subsistence fishers (those individuals who stated that they fished for their livelihood) fished an average of 6 hours per day and 198 ±98.8 $days.year^{-1}$.

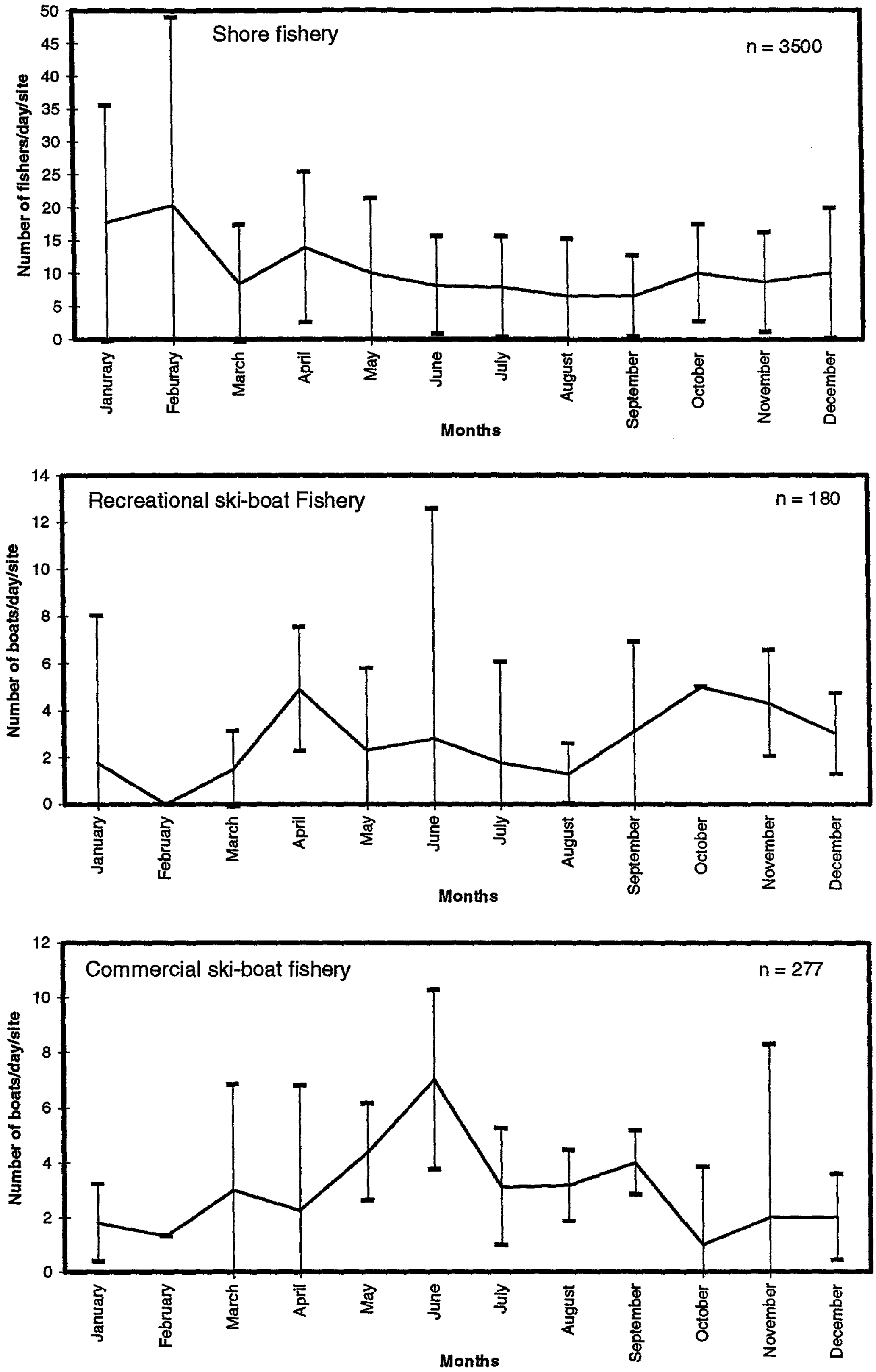


Figure 4.1: Average daily fishing effort per sample site (±SD) in the three South African linefishery sectors sampled between Kei Mouth in the East and Stil Bay in the West.

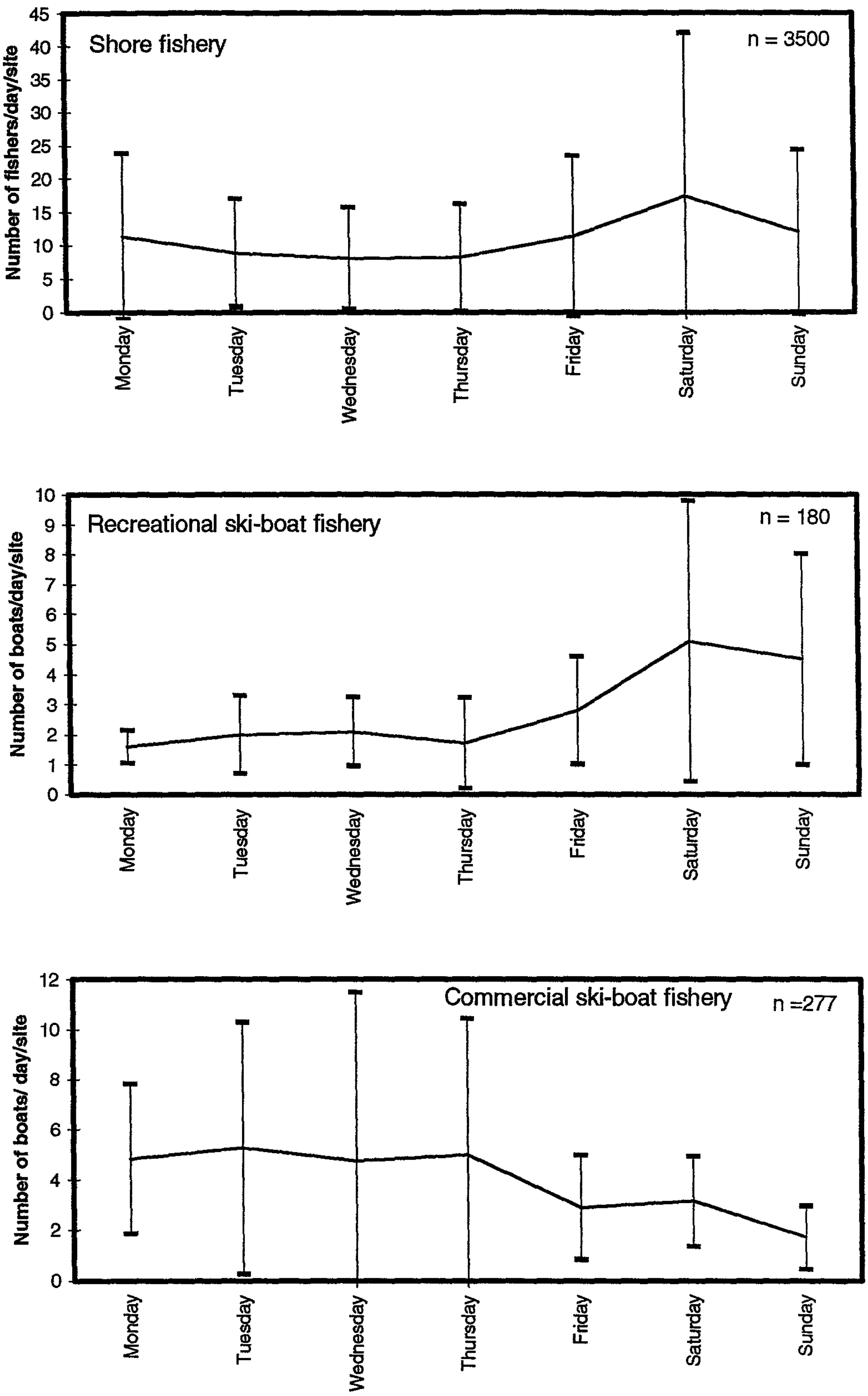


Figure 4.2: Average weekly fishing effort (±SD) in the three South African linefishery sectors sampled between Kei Mouth in the East and Stil Bay in the West.

Ski-boat fishers in both sectors usually started fishing at 08:00 in the morning (Figure 4.5). However in summer, in some areas such as Stil Bay, the commercial boats fish at night for silver kob, *Argyrosomus inodorus*, launching at sunset (18:00-20:00) and returning to the shore between 04:00 and 08:00. On average, commercial ski-boaters fished for longer hours (8h:20min±2.25) than the recreational fishers (7h:10min±2.52). Commercial fishers also averaged more fishing days per year (159 ±88.21 days.year^{-1}) than the recreationals (37 ±42.3 days.year^{-1}).

Total fisher effort in the shore fishery for the region was estimated at 903 186 fisher days.year^{-1} (±1913). The commercial ski-boat effort in the seven landing sites sampled was estimated to be 13 571 boat days.year^{-1} (±1686) or 64 266 fisher days.year^{-1}, which is almost double that of the recreational ski-boat effort (7 159 boat days.year^{-1} (±685) or 24 357 fisher days.year^{-1}). In East London ski-boat estimates were validated using harbour records. There was only a 3.6% difference between the observed and estimated effort estimates. There are 549 commercial ski-boats registered in the Eastern Cape (Sauer *et al.* in pres). Using the creel survey estimates of the ratio of boat owners registered to a ski-boat club and those not registered it was estimated that 1180 recreational ski-boats operate in the area.

Catch composition

The linefishery in South Africa is a multispecies fishery. In the Eastern Cape shore fishery there are 46 teleost species in 18 families, and 18 elasmobranchs species in 11 families (Appendix IIIA). The catch of the ski-boat fishery is also made up of teleosts and elasmobranchs. In the recreational ski-boat fishery there are 34 teleost species belonging to 14 families, and 10 elasmobranchs species in 5 families (Appendix IIIB). The commercial ski-boat fishery has a similar species composition to the recreational ski-boat sector with 36 teleost species in 13 families, and 12 elasmobranchs species belonging to 6 families (Appendix IIIC).

Average CPUE in the shore fishery varied, with peaks in late summer, winter and spring (Figure 4.6). Overall, the CPUE was low (1.15 ±7.03 kg.person^{-1}.day^{1} or 2.06 ±10.13 fish.person^{-1}.day^{-1}) and varied considerably between areas (Table 4.1). For example, in Plettenberg Bay and Mossel Bay high numbers of small fish were caught, while in Jeffreys Bay small numbers of large fish were caught. In all areas elasmobranchs formed a small proportion of the catch, with the highest numbers being caught in the Jeffreys Bay area. Although elasmobranchs are caught in all areas, due to the fact that most were released, and released fish were not included in the CPUE estimates, and the random sampling protocol, areas such as Kei Mouth were allocated 0% elasmobranchs in tables 4.1-4.3, as none were retained by fishers on the sampling days.

The recreational ski-boat CPUE is fairly consistent throughout the year with a peak in July (Figure 4.6). Few seasonal trends in CPUE were evident in the commercial ski-boat fishery (Figure 4.6), except in late summer in the Kei Mouth area, when large catches of red steenbras *Petrus rupestris* were made causing a sharp rise in overall CPUE. The average CPUE of the commercial fishers was 21.5 ±35.4 kg.person^{-1}.day^{-1} or 15.8 ±15.9 fish.person^{-1}.day^{-1}. The recreational fishers' CPUE was 9.4 ±14.7 kg.person^{-1}.day^{-1} or 5.3 ±8.3 fish.person^{-1}.day^{-1}, that is 39% lower than the commercial CPUE. Kei Mouth and Stil Bay consistently had the highest CPUE values in the commercial fishery, while Port Elizabeth and Kei Mouth had the highest CPUE values in the recreational ski-boat fishery (Tables 4.2 and 4.3). In both ski-boat sectors, the highest proportion of elasmobranchs was caught in Mossel Bay.

It was not possible to accurately estimate ski-boat effort using the aerial surveys. As a result, the total catch estimates were scaled up to include unsampled areas using the total number of commercial ski-boats listed in the area on the commercial boat registry at Sea Fisheries. The total number of recreational ski-boats registered with clubs was calculated using a club to non-club ratio. By simply scaling up the CPUE and the total effort for the area the total catch in all three sectors was 3325 tonnes per annum. The bulk (56%) of this catch was caught by the commercial ski-boat sector followed by the shore sector (31%) and the recreational ski-boat sector (12%) (Table 4.4).

Table 4.1: Regional CPUE distribution for the shore fishery between Kei Mouth and Stil Bay.

Area	Total fish		CPUE (catch person.day^{-1})		% Elasmobranches		n
	Kg	Number	Kg	Number	Kg	Number	
Kei Mouth	50.4	54	1.19 ±5.17	1.1 ±4.1	0	0	153
East London	229.2	445	0.836±2.4	2.28±10.13	0	0	467
Port Alfred	217.8	170	1.0±5.4	0.72±2.6	1.6	5.88	731
Port Elizabeth	451.7	761	0.95±4.6	2.1±8.9	7.6	0.6	1148
Jeffreys Bay	239.2	67	4.9±27.2	1.29 ±4.7	73	35.8	199
Plettenberg Bay	60.6	190	0.74±2.03	3.66 ±14.8	0	0	173
Mossel Bay	83.3	378	0.795±3.46	4.43±20.42	21	0.26	317
Stil Bay	12.6	25	1.86±6.43	2.2±9.5	0	0	94
Total	1345.0	2090			1.96	0.66	3282

Table 4.2: Regional CPUE distribution for the recreational ski-boat fishery between Kei Mouth and Stil Bay.

Area	Total fish		CPUE (catch person.day^{-1})		% Elasmobranches		n
	Kg	Number	Kg	Number	Kg	Number	
Kei Mouth	255.7	79	13.0±8.25	4.2±2.2	0	0	5
East London	1217.9	666	4.5±5.2	4.4±5.2	6	4.9	38
Port Alfred	627.7	417	8.6±13.6	6.0±6.7	0.6	0.5	20
Port Elizabeth	1445.1	450	18.26±26.1	10.4±15.7	0.6	0.2	23
Jeffreys Bay	18.6	15	4.65±0	3.75±0	0	0	1
Plettenberg Bay	223.5	131	12.1±5.3	6.3±3.7	0	0	6
Mossel Bay	1052.1	590	6.5±10.3	3.6±6.0	34.2	15.9	54
Stil Bay	25.8	25	3.2±2.1	2.3±1.2	0	0	3
Total	4866.4	2373			9.15	4.7	150

Table 4.3: Regional CPUE distribution for the commercial ski-boat fishery between Kei Mouth and Stil Bay.

Area	Total fish		CPUE (catch person.day^{-1})		% Elasmobranches		n
	Kg	Number	Kg	Number	Kg	Number	
Kei Mouth	3014.0	227	86.89±125.9	6.73±6.2	0	0	7
East London	275.0	425	18.79±11.8	29.58±24.6	1	0.2	3
Port Alfred	7406	8986	14.07±13.0	17.0±13.9	0.5	0.3	99
Port Elizabeth	1555.9	1524	14.33±12.56	14.2±14.0	0	0	22
Jeffreys Bay	36.2	76	1.53±1.23	3.3±3.3	0	0	3
Plettenberg Bay	1625.8	1415	21.8±18.21	19.6±18.2	3.5	0.9	16
Mossel Bay	1210.5	706	13.08±13.4	7.9±8.2	13.6	6.1	24
Stil Bay	6556.3	3298	36.73±47.3	18.1±21.5	5.8	2.9	46
Total	21679.8	16657			2.96	1.05	220

Table 4.4: Total annual catch estimates for the shore fishery between Kei Mouth and Stil Bay and seven ports in the recreational and commercial ski-boat fisheries sampled between Kei Mouth and Stil Bay.

Fishery	Mass (tonnes)	Number of fish
Shore	1 038	1 860 563
Recreational ski-boat	410	231 398
Commercial ski-boat	1 877	1 379 198

Comparison of effort observed during the access point survey of the commercial fishery to that reported to SFRI on the National Marine Linefish System (NMLS) (Table 4.5) revealed that total effort estimates from this survey were 20% higher than those reported to SFRI. Catch estimates would therefore be significantly higher than those recorded by the SFRI as Sauer *et al.* (in pres) noted for most species catch estimates should be scaled up by a factor of 2.

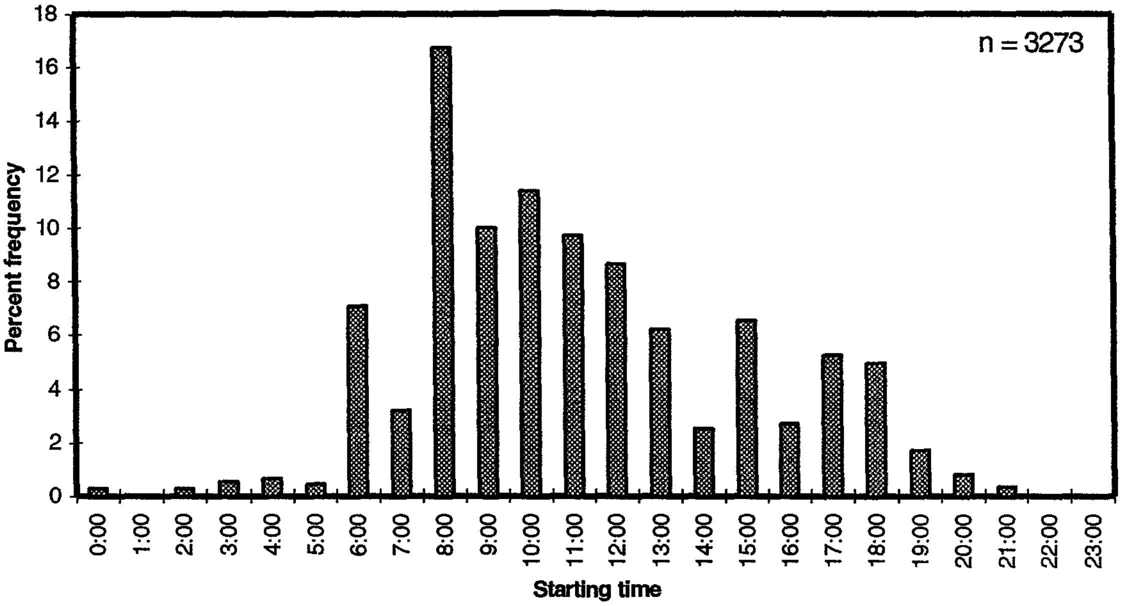


Figure 4.3: Shore fisher starting times in the Eastern Cape.

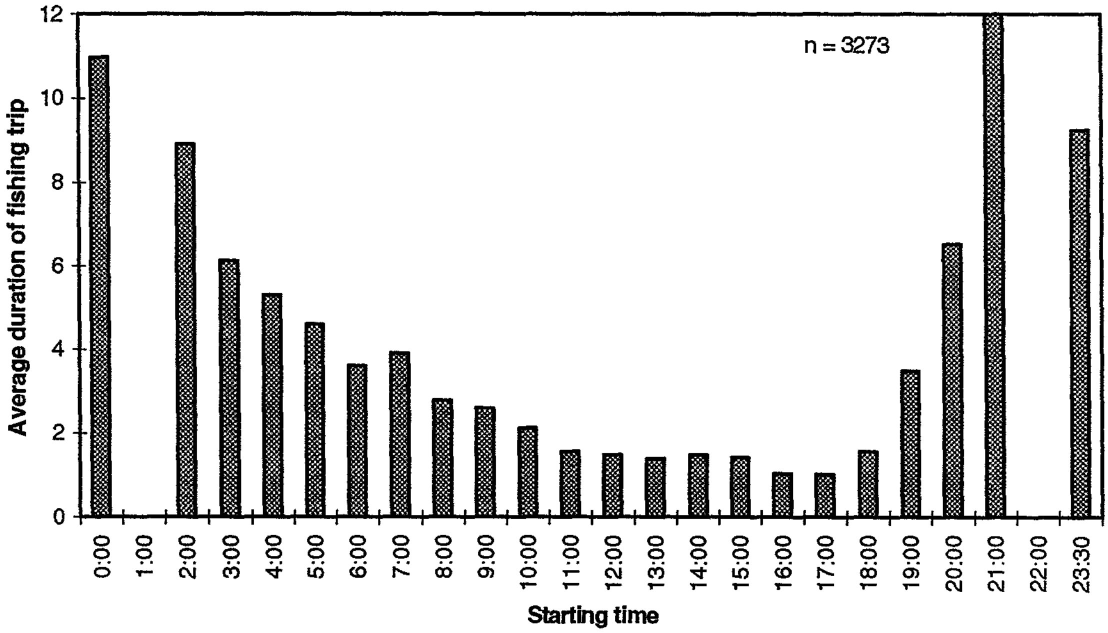


Figure 4.4: Average duration of fishing trips at the time if the interview.

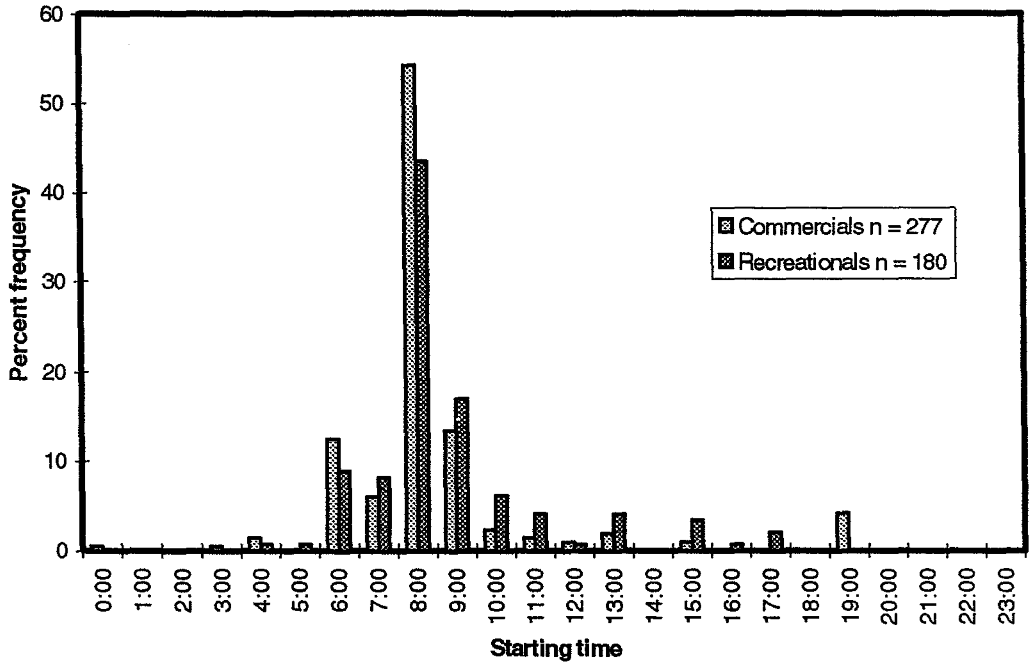


Figure 4.5: The average starting times in the ski-boat fishery in the Eastern Cape.

Table 4.5: Catches observed during the access point survey from 183 commercial ski-boats. Compared with the catch reported for the same days by the same boats to the NMLS.

Species	Reported Catch (kg)	Observed Catch (kg)
A. inodorus (silver kob)	2364	5731
M. capensis (hake)	942	2036
P. laniarius (panga)	1255	1613
A. argyrozona (carpenter)	2615	1628
C. nufar (santer)	121	307
P. rupestris (red steenbras)	930	2526
C. laticeps (roman)	53	203

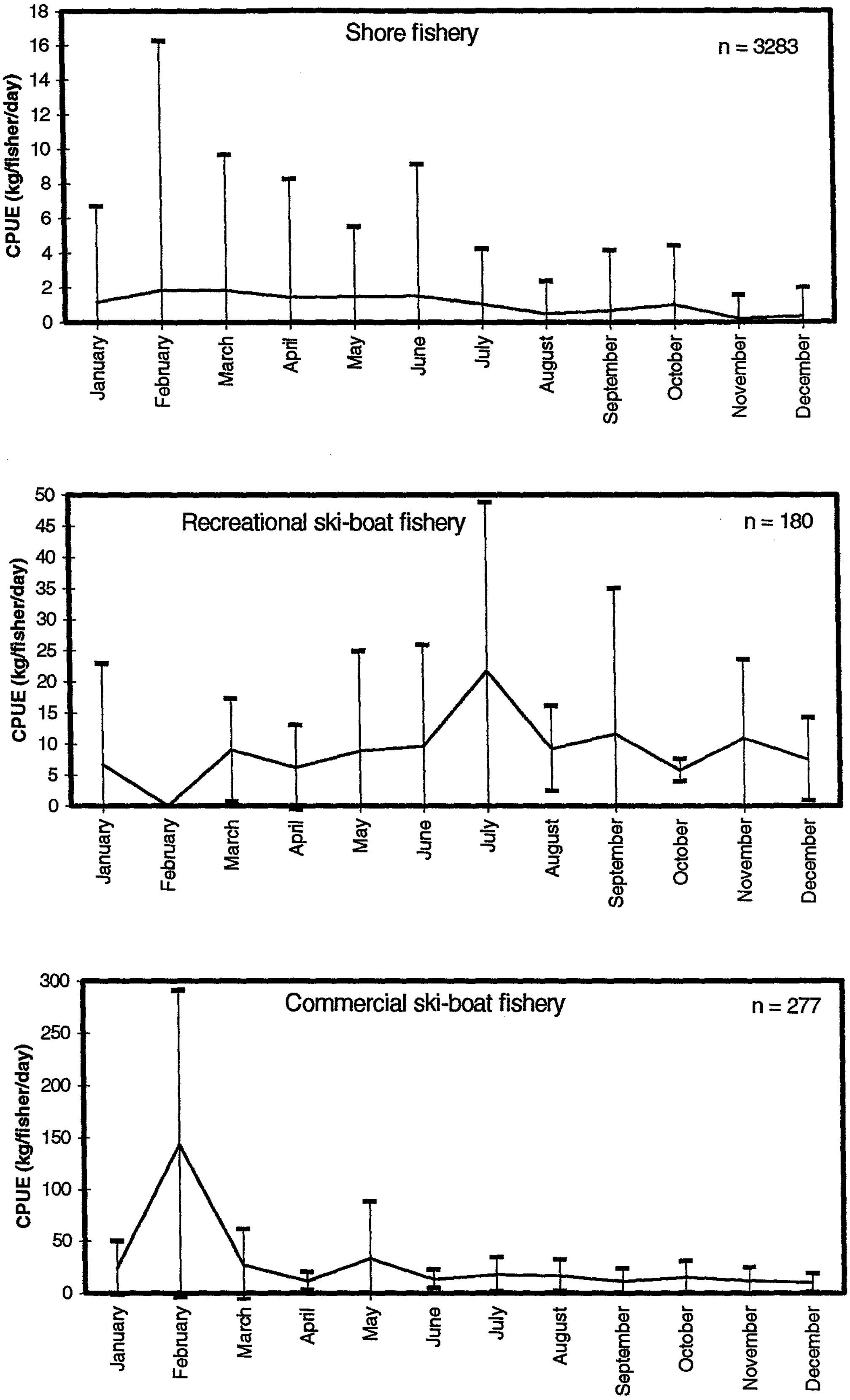


Figure 4.6: The average CPUE (±SD) within three sectors of the Eastern Cape linefishery.

Bait utilisation and targeting effort

An assessment of bait utilisation by the different sectors showed that the shore fishers use the widest variety of baits (22 different types) (Figure 4.7). Recreational ski-boaters use more bait types (8 different types) than commercial ski-boat fishers (6 different types). Recreational ski-boaters use mostly squid (*Loligo vulgaris reynaudii*), and pilchard (*Sardinops sagax*), while artificial lures and live bait were also used occasionally. In the commercial ski-boat fishery, squid and pilchard were the preferred bait types, while mackerel (*Scomber japonicus*) was used when the fishers caught it themselves, but was rarely purchased.

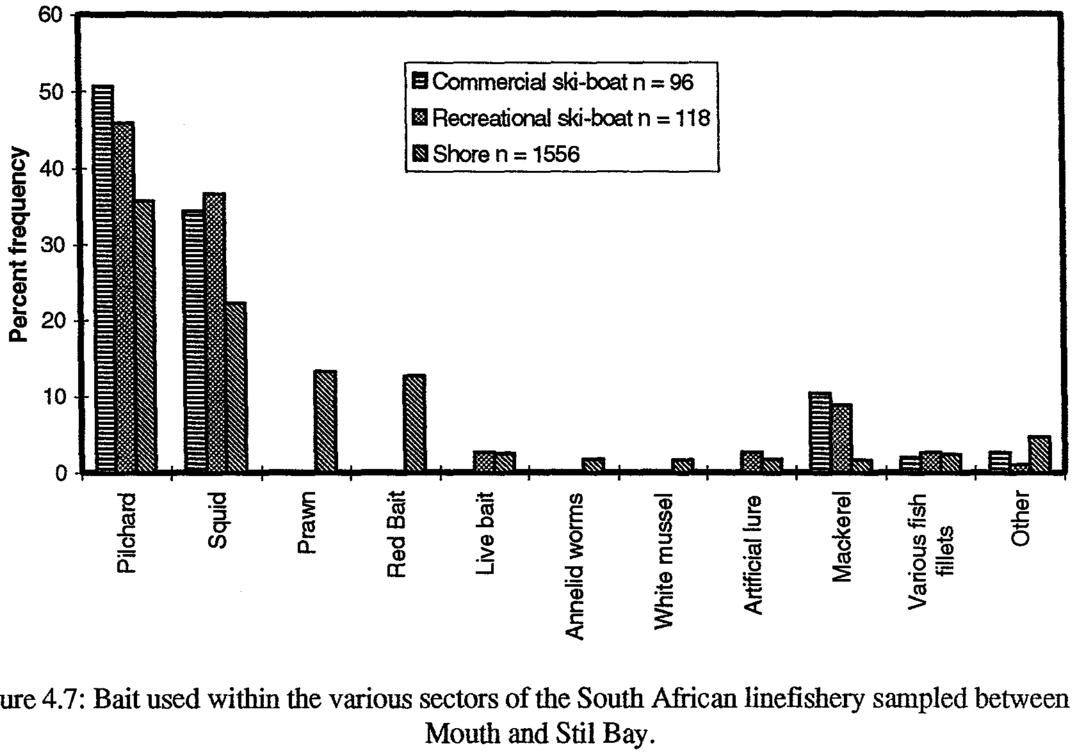


Figure 4.7: Bait used within the various sectors of the South African linefishery sampled between Kei Mouth and Stil Bay.

In the shore fishery pilchard and squid were used to catch a broad spectrum of fish as was red-bait (*Pyura stolonifera*). Red-bait and annelid worms (mostly mussel worm, *Pseudonereis variegata*

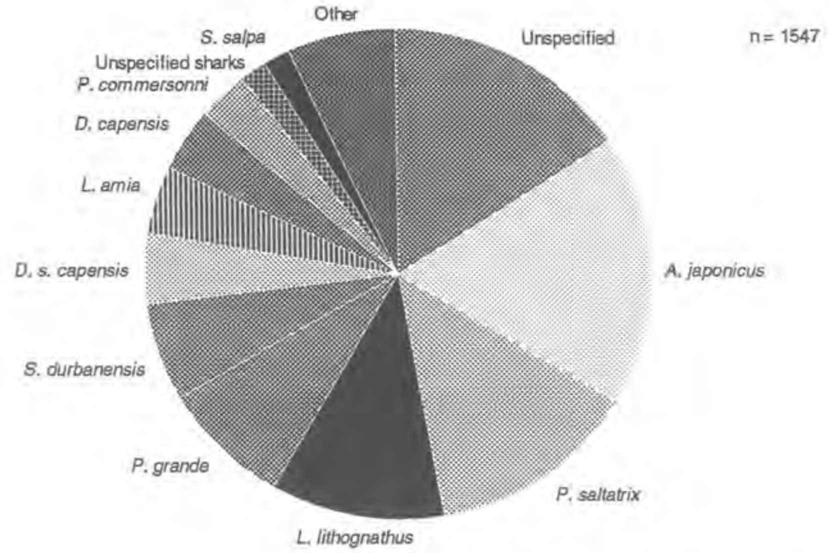


Figure 4.8: Relative proportion of directed effort in the shore fishery between Kei Mouth and Stil Bay.

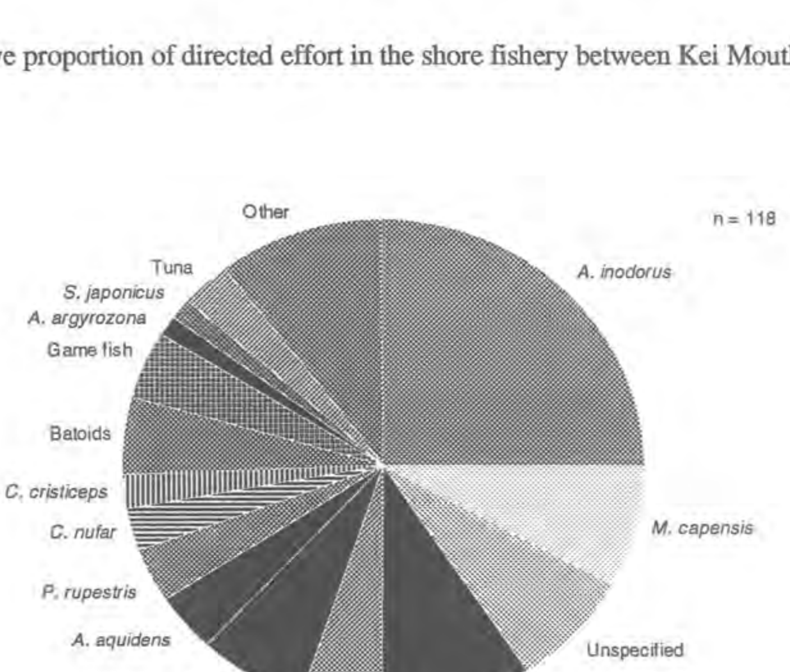


Figure 4.9: Relative proportion of the directed effort in the recreational ski-boat fishery between Kei Mouth and Stil Bay.

and wonder worm, *Eunice aphroditois*) were used when fishers were specifically targeting bronze bream (*Pachymetopon grande*) and galjoen (*Dichistius capensis*). Blacktail (*Diplodus sargus capensis*), was caught on a wide variety of bait types from pilchard to red bait. Chitons (*Dinoplax gigas*) and Venus ears (*Haliotis spadicea*) were used mainly when fishers were targeting musselcracker (*Sparodon durbanensis*). Fishers targeting leervis (*Lichia amia*) and yellowtail (*Seriola lalandi*) used mainly live bait (mostly strepie, *Sarpa salpa* and mullet) and artificial lures.

Figures 4.8-4.10 show the relative proportion of directed effort in the three sectors. Shore fishers target the widest number of species (Figure 4.7 and Table 4.5). Dusky kob, (*Argyrosomus japonicus*), shad/elf (*Pomatomus saltatrix*), white steenbras (*Lithognathus lithognathus*) and bronze bream were the predominant target species in the Eastern Cape shore fishery. A high proportion of anglers were not targeting any specific species.

Table 4.6: Species targeted in the three sectors of the Eastern Cape linefishery sampled between Kei Mouth and Stil Bay, species listed alphabetically according to family.

Species	Shore fishery	Recreational ski-boat	Commercial ski-boat
Carcharhinidae *Carcharhinus brachyurus* (Copper shark)	*	*	
C. obscurus (Dushy shark)			*
Dasyatidae *Gymnura natalensis* (Diamond ray)		*	
Odontaspididae *Carcharias taurus* (Ragged tooth shark)	*		
Rajidae *Raja alba* (Spearnose skate)	*	*	*
Sphyrnidae *Sphyrna zygaena* (Smooth hammerhead shark)		*	*
Ariidae *Galeichthys* spp. (Sea barbel)	*		
Carangidae *Lichia amia* (Leervis)	*	*	
Seriola lalandi (Yellowtail)	*	*	*
Trachinotus africanus (Southern pompano)	*		
Coracinidae *Dichistius capensis* (Galjoen)	*		
D. multifasciatus (Banded galjoen)	*		
Haemulidae *Pomadasys commersonni* (Spotted grunter)	*	*	
P. olivaceum (Piggy)	*		
Istiophoridae (Sail fishes and marlins)		*	
Merluccidae *Merluccius capensis* (Hake)		*	*
Mugilidae *Liza* species (Mullet)	*		
Pomatomidae *Pomatomus saltatrix* (Elf/shad)	*	*	*
Sciaenidae *Argyrosomus inodorus* (Silver kob)		*	*
A. japonicus (Dusky kob)	*		
Atractoscion aequidens (Geelbek)	*	*	*
Umbrina spp. (Baardman)	*		
Scomdridae *Katsuwonus pelamis* (Skipjack tuna)	*	*	
Sarda sarda (Atlantic bonito)		*	
Scomber japonicus (Mackerel)	*	*	
Thunnus albacares (Yellowfin tuna)		*	*
Scorpididae *Neoscorpis lithophilus* (Stone bream)	*		
Sparidae *Argyrozona argyrozona* (Carpenter)		*	*
Boopsoidea inornata (Fransmadam)	*	*	
Cheimerius nufar (Santer)	*		*
Chrysoblephus cristiceps (Dageraad)		*	*
C. gibbiceps (Red stumpnose)		*	
C. laticeps (Red roman)	*	*	
Cymatoceps nasutus (Poenskop)	*	*	
Diplodus cervinus hottentotus (Zebra)	*		
Diplodus sargus capensis (Blacktail)	*		
Lithognathus lithognathus (White steenbras)	*	*	
L. mormyrus (Sand steenbras)	*		
Pachymetopon grande (Bronze bream)	*		
Petrus rupestris (Red steenbras)		*	*
Polysteganus undulosus (Seventy-four)		*	
Pterogymnus laniarius (Panga)		*	*
Rhabdosargus globiceps (White stumpnose)	*		
R. holubi (Cape stumpnose)	*		
Sarpa salpa (Strepie)	*		
Sparodon durbanensis (Musselcracker)	*		
Spondyliosoma emarginatum (Steentjie)	*		
Triglidae *Chelidonichthys capensis* (Cape gurnid)			*
TOTAL	**33**	**26**	**15**

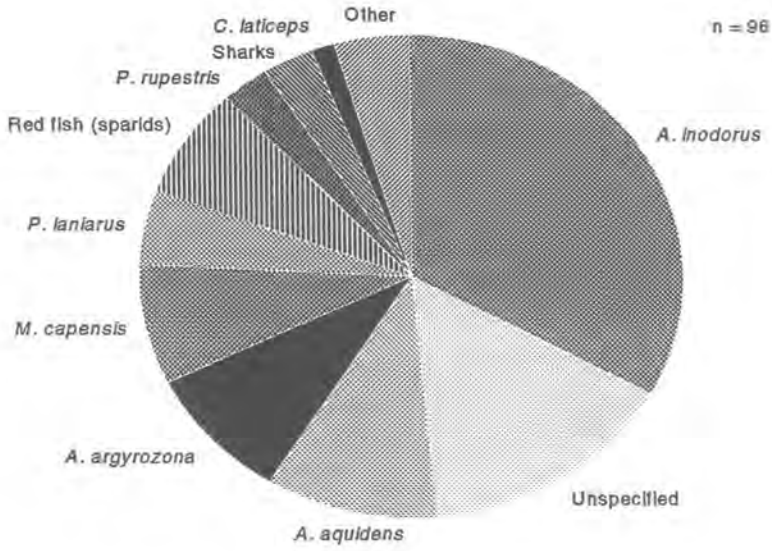


Figure: 4.10: Relative proportion of the directed effort in the commercial fishery between Kei Mouth and Stil Bay.

In both the recreational and commercial ski-boat fisheries silver kob was the most sought after species. The commercial fishers target species that yield the greatest catches such, as silver kob, geelbek (*Atractoscion aequidens*), carpenter (*Argyrozona argyrozona*), hake (*Merluccius capensis*) and panga (*Pterogymnus laniarius*). Recreational ski-boat fishers appeared to spend more time targeting species that were less abundant, such as reef dwelling sparids (for example, roman (*Chrysoblephus laticeps*), dageraad (*Chrysoblephus cristiceps*) and red steenbras), and spend more time trolling for game fish, such as tuna (*Thunnus* species) and leervis. Roman dageraad and red steenbras are also targeted by commercial fishers as these species fetch high prices. Commercial fishers work on a trade off basis between high catches of low-priced fish and small catches of high-priced fish.

DISCUSSION

Fishing effort

This study has provided a reference point of annual effort within the three sectors of the Eastern Cape linefishery. Unfortunately no other comprehensive data exist upon which to directly estimate the overall increase in effort over time along this section of coast. It is known however, from several studies that fishing effort in all sectors of the linefishery have shown a steady increase (Smale and Buxton 1985; Hecht and Tilney 1989; Guastella and van der Elst 1990; McGrath *et al.* in press). Effort in the South African shore fishery is currently estimated to be increasing at a rate of 2% per annum (McGrath *et al.* in pres.). The Port Elizabeth recreational ski-boat fishery increased by 1.6% between 1975 and 1982 (Smale and Buxton 1985).

The annual shore fishing effort appears to be seasonal in nature, increasing in summer and decreasing in winter. The strong peak in February is a consequence of two fishing competitions, during which 150 and 100 participants fished respectively, and a third ("angling week") which is an annual week-long shore angling competition involving ±300 anglers fishing between the Great Fish River and Kranshoek, west of Robberg (see Coetzee *et al.* 1989). Catch and effort data form these competitions were not excluded from the data base as they were collected during randomised sampling trips (see below for CPUE details). The peak in effort in April was caused by holiday makers during the Easter holiday period. The decline in the average number of fishers per day in winter was the result of a combination of bad winter weather and school terms, when few people were on holiday. Similar effort trends were observed in the recreational ski-boat fishery where effort was low in the winter months, increasing in summer and during school holidays. Effort estimates for both the shore and the recreational ski-boat fisheries in December was lower than expected. However, this was a consequence of uncharacteristically high rainfall throughout the Eastern Cape during December (Port Elizabeth meteorological office). The principal recreational ski-boat fishing periods appear to be related to three factors: holidays, favourable weather and the seasonal availability of target species (Smale and Buxton 1985).

The greatest effort in the commercial ski-boat fishery was recorded from May to September, when recreational ski-boat effort was low. This period coincides with the presence of valuable migratory species such as geelbek (Griffiths and Hecht 1995). Effort was lower in January and February as many of the commercial ski-boat fishers were not fishing for fish, but directing their effort at squid which was not included in the study.

Participants in the three sectors fished throughout the week. Nonetheless some strong trends were evident. Shore and recreational ski-boat fishers fished more frequently over weekends. There was also a clear increase in shore fishing effort on Friday (Figure 4.2) from 16:00 onwards, (especially in summer) when people fished for a few hours after work. Participants in the shore fishery fished at all hours of the day and night. The majority started fishing between 06:00 and 10:00. People fishing at night started between 17:00 and 21:00. No fishers were found to start their fishing trip after 22:00. However, it must be noted that sampling at this time of night was sporadic and estimates are poor.

Ski-boat fishers usually began their fishing trip in the morning and most had started fishing before 10:00. Few ski-boaters began their fishing trip in the late morning and afternoon except on Friday afternoon. Most commercial fishers put to sea before 08:00, returning approximately eight hours later. The notable exception to this was night fishing for silver kob in Stil Bay. Commercial fishers operated mainly from Monday to Friday. Subsistence shore fishers and commercial ski-boat fishers fish for more days per year than recreational shore and recreational ski-boat fishers. This is simply a consequence of the fact that they depend on fishing for their livelihood. Both commercial ski-boaters and subsistence shore fishers, fished longer hours than recreational ski-boat and shore fishers.

The annual effort estimate for the Eastern Cape shore fishery was 903 186 fisher days.year^{-1}, with a fisher density of approximately 0.39 fishers.km^{-1}. This value was low when compared to other areas in South Africa such as KwaZulu-Natal and the southwestern Cape where fisher densities were 7.23 and 1.29 fishers.km^{-1} respectively, and was lower than the national average of 2.33 fishers.km^{-1} (Brouwer *et al.* in pres). The reason for this low overall density is a consequence of fishers being concentrated around towns, and the many inaccessible areas along the Eastern Cape coast which may often only be reached with off-road vehicles. This differs from the KwaZulu-Natal south coast which is largely accessible. The study area also contained a large marine reserve (approximately 65 km), the Tsitsikamma National Park, which is a no-take zone where fishing is prohibited. Excluding the Tsitsikamma National Park from the fisher density calculations only increases the fisher density by 0.01 fishers.km^{-1}. Clarke and Buxton (1989) reported a fisher density of 1.2 fishers.km^{-1} in the Port Elizabeth area. This is only slightly lower than the densities calculated from the same area covered in this study (1.3 fishers.km^{-1}). It should be noted that although the effort increase is negligible, the CPUE of some species in this area has declined substantially (see below).

While effort in the shore fishery could be estimated along the entire coastline using aerial surveys, this was not possible for the ski-boat fishery. Ski-boat annual effort was extrapolating using the commercial and recreational ski-boat registration figures to cover the entire region. The commercial ski-boat effort data obtained during this study was found to be substantially higher than that reported to the SFRI. This resulted in total catch estimates from this study being consistently higher than those reported to the SFRI by commercial skippers. SFRI relies on fishers to report their catch. However, there is a high incidence of non-reporting because fishers believe that if they report their full catch they will be liable for higher taxes. The total effort estimates obtained in this study were therefore more accurate than the NMLS data. The reason for this is quite simply that the estimates obtained in this study were based on direct observation of the catch. It is a well known fact that direct observation data are more accurate than reported catch statistics (Essig and Holliday 1991; Fisher *et al.* 1991; Hilborne 1992; Tarrant *et al.* 1993). In South Africa, the non-response bias is high as many commercial ski-boaters do not send in catch returns. Length of recall bias (bias occurring when anglers mis-remember past events or the time in which they occurred (Pollock *et al.* 1994)) is probably low for most commercial fishers as many keep logbooks or a crew pay book from which they could extract accurate catch statistics. As a consequence of the inaccurate reporting of catch, the SFRI should account for under-reporting by calculating a correction factor. For example, the silver kob catches in Port Alfred were underestimated in the NMLS by 21% in 1995. This situation is not isolated to the Eastern Cape as in the Western Cape the hottentot *Pachymetopon blochii* catches need to be increased 6 fold (Sauer *et al.* in pres).

Catch composition

Prior to the study by Clarke and Buxton (1989) few reliable historical records of CPUE existed for the shore fishery in the Eastern Cape and reports of declining catches were speculative. When the catches reported by Clarke and Buxton (1989) were compared to the results from this study (in the same area), CPUE was notably lower for three of the most important target species (Table 4.7). Of concern is that all three species are slow growing and long lived (Buxton and Clarke 1991; Buxton and Clarke 1992; Mann and Buxton 1993). A notable exception to this trend is the three fold increase in the CPUE for shad. This is in agreement with van der Elst's (1987a; 1987b) observations that the shad fishery is recovering after a serious decline in the early 1970's.

Table 4.7: A comparison of the CPUE between 1989 and 1996 along a section of the Port Elizabeth coast from Flat Rocks to Schoenmakerskop.

Species	CPUE 1989* g.person^{-1}.hour^{-1}	CPUE 1996 g.person.$^{-1}$ hour^{-1}
P. saltatrix (shad)	74.7	228
S. durbanensis (mussel cracker)	30.3	6
D. s. capensis (blacktail)	19.4	11
P. grande (bronze bream)	12.6	9

*From Clarke and Buxton (1989)

As recently as the late 1970's and early 1980's, the catch in the "angling week" shore fishing competition was dominated by teleosts (Coetzee *et al.* 1989). This competition in 1995 and 1996 was dominated by elasmobranchs (Figure 4.11) and the CPUE for angling week was lower in 1995 and 1996 (Figure 4.12). Coetzee *et al.* (1989) had already noted that the number of elasmobranchs in the catches had begun to increase since the early 1970's. This is a major cause of concern as elasmobranch fisheries are susceptible to overfishing (Compagno and Smale 1989; Hoenig and Gruber 1990) and generally decline markedly in a short period of time (Anderson 1990). Cribb (1994) noted that when fish stocks decline, people do not stop fishing. They switch to other species and their previous target becomes an occasional capture. This has now become evident in the Eastern Cape shore fishery where many competition fishers are now solely targeting elasmobranchs.

In the shore, commercial and recreational ski-boat fisheries the CPUE of elasmobranchs is grossly underestimated. In the shore fishery, most are returned to the sea, while some, especially

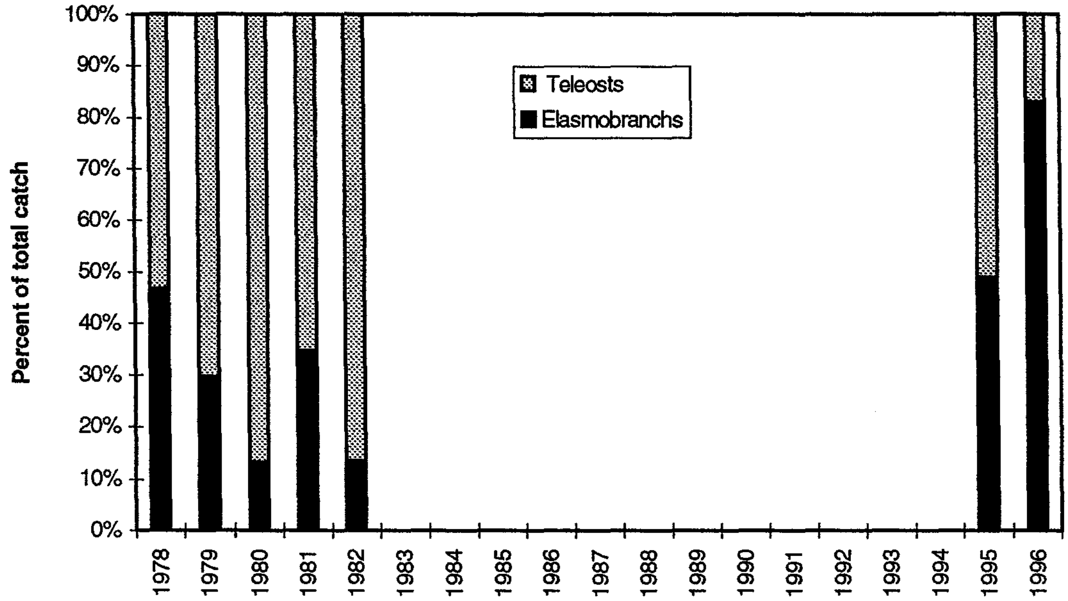


Figure 4.11: The relative proportion of teleosts and elasmobranchs caught during angling week 1978-1996 (1978-1982 data from Coetzee *et al.* 1989).

sandsharks (*Rhinobatos annulatus*) are discarded. In the ski-boat fisheries scyliorhinids are often released although many are clubbed first. Similar practices were observed by Clarke and Buxton (1989) and Smale and Buxton (1985). The survival rate of many elasmobranchs which were returned is probably low as Denton *et al.* (1987) noted that sharks after a struggle die from lactacidosis after release, if not treated with $NaHCO_3$.

Historical CPUE data exists for the ski-boat fishery. At the turn of the century the sparid catches in Knysna, Plettenberg Bay, Jeffreys Bay, Port Elizabeth and East London were dominated by seventy-four (*Polysteganus undulosus*). In the Mossel Bay area catches were dominated by

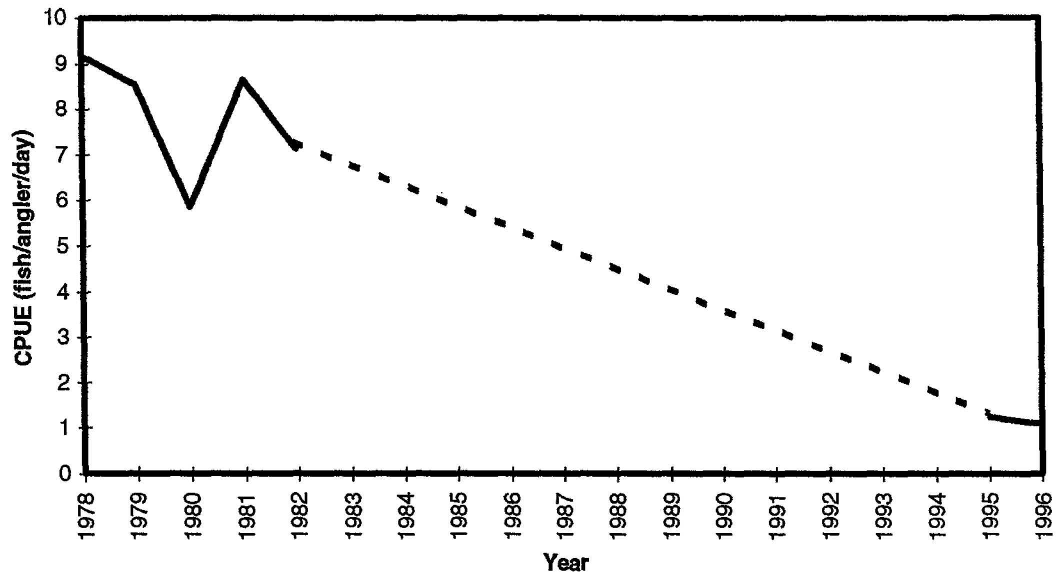


Figure 4.12: Angling week catch trends (1978-1982 data from Coetzee *et al.* 1989).

Roman and seventy-four (Crawford and Crous 1982). In Port Alfred and Port Elizabeth catches in the late 1970's were dominated by red steenbras. Catches of seventy-four were only recorded in "large" numbers at landing sites east of Port Alfred (Crawford and Crous 1982). The seventy-four fishery has since collapsed (Garratt 1993; Pilfold and Pampallis 1993), and there is much concern over the status of the red steenbras fishery (Winch 1990; Penny and Wilke 1993). At present East London and Kei Mouth are the only places where seventy-four and red steenbras are caught in any significant numbers. No seventy-four were recorded southwest of Port Elizabeth. Biden (1948) noted that red steenbras was common all year round in Port Elizabeth prior to the 1950's. However, throughout this study only one red steenbras was sampled at Port Elizabeth.

Hecht and Buxton (1993) noted that the distribution range of red steenbras has contracted and while they do not believe that the fishery is currently depleted, they do warn that increased fishing effort in Transkei waters could affect the stock. Given that the Wild Coast is now earmarked by the government for tourism development, it is expected that there will be increasing pressure exerted on the red steenbras stock.

A comparisons of the present catch to those observed by Hecht and Tilney (1989) (Table 4.8) revealed that both silver kob and carpenter catches have declined in Port Alfred. Panga catches on the other hand seem to be increasing. This supports Hecht and Tilney's (1989) observations that the fisheries for silver kob and carpenter were declining while panga was increasing. Even though the panga catches have been increasing, the landings are not enough to make up for the decreased catch of other species. The total CPUE in the Port Alfred ski-boat fishery is now 71 $kg.person^{-1}.month^{-1}$ lower than the estimates obtained by Hecht and Tilney (1989). Of greater concern, however, is the change in the species composition of the catch at Port Alfred (Hecht and Tilney 1989). A similar trend has been recorded in the ski-boat fishery in KwaZulu-Natal, where seventy-four was the principal species in the commercial fishery in the 1920's and 1930's, but declined substantially after the 1930's and since then has been replaced by slinger (*Chrysoblephus puniceus*) (Garratt 1993; Pilfold and Pampallis 1993).

Table 4.8: A comparison of the commercial ski-boat CPUE at Port Alfred between 1989 and 1996.

Species	CPUE 1989* $kg.person^{-1}.day^{-1}$	CPUE 1996 $kg.person^{-1}.day^{-1}$
A. inodorus (silver kob)	9.5	4.15
A. argyrozona (carpenter)	5.5	2.3
P. laniarius (panga)	2	3.3

*From Hecht and Tilney (1989)

Booth and Buxton (in prep) and Booth and Punt (in prep) believe that panga can be exploited at a rate of 420% higher than the current levels of fishing. This may seem encouraging as panga may be seen as the species that could sustain the Eastern Cape commercial ski-boat fishery in the future. The problem with increasing catches of panga and decreasing catches of silver kob is that the value of the catch is much less. The boat owner receives R10.50 per kilogram for silver kob, but only R4 per kilogram for panga which are smaller fish and need to be caught in large numbers before the same economic rewards are realised (Chapter 5).

The shore fishing CPUE estimates for the Eastern Cape were similar to the estimates in the southwestern Cape but higher than those in KwaZulu-Natal (Brouwer *et al.* in pres). The low mass and the high number of fish caught in KwaZulu-Natal suggests that the fish caught in this region are much smaller than those in the Eastern Cape. Similarly, the KwaZulu-Natal recreational and commercial ski-boat CPUE estimates were lower than those in the Eastern Cape. This is not surprising as KwaZulu-Natal has a substantially higher fishing effort and the fishery is considered to be under great pressure (Brouwer *et al.* in pres; Sauer *et al.* in pres).

The peak in commercial ski-boat CPUE in February should be considered as an anomaly which has the probability of occurring in only 8% of all potential fishing days. Red steenbras becomes susceptible to the fishing gear when the Agulhas current is far offshore and the fishers can get their hooks to deep reefs (usually to depths of ± 100m). When the current is inshore the fishers can not get their hooks to the seabed. Hecht and Buxton (1993) stated that the red steenbras stocks along the Transkei coast are only available to the ski-boat fishers for approximately 31 days per year. During the rest of the year the current is too strong for the fishers to fish on the red steenbras fishing grounds. Although there is no oceanographic data to support this, Smale (1988) stated that some form of protection from fishing is afforded to offshore reefs by bad weather and the strong Agulhas current which often prevents fishing. Increased exploitation of these populations could have marked effects on the stock, because those red steenbras which occur along the Transkei coast have been shown to be the breeding population (Garratt 1988; Smale 1988). For these reasons it is important to ensure that these populations receive adequate protection. However, since they live in deep water and suffer from barotrauma when caught, closed areas are probably the only way to offer this species effective protection.

Hilborn (1985) noted that it is common knowledge that some fishers catch more fish than others but the causes of this variation are little understood. Similar findings were made during this study. The reason for the high variation in CPUE is ascribed to varying fisher experience and knowledge of the specific area. Varying levels of skill and knowledge became very obvious when club and non-club catches are compared. Shore anglers belonging to angling clubs caught a higher daily mass of fish than non-club fishers. For example, excluding the competition data from the calculation of the individual CPUE in the Eastern Cape reduced the CPUE from 1.15 $kg.person^{-1}.day^{-1}$ and 2.06 $fish.person^{-1}.day^{-1}$ to 0.9 $kg.person^{-1}.day^{-1}$ and 1.6 $fish.person^{-1}.day^{-1}$. This was markedly lower than the CPUE of competition fishers (6.38 $kg.person^{-1}.day^{-1}$ and 11.82

fish.person^{-1}.day^{-1}). The club fishers target and caught larger fish using more sophisticated equipment, whereas many of the fish caught by non-club fishers were small species such as strepie, mullet and blacktail.

The fishery for strepie was complicated by the fact that these fish were targeted by two distinct groups of fishers. Firstly, they are targeted by fishers who use this species as bait. Secondly, because of the abundance of strepie it is also a major target of the subsistence fishers. CPUE estimates for strepie in the Eastern Cape were similar to those found in KwaZulu-Natal (0.2 fish.hour^{-1}) (van der Walt 1995).

Bait utilisation and targeting effort

Many of the shore fishers collect bait such as red bait, sand prawn (*Callianassa kraussi*) and sand mussels from the environment prior to or during the course of a fishing trip. Most, however, purchase bait such as pilchards and squid. Pilchard and squid are used by fishers who are not targeting specific species. Pink prawn, a commercially available penaeid, is more expensive than other baits and is used specifically to target bronze bream. Clarke and Buxton (1989) noted that 91.4% of bronze bream were caught on pink prawn, sand mussels and swimming prawn (live caught penaeids). Abalone (*Haliotis midae*) and siffie (*Haliotis spadicea*), chiton and alikreukel (*Turbo sarmaticus*) were used when fishers were targeting musselcracker. Live bait (strepie, piggie (*Pomadasys olivaceum*), Cape stumpnose (*Rhabdosargus holubi*) or mullet), pilchard and fresh fish fillets (strepie, piggy and mullet), were used by fishers who specifically targeted shad and dusky kob.

Commercial ski-boat fishers usually target the most abundant species. In the Eastern Cape, the majority of commercial ski-boat fishers actively targeted silver kob. The most common bait used for this species was pilchard and squid. Squid and pilchards were also used for targeting carpenter, geelbek and hake. Mackerel was the only other bait commonly used by commercial fishers, although some also used small unmarketable fish such as fransmadam (*Boopsoidea inornata*) and steentjie (*Spondylosoma emarginatum*) with the result that the CPUE estimates for these species were probably significantly higher than the estimates quoted in Appendix IIIC.

Although silver kob was targeted by many recreational ski-boaters, other species were also important to fishers in this sector. The obvious difference between the commercial and recreational ski-boaters was the higher fishing effort by recreationals on reef species such as roman and other sparids and their preference for game fish such as leervis and tunas. This increased specialisation and more specific targeting effort was reflected by the wider variety of bait types compared to the commercial fishers. Notable examples were the use of artificial lures and live bait within the recreational ski-boating sector.

The proportion of fishers targeting elasmobranchs was low in all sectors. Only 2.3% of shore fishers, 3.6% of the commercial fishers and 11.6% of recreational ski-boaters targeted sharks and rays. Few commercial fishers fished for elasmobranchs because of their low market value (R4 per kg). The relatively high percentage of recreational ski-boat fishers targeting elasmobranches was due to the high proportion of club fishers (76.3%) in this sector. In recreational fisheries, club fishers were more likely to target elasmobranchs because they are usually heavier than teleosts and score more points in competitions (personal observation).

Management implications

The Eastern Cape is a transition zone between subtropical KwaZulu-Natal and the cold temperate Western Cape waters and many species from these two regions are caught in the Eastern Cape. The high number of species found in the area complicates management. The management of multispecies fisheries has two basic problems which are biological and socio-political in origin. Biological problems include longevity (Buxton and Clarke 1989), sex change (Buxton 1992), residency (Buxton and Allen 1989), barotrauma (Feathers and Knable 1983), the lack of understanding of ecosystem functioning and in some instances a lack of biological research (van der Elst and Adkin 1991). Socio-political issues include the multi-user nature of the fisheries, open access to the recreational fisheries and lumping of species under one name in catch records. Hecht and Tilney (1989) were of the opinion that the biological and socio-political problems apply to the South Africa linefishery as a whole. Some of the perceived socio-political problems are generally unfounded as there is little overlap between the offshore and inshore sectors of the fishery. However, there is considerable overlap between the commercial and recreational ski-boat sectors (Figure 4.13). This overlap is the cause of conflict between the commercial and recreational ski-boaters. Each blames the other for the decline in catches (Chapter 3). This animosity has resulted in some ski-boat clubs prohibiting commercially licenced boats from using their slipways.

While each fishery was characterised by a large number of species, only 15% of the species made up most of the catch (75% in the shore fishery, and 83% and 90% in the recreational and commercial ski-boat fisheries respectively). The most important species in the shore fishery were shad, strepie, dusky kob, white steenbras and southern mullet. These species were targeted by

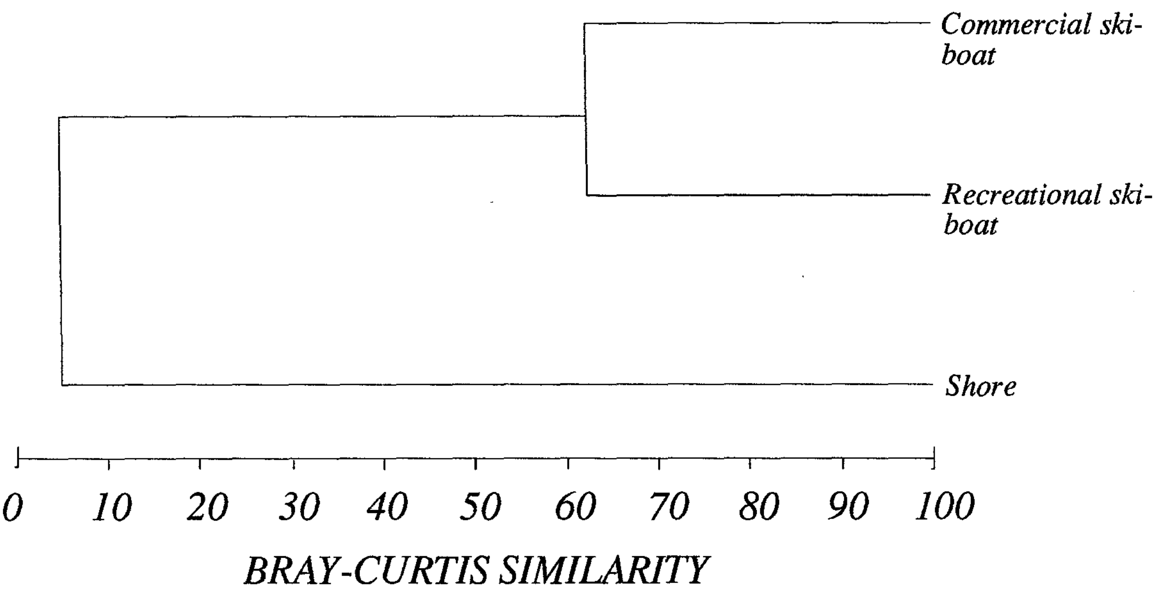


Figure 4.13: Bray-Curtis species similarity index between three user groups in the South African linefishery between Kei Mouth and Stil Bay.

distinct groups of fishers. Shad was targeted by the widest variety of fishers. Firstly, there are shad specialists, who only target this species. They fish in specific areas for shad and usually stop fishing during the closed season. The second group are the generalists, that is people who fish with pilchard in the hope of catching any species of fish. The third group are the subsistence fishers who target any species. However those that have rods and reels target shad when they are abundant as they are easy to catch in large numbers and are larger than strepie. Large dusky kob and white steenbras are targeted by more experienced fishers, with small specimens occasionally being caught by subsistence fishers.

In general, the trends from this study show that, effort in the fisheries has increased slightly, in comparison to historical studies (Clarke and Buxton 1989; Coetzee *et al.* 1989; Hecht and Tilney 1989), but CPUE estimates were lower than these historical records. More importantly, the species composition of the catches has changed and slow growing sparids were less abundant in catches than previously recorded.

CHAPTER 5 - ECONOMICS

INTRODUCTION

Modern fisheries management should include an understanding of how economic and ecological forces, in combination with management decisions, affect the distribution of fishing opportunities over time and space (Cole and Ward 1994). How these forces effect changes in the distribution of fishing effort, and how management decisions affect the welfare of the angling public, can be assessed with socio-economic information. In a critical review of some economic methods for fishery evaluation Edwards (1991) concluded that the best means of assessing a recreational fishery was to determine what the anglers were willing to pay to use the resource. This view was supported by Swanson and McCollum (1991) and Cole and Ward (1994). Such assessments have been undertaken by measuring consumer surplus where the difference between the benefit derived from a good (in this case fishing) and the price paid for that good were calculated. To do this, these studies produced a demand function for fishing. Estimating the demand function for recreational fishing is difficult as a price cannot be given to the benefits of recreation. The price which is used to determine value is imputed from the willingness to pay for fuel and other travel costs (Swanson and McCollum 1991). However, a problem with this method occurs because some anglers may be forced to travel long distances to fish because of poor fishing conditions locally. Furthermore, neither the investment in time nor the existence value of the fishery (by non-fishers) is considered. As with all recreational activities, problems also arise when attempts are made to measure the benefits of recreation to the economy of a region. A fishing trip does not simply involve the purchase of food, drinks, lodgings, fuel and fishing gear. It is an experience which involves relaxation, friendship, enjoyment of the outdoors, challenge and an opportunity to catch and consume fish. There is a planning phase, the trip itself and a recollection phase, each of which is valued by the fisher (Pollock *et al.* 1994).

Biological research is an essential grounding for effective fisheries management (Riechers *et al.* 1991). However, for the characteristics of a fishery to be fully understood, and when resource allocation is a priority for management, social and economic data becomes important. Traditionally, the most frequent use of economic data in fisheries has been to provide a measure of worth (Pollock *et al.* 1994). Fish stock allocation is usually based on a combination of biological and social parameters. For example, fast growing species such as geelbek which were considered to have stocks in a healthy state were allocated to the commercial sector with unlimited bag limits. Other species that were severely depleted such as seventy-four were placed on the critical list, and species such as blacktail, which are caught predominantly by shore fishers, were placed on the recreational list with a bag limit. In order to distribute linefish stocks to all sectors, economic factors should feature as a background for the formulation of a management plan. For example, how would the changing of a regulation affect the commercial fishers and the economy of coastal regions? However, this does not necessarily have to favour the commercial industry as economic factors are also important for the subsistence and recreational sectors.

In contrast to the United States of America where economic analyses have been conducted since the 1950's (Fisher and Grambsch 1991; Pollock *et al.* 1994), few economic analyses have been conducted in South Africa. Although some studies have included economic parameters (Smale and Buxton 1985; Hecht and Tilney 1989), these were not used to assist resource allocation. Independent assessments have been carried out by recreational fishers in an attempt to increase their access to linefish stocks and gain the right to sell their fish using economic studies (Ferreira

1993, Rorke 1996). Fortunately, because of the one sided nature of these assessments they have not been considered seriously. Fisheries economics therefore has two main uses, firstly, to indicate the value of a fishing activity to local, regional or national economies in order to facilitate planning for the provision of appropriate access, infrastructure and support industries. Secondly, in combination with social and community interests, to facilitate determination of appropriate allocation of fish resources among competing user groups.

The economic data for this study was collected during the surveys (see Appendix IIA and IIB for the questionnaires) on all three sectors of the linefishery. A detailed description of the methods is given in Chapter 2.

RESULTS

The occupations of fishers were highly variable, with all forms of profession and trade being reported (Table 5.1). In the shore fishery the majority of anglers fell into the professional and technical occupations. The recreational ski-boat sector had a higher proportion of participants belonging to the skilled/professional employment categories. "Professional" and "technical" people included those needing tertiary education to do their job.

Most commercial ski-boaters fished full-time. Ninety-five percent of the A- licenced commercial ski-boat fishers were employed full-time in the fishery and did not use fishing to supplement other occupations. While 67% of B-licenced commercial fishers considered themselves to be employed full-time in the fishery, 33% had other occupations (Figure 5.1). The commercial ski-boat fishery in the Eastern Cape directly employed an estimated 3184 people.

Considering their annual income, participants in the shore fishery could be placed in income brackets ranging from below the breadline or living in poverty (the bottom two quintile levels of wealth) to wealthy (the top quintile level). However, only a small proportion (4.7%) of fishers in this sector were living in poverty. Not surprisingly, recreational ski-boat anglers were all in the top income brackets. Commercial skippers generally earned a moderate salary after their expenses (Table 5.2). The crew on commercial ski-boats received a low wage and lived on the poverty line.

Table 5.1: The distribution of occupations of recreational anglers interviewed along the Eastern Cape coast, between Kei Mouth and Stil Bay and the national average from McGrath *et al.* (in pres). NEA is Not Economically Active.

Occupation	National Average	Shore	Recreational ski-boat
Retired	12.7	12.6	15.8
Unemployed and NEA	43.5	7.9	0
Professional & technical	5.9	12.1	15.8
Managerial, exec. & admin.	2.7	6.4	20.2
Clerical and sales	6.2	5.9	8.8
Transport eg. truck driver	2.3	1.8	1.8
Services	6.5	15	25.4
Agricultural	2.2	6	2.6
Artisan/apprentice	3.2	0.4	0
Foreman, supervisor & mining	1.3	3.7	3.2
Operations and semi-skilled	4.0	9.8	6.1
Labourers	9.4	7.9	0
Student/scholar		10.3	0

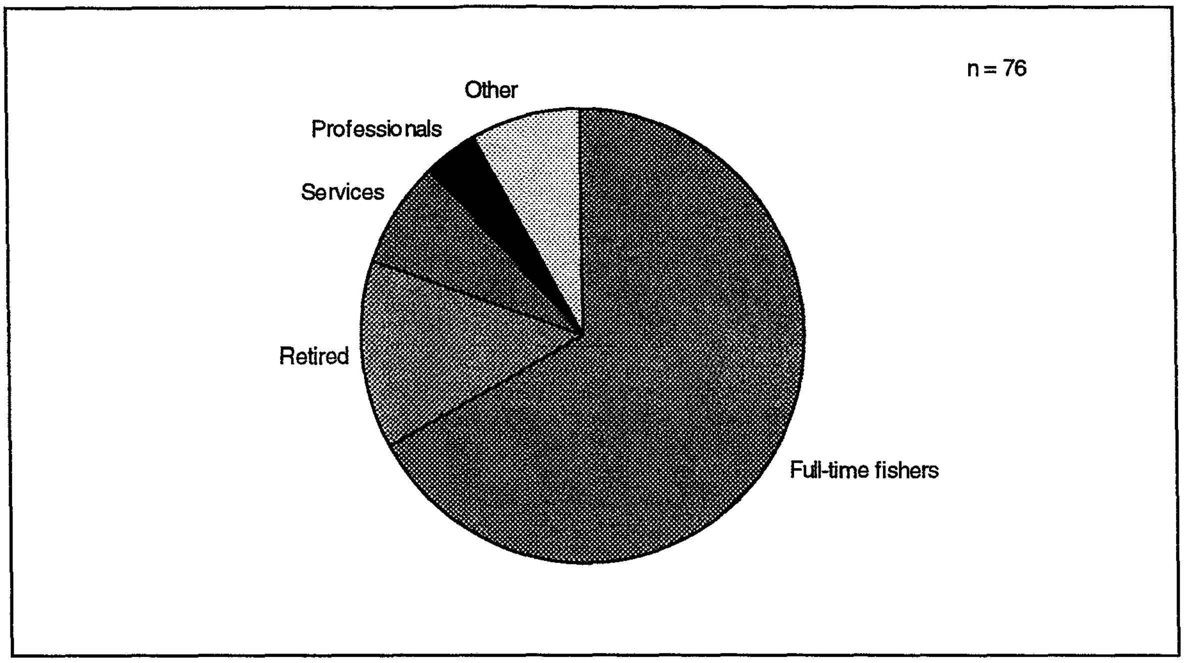


Figure 5.1: B-licenced fisher occupations

Table 5.2: The average earnings of commercial fishers interviewed between Kei Mouth and Stil Bay. These values have accounted for the trip expenses but exclude loan repayments on equipment.

	Skipper	Crew
Average wage per trip	R259.52 (range -R350 to R8 700)	R50.54 (range R1.50 to R620)
Estimated average annual income	R42 986 (range -R14 500 to R1 342 119)	R8 035 (range R239 to R98 580)
Average value of catch per trip	R617.87	

The distribution of fisher expenditure, adjusted to account for avidity bias using methods recommended by Thompson (1991), is summarised in Table 5.3. Overnight shore fishers travelled further to fish and spent more money on daily fishing than did the day-trip shore fishers. Commercial ski-boaters were generally more efficient as they spent less money on daily trips and travelled shorter distances to the fishing area than their recreational counterparts.

Fish prices are generally variable depending on the location and the species. The average wages received by the boat owner and the wholesaler are listed in Table 5.4. These values were used to determine commercial fishers' income.

The shore fishery generated the most money in terms of annual expenditure, and the recreational ski-boat fishery as a whole was the most valuable in the form of capital investment (Table 5.5).

McGrath *et al.* (in pres) produced a demand function for the recreational fishery in South Africa which included the Ln cost of the fishing trip. This value was -0.1691 for the shore fishery and -0.8378 for the recreational ski-boat fishery. These low values demonstrate that the demand for fishing was not price-dependent for the majority of participants. This effectively means that increasing the cost of fishing will not reduce the fishing effort.

Table 5.3: The distribution of average fisher expenditure in the different linefishing sectors along the Eastern Cape between Kei Mouth and Stil Bay.

	Shore		Ski-boat	
	Day trip	Overnight	Recreational	Commercial
Distance travelled (km)	18	53.3	18.6*	16.6*
Cost per day	R19.97	R30.41	R136.73	R122.26
Travel costs	R7.5	R19.28	R262.03	R174.72
Tackle (Rand per month)	R33.28	R59.14	R381.22	R121.04
Rod and Reel (Rand per year)	R193.89	R189.66	R881.97	R908.73
Ski-boat rig	N/A	N/A	R60372.41	R71879.12
Vehicle	R17967.74 (12%)[⊖]	R48427.42 (29%)[⊖]	R50404.76 (45%)[⊖]	R27809.52 (23%)[⊖]

* = distance travelled at sea.
⊖ = value in parentheses is the percentage of fishers who use their vehicle exclusively for fishing or towing their boat.

DISCUSSION

Shore fishers represented the entire spectrum of society, while recreational ski-boat skippers were from the more affluent sectors. These data are similar to the national averages (McGrath *et al.* in pres). No recreational ski-boat owners were unemployed, nor were any employed as labourers or apprentices. This was not surprising considering the high initial cost of purchasing a boat and the high running costs. There were relatively few unemployed fishers in the shore fishery. This was unexpected due to the high unemployment rate (45.3%) in the Eastern Cape (van der Heever 1997), which could be expected to create large numbers of subsistence fishers. This was similar to the findings of McGrath *et al.* (in pres) for the entire South African coastline (excluding the Transkei). The low numbers of subsistence fishers could have been due to obstacles preventing entry into the fishery, such as the high costs associated with the purchase of fishing equipment, or the fact that unemployed people subsisted elsewhere. The first reason was unlikely as a pole and line could be obtained cheaply (R0-R25). However, the perception that these barriers exist could reduce the entry of subsistence fishers, as some people believed that expensive angling equipment was necessary for fishing success. In rural areas, other forms of subsistence such as agriculture were available. Most subsistence fishers were located in cities such as East London, Port Elizabeth and Mossel Bay, while few were found in predominantly rural areas such as at Kei Mouth and along the Ciskei coast. Although the proportion of subsistence fishers was low country-wide, subsistence fishing is the main source of protein for approximately 20 000 poverty-stricken households along the entire South African coastline (McGrath *et al.* in pres) these figures are significant as it could represent as many as 120 000 people or more.

Most A-licenced commercial skippers were employed full-time in the fishery and only 5% had other jobs. On the other hand 33% of B-licenced holders had full-time employment outside of the fishery. Retired people who were supplementing their retirement income made up the bulk of the latter group (Figure 5.1). The remainder were people who generally fish recreationally but use their licence to sell their catch legally. These fishers could be encouraged to sell their licences to people from historically disadvantaged population groups since they are not dependent on fishing for their livelihood and are not using their licence to its full capacity. This, however, would be difficult to implement and it would be expensive to buy back the licences from the current owners, as each case would have to be individually assessed.

Table 5.4: Average 1996 fish prices per kilogram for species caught by commercial ski-boaters and traded by wholesalers in the Eastern Cape between Kei Mouth and Stil Bay, these prices differ from region to region and seasonally, depending on fish abundance.

Species	Boat price	Wholesale price
M. capensis (hake)	R7-8 kg^{-1}	R 18 kg^{-1}
A. inodorus (silver kob)	R10.50 kg^{-1}	R 14kg^{-1}
A. argyrozona (carpenter)	R4 kg^{-1}	R8 kg^{-1}
P. rupestris (red steenbras)	R14-16 kg^{-1}	R 18 + kg^{-1}
P. laniarius (panga)	R4 kg^{-1}	R 8 kg^{-1}
Selected linefish*	R10 kg^{-1}	R15 kg^{-1}
Smalls♣	R4 kg^{-1}	R 6-8 kg^{-1}
Elasmobranchs	R4 kg^{-1}	R 5.50-6 kg^{-1}
S. japonicus (mackerel)	R2 kg^{-1}	R 3 kg^{-1}
Game fish ♦	R 10.50 kg^{-1}	R 14 kg^{-1}

* Mostly reef dwelling sparids such as roman, and dageraad. This category also includes all serranids.

♣ Includes all small "non-linefish" sparids.

♦ Tunas and yellowtail, *Seriola lalandii*

Table 5.5: The expenditure by linefishers in all sectors along the East coast of South Africa from Kei Mouth to Stil Bay, excluding holiday expenses not associated with fishing.

Fishing sector	Annual expenditure	Capital investment
Shore fishery	R18 402 600	R69 655 200
Recreational ski-boat	R8 314 700	R98 004 400
Commercial ski-boat	R5 326 600	R42 973 100

Commercial ski-boat skippers in the Eastern Cape earned a lower annual income than their counterparts elsewhere in South Africa (McGrath *et al.* in pres). This is a consequence of a low catch rate. The commercial ski-boat crew earned only approximately 19% of the skipper's salary. However, it must be noted that the crew have no costs, no capital investment and no financial risk. As with most fisheries, income is erratic. This is due to variability in weather conditions and fish availability, and the fact that both skipper and crew got paid according to their daily catch. The crew on commercial ski-boats are traditionally allowed to take some fish home to sell or to eat. These fish, referred to as "fries", were mostly low value species such as barbel (*Galeichthys* spp.), smalls or "doppies", which consisted primarily of small panga or blue hottentot (*Pachymetopon aeneum*), and other small species, such as fransmadam and steentjie, which were otherwise used as bait. Most of the barbel were sold for R0.5-R2 each. During peak holidays, some of the fishers sold their sparid catch directly to tourists for ±R5-R10 per fish. This sale of fish supplemented their income by approximately R1690 per annum. The annual income of crew on commercial ski-boats (R8035) is almost double that of the average per capita income of the general population in the Eastern Cape (R4 151) and only slightly lower than the national average (R8 704) (van der Heever 1997).

Overnight/holiday anglers spent more money per trip, but spent fewer days per year (25) than day trippers/local fishers (62). Day trippers spent more money on an annual basis in the local economy than the overnight anglers. Shore fishers and recreational ski-boaters spent an average of R2289 and R6275 per annum respectively on holiday accommodation and locally bought commodities. These values were probably underestimated as Pollock *et al.* (1994) noted that holiday anglers often incur unanticipated expenses that would not be included in these estimates. However, it would be naive to assign this entire value to the fish resource, a view supported by Peterson and Cordell (1991) and Ozuna and Stoll (1991), as 76% of these trips were made in the company of people who were not fishing, but were attracted to the coast for other reasons, such as relaxation and enjoyment of the environment.

Recreational anglers fish for leisure. If they stopped fishing, the money previously spent on fishing would be spent on another recreational activity. If, on the other hand, commercial fishers stopped fishing they would become economically inactive. This argument contradicts the view of recreational ski-boat fishers who demand equal access to fish stocks as commercial fishers have. Recreational ski-boaters usually down-play the value of the commercial sector. This demonstrates the value of independent economic assessments as the data shows that there would be no economic benefit to the region if access to the recreational fisheries was increased.

The low demand function values demonstrated the inelastic nature of the demand for recreational fishing. This means that the willingness to fish is not price related. According to this model, if the cost of recreational fishing increased by 100%, the demand for fishing would decrease by only 16%. As the demand for fishing was not strongly linked to the cost of fishing, a fishing licence would be an ineffective tool for controlling effort. A fishing licence would, however, be an effective means of raising revenue to fund fisheries research, management and control. These findings correlate well with those in Chapter 3 where a high proportion of fishers (54% of shore fishers) were willing to pay for an angling licence. The inelastic nature of the demand for fishing also revealed that changes in the catch rate of the recreational fishery would not affect effort, i.e. if catches declined substantially recreational fishing effort would not decrease on a proportional basis.

Economic losses to coastal areas associated with fishery control, environmental change and change in catch can be determined by calculating expenditure in a fishery (Riechers *et al.* 1991). Total economic value can be used to predict how changes in catch would affect the income of commercial fishers and their crew. Catches in Port Alfred were down by 71 $kg.person^{-1}.month^{-1}$ in 1996. This can be equated to a potential loss in earnings of R2359 per annum for the skipper and R194 per annum for each crew member. These figures suggest a loss of R193 971 per annum to Port Alfred. To compound this problem, the species composition is changing and less valuable species such as panga are becoming more important in the catch, reducing revenue further. These losses are noteworthy, as many if not most, fisheries are faced with serious ecological, economic and social problems (Charles 1995). If catches could be improved, fishers' revenue would increase. This highlights the need for effective management from an economic perspective and supports a policy of sustainable utilisation. With better economic management, better marketing and improved fish quality, fishers could receive higher prices per kilogram, elevating their income.

Due to the erratic nature of fisheries, management is complicated (Catanzano and Mesnil 1995). For example, under certain circumstances, fishers will ignore fishery regulations in order to increase their catch. Commercial fishers were willing to risk being caught by inspectors when the opportunity of substantial catches arose. This was evident in February 1996 at Kei Mouth, where oceanographic conditions permitted commercial ski-boat operators to fish on deep reefs and catch red steenbras and seventy-four. The creel census revealed that all of the commercial fishers went over their bag limits as the catch was valuable and the risk of inspection was low. All of the fishers however, stated that such situations seldom arose, and that they were willing to take the risk of a fine in order to offset losses accumulated during bad fishing days. Such behaviour reduces the effectiveness of fishery regulations that are designed to stop excessive catch. This problem can be overcome by increasing the inspection rate and penalties for guilty fishers, so that the risk of being caught outweighs their willingness to retain more fish than the bag limit allows.

It is possible to monitor the economic effects of policy changes on the income of commercial fishers (Propst and Gravrilia 1987). The current body of evidence suggests that the present linefish management plan is ineffective and that an updated plan is needed. It is possible, using the data collected during this study and those data collected along the West Coast, Western Cape and KwaZulu-Natal, to determine what effect possible changes to the linefish management plan would have on the income of fishers. For example, if seventy-four, a species listed as critical, was de-commercialised it would result in an average loss of earnings of R860 per fisher per annum or a 1.9% reduction in annual income. However, this would only affect the commercial fishers in the Kei Mouth region. Thus, the economic losses to the region as a whole would be minimal. Unfortunately, the economic losses to the individual fishers in Kei Mouth would be 14% of their annual income. The affected fishers would most likely re-direct their effort towards other species, to minimize their economic losses. The seventy-four fishery is in a critical state (van der Elst and de Freitas 1988; Garratt 1993; Pilfold and Pampallis 1993) that de-commercialisation or closure of the fishery should be seriously considered.

When considering potential changes to fishery regulations, Smith (1995) noted that financial losses were one of the major concerns of commercial fishers. The economic data from this study can be used by management to assess changes in size limits. Changing the size limits of some species would affect the income of commercial fishers. For example, Smale (1988) noted that the current minimum size limit of red steenbras is too small, as the size at 50% maturity is 630mm. If the current size limit was to be increased from 400mm to 600mm it would effectively exclude 24% of the current catch. This would result in a loss of earnings totalling R73 934 (±5 tonnes) for the commercial fishery in the Eastern Cape.

This chapter has illustrated the economic value of the Eastern Cape linefishery (capital investment exceeds R210 million and operational costs exceed R32 million), its importance for providing employment in the commercial sector (3184 fishers), and the possible effects of some changes in linefish regulations. The chapter demonstrates the need for regular surveys to determine the economic ramifications to fishing communities when changes in catch are experienced and regulation changes are introduced.

CHAPTER 6 - GENERAL DISCUSSION AND MANAGEMENT CONSIDERATIONS

The South African linefishery has been characterised by substantial growth in fishing effort since the turn of the century. This growth has had a significant negative impact on the fishery in several ways. These include a change in species composition of catches, significant decreases in CPUE and a decrease in the mean size of the species caught (Hecht and Tilney 1988; Bennett 1991; Buxton 1993; Garratt 1993). The trends observed during this study were similar to the above historical tendencies: declining CPUE and changes in species composition, with valuable slow growing species being replaced by less valuable species.

The South African linefishery is a truly multiuser and multispecies fishery. The users include recreational, commercial and subsistence fishers and the species consist of fishes exhibiting a wide variety of biological characteristics, from slow to fast growth (Griffiths 1988; Buxton and Clarke 1989), resident to migratory (Buxton and Allen 1989), and gonochorist to sex changing (Nepgen 1977; Buxton 1992). The multispecies, multiuser nature of the fishery complicates management and has resulted in a wide ranging set of regulations (Buxton 1992). These include minimum size limits, bag limitations, closed seasons and marine reserves. The regulations are enforced by the Sea Fisheries inspectorate in the Eastern, Western and Northern Cape coastal provinces and by the Natal Parks Board in KwaZulu-Natal. This study has shown that the fishers generally agree with the current regulations, but they do not always obey them. The consistent decline in CPUE since the turn of the century (Bennett 1993; Garratt 1993) suggests that the current management plan, which was implemented in 1984, is not having the desired effect of sustaining the fishery. The reasons for this are difficult to pinpoint, but include lack of support from fishers, the assumption that barotrauma species survive release, incorrect setting of size (Smale 1988) and bag limits (Attwood and Bennett 1995a) and, in some instances, the implementation of corrective action only after the fishery for a specific species has collapsed. While the inspectorate is competent, it is clear from this study that the rate of inspection is inadequate. For example, in KwaZulu-Natal approximately 11% of all shore fishing trips were inspected while in the Eastern Cape only about 1% of all trips were inspected (Brouwer *et al.* in pres). This is clearly a function of the number of inspectors, as there is approximately one inspector for every 4.2 km in KwaZulu-Natal while there is only one inspector for every 43 km in the Eastern Cape. Management is also complicated as very little modelling of how specific regulations affect the fishery in the long term has been conducted. The study by Attwood and Bennett (1995a) demonstrates the value of this type of modelling.

This study has demonstrated that the Eastern Cape linefishery is an economically valuable resource. Minimum capital investment for all sectors is in the region of R210 million and more than R32 million is spent annually on linefishing in the Eastern Cape. To achieve maximum economic benefit in the long term, it is of primary importance that the fishery be managed with sustainable utilisation as the primary long term goal.

Fishers in all sectors were of the opinion that the linefishery had declined, and blamed this on trawlers, pollution and the sector perceived to be their direct competitors. Many of these reasons were unfounded as there was little overlap in the catch composition between the shore fishery and offshore sectors. The catch composition within the two ski-boat sectors were similar and this resulted in conflict between them. The likely reason for the overall decline in the fishery is probably a synergistic combination of increased fishing effort and the biological characteristics of many of the species, such as slow growth and residency. This is supported by the fact that there have been no signs of declines in marine protected areas where fishing is prohibited (Buxton 1993; Attwood and Bennett 1995b).

Management regulations must be easy for the users to understand and should accommodate all sectors of the fishery, and at the same time offer adequate protection to the fish. This is not easy in a multispecies fishery, as the different life-history styles of the fish ideally require a suite of specific regulations tailored to suit their biology. To reduce complications species have been lumped into groups of related species. This has resulted in ineffective protection for some species. Fortunately, the linefish regulations are dynamic and can (and indeed are) changed as new biological data and stock assessment comes to light. However, changes in the regulations result in angler confusion. To overcome this problem it is strongly recommended that education should become a major part of the linefish management plan, and should include an easy to follow set of regulations that is available to all participants. Currently, the only attempt at education is a small pamphlet issued by Sea Fisheries ("Marine conservation Do's and Don'ts") comprising a simple list of regulations. This document is only available in English and Afrikaans but most of the people in the Eastern Cape are Xhosa speaking. According to Shindler (1994) only 33.4% of the African population in the Eastern Cape were literate. This creates a problem as illiterate and partially literate people would not be able to understand the "Marine conservation Do's and Don'ts". A better option would be to have pamphlets that can be understood by illiterate people. All that is required is a picture of the species caught in that fishery, with a size bar below each representing the size limit, and a number next to the fish to indicate the bag limit. These pictures could be erected on sign-boards at popular shore fishing sites and slipways. According to Matlock (1991), the best hope for achieving compliance is to educate fishers about the purpose of and the basis for the regulations. What is needed in this regard is a dedicated public relations department in Sea Fisheries that has the sole purpose of informing the public about the regulations and the reasons behind them.

For any fishery regulation to serve the purpose of sustainable management they should be understood and adhered to by the participants. The data presented in Chapter 3 highlights two relevant points. Firstly, fishery regulations that have been in place for a number of years are acceptable to fishers. Govender (1996) noted that the first restrictions on *P. saltatrix* (size limits, bag limits and closed seasons) sparked much debate and were extremely unpopular when implemented in the late 1970's. However, they are now acceptable to the majority of fishers. Secondly, although the current regulations were accepted by fishers, they were not well known, nor was the motivation behind their implementation understood. These problems must be overcome in order to implement any new regulations effectively.

Declining CPUE trends suggest that alternative management measures are desperately needed. Brousseau and Armstrong (1987) noted that a slot limit was an appropriate management tool for walleye (*Stizostedion vitreum*) in the United States of America. Maximum size and slot limits would, however, be unpopular in both the commercial and recreational fisheries. The commercial fishers prefer large fish as they get paid per kilogram, and many recreational fishers are trophy fishers who target the bigger fish. In addition, barotrauma would still be a problem in the ski-boat fishery. Therefore, maximum size and slot limits are not a viable management option for the offshore South African linefishery, and marine protected areas are probably a more viable method of fish protection. Brousseau and Armstrong (1987) noted that maximum size limits have not been widely used due to social rather than biological reasons, and that they are best instituted in new fisheries before fishers have a chance to fish under conventional regulations. Therefore, slot limits could be used to control catch in new fisheries such as those developing for live-caught aquarium fish (for example the doublesash butterflyfish *Chaetodon marleyi*).

All management options rely on the agencies responsible for enforcement to control catch. If enforcement is ineffective, then compliance is low and regulations become ineffective. Licencing would help enforcement by increasing funding and by reducing the risk of people concealing their identity when caught breaking the law. It is recommended that an annual licence fee of R20 for the shore fishery and R50 for the recreational ski-boat fishery should be implemented.

To successfully implement a change in the regulations, long term monitoring of the fishery is essential to assess the effectiveness of the new regulation and to gauge fishers' opinions of that regulation. The Sea Fisheries Research Institute currently only monitors catch and effort in the commercial fishery, but the accuracy of data provided needs to be constantly checked. On site validation of reported catches should be used to assist in correcting this bias. Access point surveys were effective for monitoring these fisheries and for the collection of concomitant fisher information. Such surveys should be conducted on a regular basis, similar to surveys conducted in the United States of America where creel surveys are conducted on a five yearly basis (Grambsch and Fisher 1991). Data collected in this manner is superior to fishery-dependent data (Hilborn 1992). Fishery-dependent data should be checked and modified by verifying them with independent fishery survey data. As Hilborn (1992) noted, the fisheries crisis in eastern Canada was induced by the reliance on commercial CPUE data which showed stock increases while survey data (now thought to be correct) showed much slower stock growth.

The data demonstrated that effort in the recreational fishery will not be significantly reduced by declining catches. In contrast, the commercial fishers would theoretically stop fishing, since they are driven by economic forces. However, if a situation arises where a fishery is no longer viable from an economic perspective, then the CPUE is probably so low that the fishery is in serious need of rehabilitation. As a result, reliance on economic forces alone to limit fishing effort is unacceptable and oversimplified.

Marine reserves were one of the most widely accepted management measures and were seldom violated. This sentiment was echoed by Robinson (1989) who stated that "...it would appear that reserves are becoming a more popular protection measure than many other forms of control." Marine reserves have a number of advantages over the other regulations. They are effective for protecting species that suffer from barotrauma, they are relatively easy to control, they protect all the species in that area, they are a good means of protecting the parent stock of a species and they follow the IUCN principals of ecosystem protection (Buxton 1987). According to Attwood and Bennett (1995b), marine reserves are likely to be the only means by which yield can be substantially increased in the future. The establishment of a marine reserve could also have economic benefits for an area as they will attract tourists and create non-consumptive recreation in the area. Buxton (1987) and Hecht and Buxton (1993) noted the importance of the protective nature of the Transkei waters as there was little fishing effort in that area. However, the subsidence of political violence in that area will lead to an increase in tourism and the fishery is expected to expand (Fielding *et al.* 1994). A well defined marine protected area in this area that extends to the edge of the continental shelf in the Transkei is important for the South Africa linefishery as it would create protection for many species including three on the critical list, namely red steenbras, seventy-four and poenskop. A study should be conducted in the Transkei to determine the impacts of creating a marine reserve, and where along the coast a marine reserve would be most effective for fisheries protection.

To conclude, the results presented in this thesis demonstrated the usefulness of fisher contact surveys for assessing the South African linefishery. It is now recognised that there is no single appropriate objective for any fishery, and biological, social, economic and political concerns need to be considered in every circumstance (Hilborn 1992). Size limits and bag limits for the various species should be reconsidered in order to ensure their effectiveness. Species that have shown substantial declines in catch should be de-commercialised or in extreme cases have a total ban placed on their catch, as this measure will greatly reduce the total catch and would have minimal economic impacts on the fishery. A recreational fishing licence should be implemented and the funds used to increase the national research, management and control effort on this very valuable fishery. A dynamic and aggressive fisher education programme should also be initiated. Regular (five yearly) national surveys should be conducted covering all sectors of the linefishery. This would improve the quality of the NMLS database and would provide the information upon which to assess the effectiveness of the regulations.

APPENDIX I

Almost all fish species in South Africa are subject to some form of catch restriction. The fishery is divided into recreational and commercial sectors, the restrictions differ according to the type of licence held by the person catching the fish and by the category that the fish holds. All species are classed according to their abundance. These classes are critical, restricted, exploitable, recreational and bait species. The limits pertaining to these particular species classes (as specified by the Sea Fisheries act No. 12 of 1988) are shown below, including the 1992 amendments to the act (Government Gazette No. 14353 of 1992).

Closed seasons have been imposed on shad, red steenbras and seventy-four from 1 September to 30 November and on Galjoen between 15 October and 28 February. No recreational angler may sell or offer any fish for sale and no fish on the recreational list may be sold or offered for sale.

Critical list: Recreational fishers and B-licenced commercial fishers are allowed to catch 2 of the fish listed below per person per day. A - licenced commercial fishers are allowed 2 fish per person per day except for red steenbras of which 5 fish per person per day is allowed.

Brindle bass*	*Epinephelus lanceolatus*
Potato bass*	*Epinephelus tukula*
Great white shark*	*Carcharodon carcharias*
Natal Wrasse*	*Anchichoerops natalensis*
Poenskop	*Cymatoceps nasutus*
Seventy-four	*Polysteganus undulosus*
Red steenbras	*Petrus rupestris*

* indicates that no fish of that species is allowed to be caught by any angler.

Restricted list: Recreational fishers and B-licenced commercial fishers are allowed to catch 5 fish per person per day in total A-licenced commercial fishers have unlimited catch except for shad in Natal where 5 per day are permitted.

Bludger	*Carangoides gymnostethus*
Blue Hottentot	*Pachymetopon aeneum*
Dageraad	*Chrysoblephus cristiceps*
Dane	*Procostoma dentata*
Elf/Shad	*Pomatomus saltatrix*
Englishman	*Chrysoblephus anglicus*
Red Stumpnose	*Chrysoblephus gibbiceps*
Rock cods#	Serranidae
Roman	*Chrysoblephus laticeps*
Scotsman	*Polysteganus praeorbitalis*
Slinger	*Chrysoblephus puniceus*
West coast steenbras	*Lithognathus aureti*
Zebra	*Diplodus cervinus hottentotus*

= the regulations apply to all species belonging to that group.

Exploitable list: Recreational fishers are allowed to catch 10 fish per person per day. A- and B-licenced commercial fishers have unlimited access to these species. This list includes all other species not listed by the regulations.

Blueskin	*Polysteganus coruleopunctatus*
Cape gurnard	*Cheliodonichthys capensis*
Carpenter	*Argyrozona argyrozona*
Dorado	*Coryphaena hippurus*
Elasmobranchs # (excluding the great white shark)	Elasmobranchii
Geelbek	*Atractoscion aequidens*
Hake	*Merluccius capensis* and *M. paradoxus*
Hottentot	*Pachymetopon blochii*
Juvenile grunter	*Pomadasys kaakan*
King mackerel	*Scomberomorus commerson*
Kob	*Argyrosomus* spp.
Panga	*Pterogymnus laniarius*
Queen mackerel	*Scomberomorus plurilineatus*
Red tjor-tjor	*Pagellus bellottii natalensis*
Santer	*Cheimerius nufar*
Snapper kob	*Otolithes ruber*
Snoek	*Thyrsites atun*
Suqaretail kob	*Argyrosomus thorpei*
Tunas #	*Thunnus* spp.
White stumpnose	*Rhabdosargus globiceps*
Yellowtail	*Seriola lalandi*

= the regulations apply to all species belonging to that group.

Recreational list: Fishers in all sectors are allowed to catch 10 fish in this group per person per day but only 5 of the same species.

Bardman	*Umbrinia canariensis* and *U. rhonchus*
Banded galjoen	*Dichistius multifasciatus*
Billfishes #	
Blacktail	*Diplodus sargus capensis*
Bronze bream	*Pachymetopon grande*
Cape knifejaw	*Oplegnathus conwayi*
Cape stumpnose	*Rhabdosargus holubi*
Galjoen	*Dichistius capensis*
Garrick	*Lichia amia*
Janbruin	*Gymnocrotaphus curvidens*
Kingfishes # (Excluding Bludger and Horse Mackerel)	Carangidae
Large-spot pompano	*Trichinotus botla*
Musselcracker	*Sparodon durbanensis*
Natal knifejaw	*Oplegnathus robinsoni*
Natal stumpnose	*Rhabdosragus sarba*
River Bream	*Acanthopagrus berda*
River snapper	*Lutjanus argentimaculatus*
Southern pompano	*Trachinotus africanus*
Springer	*Elops machnata*
Spotted grunter	*Pomadasys commersonni*
Stonebream	*Neoscorpis lithophilus*
Swordfish	*Xiphias gladius*
White steenbras	*Lithognathus lithognathus*

= the regulations apply to all species belonging to that group.

Bait list: All groups of fishers are allowed to catch an unlimited number of fish.

Anchovies #	Engraulidae
Fransmadam	*Boopsoidea inornata*
Garfishes #	Bleonidae
Glassies #	Ambassidae
Half beaks #	Hemiramphidae
Horse mackerel	*Trachurus trachurus capensis*
Chub mackerel	*Scomber japonicus*
Mullets #	Mugilidae
Pinky	*Pomadasys olivaceum*
Sardines #	Clupeidae
Steentjie	*Spondyliosoma emarginatum*
Streepie	*Sarpa salpa*
Cutlassfish	*Trichiurus lepturus*
Wolfherring	*Chirocentrus dorab*

= the regulations apply to all species belonging to that group.

Size restrictions: No fish of the following species are allowed to be retained below the specified size in total length. These restrictions apply to all classes of fishers.

Size limit (cm)	Species
15:	Streepie - *Sarpa salpa*
20:	Cape stumpnose - *Rhabdosargus holubi*
	Blacktail - *Diplodus sargus capensis*
22:	Hottentot - *Pachymetopon blochii*
25:	Natal stumpnose - *Rhabdosargus thorpii*
30:	River bream - *Acanthopagrus berda*
	Silverfish - *Argyrozona argyrozona*
	Slinger - *Chrysoblephus puniceus*
	White stumpnose - *Rhabdosargus globiceps*
35:	Galjoen - *Dichistius capensis*
40:	Catface rockcod - *Epinephelus andersoni*
	Kob - *Argyrosomus* spp.
	Red steenbras - *Petrus rupestris*
	Seventy-four - *Polysteganus undulosus*
	Spotted grunter - *Pomadasys commersonni*
	Squairtail kob - *Argyrosomus thorpei*
	West coast steenbras - *Lithognathus aureti*
	Yellowbelly rockcod - *Epinephelus marginatus*
50:	Poenskop - *Cymatoceps nasutus*
60:	Geelbek - *Atractoscion aequidens*
	Musselcracker - *Sparodon durbanensis*
	Snoek - *Tyhrystes atum*
	White steenbras - *Lithognathus lithognathus*
70:	Garrick - *Lichia amia*

APPENDIX IIA

SHORE ANGLING QUESTIONNAIRE

SECTION A: **CATCH AND EFFORT DATA**

Questionnaire number:_______________

Locality:_______________ Date:_____________ Time:_____________ Number of rods:_____________ Beach vehicle:_______

Bait: Pilchard_____________ Squid_____________ Prawn_____________ Red bait_____________ Other_______________

What time did you start fishing?____________________

What are the three main species you try to catch?____

SECTION B: **ANGLER INFORMATION**

Angler age:____________ Sex:________ Code:__________ Club affiliation:_______________________________

How many days have you been fishing in the last week,_________ month________, year_________

Do you fish at night?_________________ If YES, how often in the last 12 months?_____________________

How many years have you been fishing for?_____________

Which stretch of coast do you normally fish?____

SECTION C: **ECONOMIC INFORMATION**

What is your occupation (writ e in detail):____

Where do you live (postal code)?____

Are you on an ovemight, weekend or longer trip/holiday? YES / NO

> If YES, where are you staying (Postal code)?____
>
> What method of transport did you yes to come on this trip?_______________________________________
>
> How many people came with you? _____________ How many of them will fish?_______________________
>
> How many days will you spend away from home on this trip?____________ How many days will you fish?____________
>
> What is the estimated cost of your trip (for all members, excluding your transport costs)?_____________

How far did you come fishing today (kilometres one way)?____

What method of transport did you use (describe vehicle type, model etc.)?____________________________

If **NOT OWN** vehicle what were your transport costs?____

If **OWN** vehicle how many people came with you? _________________ How many of them will fish?______________

How much did you spend this outing on: Bait?______________ Refreshments?____________ Other?__________________

How much have you spent on tackle in the last month? ____

How much have you spent on rods and reels in the last 12 months? ____________________________________

What is the estimated value of all your shore angling equipment (ie what would they sell for)?

Beach vehicle?_____________________ Rods?______________________________ Reels?__________________

Tackle?________________________

Is your beach vehicle used exclusively for fishing?____

Why do you fish? Food__________Recreation______________Competition__________Livelihood__________Other (specify)_________

SECTION D: **ANGLER ATTITUDES**

Which of the following regulations, in your opinion, are effective ways of managing our fish stocks?

Minimum size limits?________________ Bag limits?____________ Closed seasons______________ Marine reserves?_________________

Do you obey these regulations? (Ask each regulation specifically eg. Have you ever kept an undersized fish?)

Minimum size limits?________________ Bag limits?____________ Closed seasons______________ Marine reserves?_________________

Have you ever sold your catch?____

There are other possibly ways to manage a fishery, would you support a:

Limited access system?___________ Maximum size limit?__________ Licensing system?______________ if YES, how much?________

Has the fishing deteriorated over the years? YES \ NO If YES, What has cased this decline?

Pollution_________Gill netting_________ Trawling_________Commercial linefishing________ Ski-boats (recreational)_________________

Shore angling____________ Other (specify)____

Do you do any other type of angling (specify)?______________________________ Is angling you major sport?___________________

Have you ever tagged a fish? __________________ Have you ever caught a tagged fish before?____________________________

What did you do with the tag?____

Test questions:

Species			
Minimum size			
Bag limit			
Closed season			

When was the last time your catch was inspected by a fisheries officer?________________________________

Remarks:

APPENDIX IIB

SKI-BOAT FISHING QUESTIONNAIRE

SECTION A: **CATCH AND EFFORT DATA**

Questionnaire number:______ Boat registration number:______ Locality:______ Date:______ Time:______

What time did you start fishing?______ What time did you stop fishing?______

What are the three main species you try to catch?______

Deckboat	1	Commercial	A
Ski-boat	2	Semicommercial	B
Inflatable	3	Charter	C
FRESHWATER/ Est	4	Recreational	D

Equipment	Y/N	Bait Type	Y/N
Beach Vehicle		Pilchard	
Rods		Squid/octo	
Handline		Prawn	
Other		Other	

Number of rods [ ] Crew Size [ ] Crew composition

	1	2	3	4
M				
F				

SECTION B: **ANGLER INFORMATION**

Skipper age: ______ Sex:______ Code:______ Club affiliation:______

How many days have you been fishing in the last week,______ month______, year______

Do you fish at night?______ If YES, how often in the last 12 months?______

How many years have you been ski-boat fishing for?______

Which stretch of coast do you normally fish?______

SECTION C: **ECONOMIC INFORMATION**

What is your occupation (write in detail):______

Where do you live (postal code)?______

Are you on an overnight, weekend or longer trip/holiday? YES / NO

> If YES, where are you staying (Postal code)?______
>
> What method of transport did you yes to come on this trip?______
>
> How many people came with you? ______ How many of them will fish?______
>
> How many days will you spend away from home on this trip?______ How many days will you fish?______
>
> What is the estimated cost of your trip (for all members, excluding your transport costs)?______

How far did you come fishing today (kilometres one way)?______

What method of transport did you use (describe vehicle type, model etc.)?______

If **NOT OWN** vehicle what were your transport costs?______

If **OWN** vehicle how many people came with you? ______ How many of them will fish?______

How much did you spend this outing on: Boat Fuel?:______ Bait?______ Refreshments?______ Other?______

How much have you spent on tackle in the last month? ______

How much have you spent on rods and reels in the last 12 months? ______

What is the estimated value of all your ski-boat angling equipment (ie what would they sell for)?

Tow vehicle?______ Boat(plus accessories)?______ Motors?______ Trailer?______

Rods?______ Reels?______

Tackle?______

Is your vehicle used exclusively for Towing your boat?______

Why do you fish? Food______Recreation______Competition______Livelihood______Other (specify)______

How many crew do you employ?______ How much do you pay them per person per day?______

Do you ever take charters? YES / NO. If YES, how many times in the last 12 months?______

On average how many people do you take?______ How much do you charge per person?______

SECTION D: **ANGLER ATTITUDES**

Which of the following regulations, in your opinion, are effective ways of managing our fish stocks?

Minimum size limits?______ Bag limits?______ Closed seasons______ Marine reserves?______

Do you obey these regulations? (Ask each regulation specifically eg. Have you ever kept an undersized fish?)

Minimum size limits?______ Bag limits?______ Closed seasons______ Marine reserves?______

Have you ever sold your catch?______

There are other possibly ways to manage a fishery, would you support a:

Limited access system?______ Maximum size limit?______ Licensing system?______ if YES, how much?______

Has the fishing deteriorated over the years? YES \ NO If YES, What has cased this decline?

Pollution______Gill netting______ Trawling______Commercial linefishing______ Ski-boats (recreational)______

Shore angling______ Other (specify)______

Do you do any other type of angling (specify)?______ Is angling you major sport?______

Have you ever tagged a fish? ______ Have you ever caught a tagged fish before?______

What did you do with the tag?______

Test questions:

Species			
Minimum size			
Bag limit			
Closed season			

When was the last time your catch was inspected by a fisheries officer?______

Remarks:

APPENDIX IIIA

Species in the catches of shore fishers sampled between Kei Mouth and Stil Bay 1994-1996. Species listed alphabetically by family, CPUE in kg or number of fish .person^{-1}.day^{-1}.

Species	Total (kg)	Total (#)	CPUE (kg)±SD	CPUE (#) ±SD
CHONDRICHTHYES				
Callorhinchidae				
Callorhinchus capensis	3.7	1	0.0008±0.046	0.0002±0.012
Carcharhinidae				
Carcharhinus brachyurus	71.5	6	0.033±1.15	0.002±0.07
Carcharhinus brevipinna	5.7	1	0.002±0.14	0.0004±0.02
Carcharhinus obscurus	62.1	6	0.13±52	0.017±0.07
Carcharhinus spp.	24	2	0.006±0.23	0.0005±0.019
Dasyatidae				
Dasyatis marmorata	r			
Gymnura natalensis	5	1	0.002±0.12	0.0004±0.023
Myliobatidae				
Myliobatus aquila	r			
Odontaspididae				
Carcharias taurus	r			
Rajidae				
Raja alba	19	1	0.008±0.37	0.0006±0.034
Rhinobatidae				
Rhinobatos annulatus	25.56	11	0.018±0.51	0.007±0.21
Scyliorhinidae				
Haploblepharus fuscus	2.6	3	0.001±0.06	0.0016±0.07
Poroderma africanum	r			
Poroderma pantherium	2	2	0.0015±0.09	0.002±0.09
Sphyrnidae				
Sphyrna zygaena	6.25	1	0.003±0.18	0.0005±0.03
Squalidae				
Squalus megalops	4	5	0.0017±0.07	0.002±0.08
Triakidae				
Mustelus mustelus	35.1	3	0.03±1.1	0.002±0.09
Triakis megalopterus	r			
OSTEICHTHYES				
Ariidae				
Galeichthys ater	1.5	1	0.0007±0.03	0.0008±0.05
Galeichthys feliceps	2.85	8	0.011±0.6	0.04±2.07
Galeichthys spp.	0.5	1	0.0001±0.008	0.0003±0.016
Carangidae				
Lichia amia	56.64	12	0.03±0.59	0.006±0.11

Pseudocaranx dentex	1.8	4	0.0007±0.027	0.001±0.04
Seriola lalandi	12.89	2	0.0018±0.88	0.002±0.1
Trachinotus africanus	0.56	4	0.0006±0.03	0.003±0.14
Cheliodactylidae				
Chirodactylus brachydactylus	0.3	3	0.0004±0.018	0.004±0.18
Clinidae				
Clinus superciliosus	r*			
Coracinidae				
Dichistius capensis	23.29	23	0.01±0.18	0.009±0.17
Dichistius multifasciatus	2.23	4	0.001±0.05	0.002±0.08
Dinopercidae				
Dinoperca petersi	0.34	1	0.0005±0.03	0.001±0.09
Elopidae				
Elops machnata	1.2	1	0.0005±0.03	0.0005±0.03
Gobiesocidae				
Chorisochismus dentex	r			
Haemulidae				
Pomadasys commersonni	16.24	14	0.009±0.18	0.009±0.185
Pomadasys olivaceum	10.45	265	0.008±0.1	0.23±2.67
Pomadasys striatum	0.1	2	6.7×10^{-5}±0.003	0.001±0.08
Mugilidae				
Liza spp.	4.97	21	0.003±0.09	0.013±0.36
Liza dumerilii	1.6	6	0.0003±0.01	0.0014±0.07
Liza richardsonii	24.24	119	0.014±0.31	0.08±1.93
Liza tricuspidens	10.95	26	0.005±0.13	0.012±0.3
Mugil cephalus	0.51	3	0.0002±0.009	0.0009±0.05
Plotocidae				
Plotosus nkunga	6.97	8	0.01±0.4	0.002±0.055
Pomatomidae				
Pomatomus saltatrix	340.79	448	0.304±2.7	0.42±3.78
Sciaenidae				
Argyrosomus japonicus	139.45	59	0.086±1.74	0.04±0.58
Umbrina ronchus	11.06	5	0.01±0.3	0.006±0.15
Scombridae				
Scomber japonicus	2.15	5	0.0006±0.036	0.0014±0.08
Scorpididae				
Neoscorpis lithophilus	27.55	33	0.017±0.41	0.019±0.4
Serranidae				
Acanthistius sebastoides	0.82	2	0.0003±0.016	0.001±0.04
Epenephelus marginatus	0.78	2	0.0004±0.19	0.0009±0.52

Sparidae				
Boopsoidea inornata	1.57	13	0.001±0.03	0.008±0.23
Cheimerius nufar	3.99	15	0.002±0.05	0.008±0.22
Chrysoblephus laticeps	3.65	4	0.003±0.13	0.005±0.23
Cymatoceps nasutus	4.09	3	0.001±0.06	0.0012±0.04
Dipolodus cervinus hottentotus	11.25	15	0.03±1.19	0.028±1.08
Diplodus sargus capensis	63.31	161	0.06±0.64	0.155±1.34
Gymnocrotaphus curvidens	0.55	1	0.0003±0.02	0.0006±0.03
Lithognathus lithognathus	39.3	29	0.045±0.75	0.03±0.52
Lithoganthus mormyrus	4.49	53	0.004±0.09	0.05±1.0
Pachymetopon aeneum	0.91	1	0.0003±0.02	0.0004±0.024
Pachymetopon grande	108.57	82	0.076±0.84	0.057±0.63
Pagellus bellottii natalensis	1.96	11	0.003±0.1	0.016±0.58
Pterogymnus laniarius	1.06	2	0.0001±0.007	0.0002±0.01
Rhabdosargus globiceps	1.65	16	0.003±0.013	0.03±1.08
Rhabdosargus holubi	11.05	70	0.014±0.03	0.08±1.03
Sarpa salpa	56.09	490	0.067±0.84	0.58±7.3
Sparodon durbanensis	64.91	16	0.06±1.6	0.019±0.56
Spondyliosoma emarginatum	1.55	15	0.002±0.06	0.018±0.62
Tetraodontidae				
Amblyrhynchotes honkenii	r*			
Chelonodon patoca	r*			

r = all released
r* = released or discarded

APPENDIX IIIB

Species in the recreational ski-boat catches sampled between Kei Mouth and Stil Bay 1994-1996. Species listed alphabetically by family, CPUE in kg or number of fish .person^{-1}.day^{-1}.

Species	Total (kg)	Total (#)	CPUE (kg) ±SD	CPUE (#) ±SD
CHONDRICHTHYES				
Carcharhinidae				
Carcharhinus brachyurus	136	37	0.27±1.77	0.076±0.46
Carcharhinus obscurus	9.6	2	0.02±0.2	0.004±0.034
Carcharhinus spp.	29.5	11	0.06±0.5	0.023±0.188
Scyliorhinidae				
Poroderma africanum	4.4	1	0.014±0.17	0.003±0.04
Sphyrnidae				
Sphyrna zygaena	8	2	0.017±0.2	0.004±0.054
Squalidae				
Squalus megalops	18.72	23	0.03±0.3	0.043±0.39
Triakidae				
Galeorhinus galeus	20.6	11	0.04±0.2	0.023±0.14
Mustelus mustelus	40.39	38	0.37±2.5	0.075±0.5
Mustelus palumbes	21.72	5	0.04±0.31	0.1±0.66
Triakis megalopterus	10.18	1	0.022±0.2	0.002±0.027
OSTEICHTHYES				
Ariidae				
Galeichthys ater	7.9	17	0.017±0.13	0.0367±0.27
Galeichthys feliceps	11.8	22	0.019±0.15	0.036±0.3
Galeichthys spp.	29.9	11	0.01±0.12	0.018±0.22
Carangidae				
Lichia amia	15.8	2	0.03±0.27	0.004±0.038
Trachurus trachurus	29.3	13	0.02±0.18	0.027±0.22
Haemulidae				
Pomadasys olivaceum	0.4	2	0.001±0.009	0.0056±0.049
Merlucciidae				
Merluccius capensis	1094.3	751	2.22±9.9	1.45±6.8
Polyprionidae				
Polyprion americanus	13.4	4	0.015±0.18	0.008±0.052
Pomatomidae				
Pomatomus saltatrix	20.1	29	0.026±0.28	0.048±0.51
Sciaenidae				
Argyrosomus inodorus	876.5	450	1.58±4.03	0.96±2.34
Atractoscion aequidens	638.6	111	1.07±7.13	0.19±1.2
Umbrina canariensis	0.8	1	0.001±0.016	0.003±0.04
Scombridae				

Katsuwonus pelamis	201.2	66	0.35±1.46	0.11±0.47
Scomber japonicus	55	49	0.055±0.59	0.053±0.48
Thunnus albacares	494.9	30	0.85±5.86	0.05±0.29
Serranidae				
Acanthistius sebastoides	0.6	2	0.0009±0.007	0.003±0.026
Epinephelus marginatus	36	7	0.06±0.32	0.014±0.068
Sparidae				
Argyrozona argyrozona	105.2	181	0.16±0.54	0.32±1.03
Boopsoidea inornata	3.3	12	0.007±0.043	0.024±0.158
Cheimerius nufar	152.5	178	0.278±1.24	0.35±1.78
Chrysoblephus cristiceps	107.77	65	0.278±2.13	0.139±0.625
Chrysoblephus gibbiceps	58.9	19	0.097±0.397	0.031±0.12
Chrysoblephus laticeps	118.64	124	0.26±0.8	0.26±0.85
Diplodus sargus capensis	0.32	1	0.0005±0.005	0.0018±0.022
Pachymetopon aeneum	63.6	69	0.1±0.31	0.12±0.41
Pagellus bellottii natalensis	5.41	23	0.012±0.079	0.051±0.317
Petrus rupestris	266.6	26	0.4±2.35	0.042±0.2
Polysteganus coeruleopunctatus	1.5	6	0.003±0.023	0.012±0.09
Polysteganus praeorbitalis	6.6	2	0.014±0.16	0.004±0.03
Polysteganus undulosus	93	33	0.163±0.84	0.058±0.29
Pterogymnus laniarius	245.9	301	0.256±1.28	0.5±2.36
Rhabdosargus globiceps	2	5	0.0049±0.039	0.012±0.089
Spondyliosoma emarginatum	3.7	15	0.0067±0.042	0.027±0.2
Stromateidae				
Stromateus fiatola	1	2	0.0017±0.02	0.003±0.04
Trichiuridae				
Lepidopus caudatus	2	2	0.006±0.049	0.006±0.049
Triglidae				
Chelidonichthys capensis	9.47	11	0.02±0.11	0.023±0.15

APPENDIX IIIC

Species in the commercial ski-boat catches sampled between Kei Mouth and Stil Bay 1994-1996. Species listed alphabetically by family, CPUE in kg or number of fish .person^{-1}.day^{-1}.

Species	Total (kg)	Total (#)	CPUE (kg) ±SD	CPUE (#) ±SD
CHONDRICHTHYES				
Callorhinchidae				
Callorhinchus capensis	6.56	3	0.008±0.09	0.003±0.04
Carcharhinidae				
Carcharhinus brachyurus	149.7	48	0.198±1.28	0.063±0.39
Carcharhinus brevipinna	12	1	0.003±0.045	0.002±0.02
Carcharhinus obscurus	54.6	6	0.05±0.48	0.006±0.05
Carcharhinus spp.	111.5	3	0.006±0.09	0.002±0.034
Lamnidae				
Isurus oxyrinchus	4.4	1	0.005±0.074	0.001±0.017
Sphyrnidae				
Sphyrna zygaena	5.7	2	0.006±0.06	0.0019±0.02
Squalidae				
Squalus megalops	19.34	20	0.019±0.15	0.023±0.2
Triakidae				
Galeorhinus galeus	73.2	15	0.11±0.85	0.018±0.11
Mustelus mustelus	35.98	44	0.15±0.82	0.043±0.22
Mustelus palumbes	3.27	1	0.004±0.055	0.001±0.017
Triakis megalopterus	46.93	4	0.065±0.56	0.006±0.05
OSTEICHTHYES				
Ariidae				
Galeichthys ater	17.1	38	0.019±0.12	0.043±0.234
Galeichthys feliceps	13.1	28	0.017±0.12	0.035±0.26
Galeichthys spp.	299.7	590	0.31±1.8	0.583±3.32
Carangidae				
Trachurus trachurus	47.9	86	0.059±0.27	0.075±0.33
Haemulidae				
Pomadasys olivaceum	3.4	20	0.003±0.03	0.019±0.22
Merlucciidae				
Merluccius capensis	6257	2139	2.81±8.98	2.23±7.86
Parascorpididae				
Parascorpis typus	1.1	1	0.0007±0.01	0.0006±0.01
Pomatomidae				
Pomatomus saltatrix	204.3	320	0.17±0.68	0.268±1.1
Sciaenidae				
Argyrosomus inodorus	7904	4584	8.504±21.86	4.66±9.5
Argyrosomus japonicus	99	2	0.109±1.6	0.002±0.03

Atractoscion aequidens	252.9	186	0.59±4.5	0.17±1.17
Umbrina canariensis	4.4	9	0.0038±0.02	0.009±0.05
Umbrina spp.	0.2	1	0.0005±0.007	0.002±0.033
Scombridae				
Katsuwonus pelamis	6.2	1	0.007±0.1	0.001±0.017
Scomber japonicus	178.8	401	0.17±1.25	0.379±2.8
Scorpaenidae				
Helicolenus dactylopterus	1.7	4	0.001±0.015	0.003±0.036
Serranidae				
Acanthistius sebastoides	4.1	19	0.0037±0.055	0.017±0.26
Epinephelus chabaudi	20.6	3	0.019±0.2	0.0027±0.03
Epinephelus marginatus	132.6	31	0.102±0.74	0.031±0.2
Sparidae				
Argyrozona argyrozona	2114	2885	1.83±6.1	2.429±7.17
Boopsoidea inornata	8.1	22	0.008±0.04	0.023±0.12
Cheimerius nufar	363	450	0.33±0.95	0.39±1.22
Chrysoblephus cristiceps	270.73	177	0.25±1.09	0.17±0.63
Chrysoblephus gibbiceps	120.42	36	0.1±0.74	0.029±0.19
Chrysoblephus laticeps	214.48	222	0.19±0.66	0.2±0.68
Cymatoceps nasutus	131.2	23	0.14±1.06	0.025±0.14
Diplodus cervinus hottentotus	0.4	1	0.0006±0.009	0.002±0.02
Lithognathus lithoganthus	12	2	0.012±0.13	0.002±0.024
Pachymetopon aeneum	254	331	0.23±0.78	0.297±0.98
Pachymetopon grande	8.1	5	0.005±0.043	0.004±0.03
Pagellus bellottii natalensis	13.2	29	0.0125±0.12	0.028±0.2
Petrus rupestris	2555.3	180	2.27±22.11	0.147±0.99
Polysteganus praeorbitalis	4.6	4	0.004±0.05	0.003±0.041
Polysteganus undulosus	404.3	48	0.369±5.12	0.044±0.57
Pterogymnus laniarius	1882	3525	1.7±3.57	3.07±6.78
Rhabdosargus globiceps	10.1	26	0.01±0.06	0.029±0.15
Spondyliosoma emarginatum	2.7	11	0.002±0.013	0.009±0.05
Triglidae				
Chelidonichthys capensis	66.75	75	0.057±0.21	0.066±0.25
Zeidae				
Zeus capensis	2.89	2	0.0033±0.049	0.002±0.03

APPENDIX IV

Method to calculate a factor to convert from instantaneous shore fisher counts to daily effort

by: Colin Attwood
Sea Fisheries Research Institute:

Philosophy: Given that an angler will be on the beach on a particular day, use known starting time distribution and mean (time dependant) duration of fishing to calculate the probability of encountering the angler on the beach at any given time.

To facilitate calculations and to avoid integration, probability distributions are discrete. Time is rounded-off to the nearest hour.

Symbols:

A_d : Number of anglers on the beach on day d.
O_{dt} : Number of observed anglers on day d at time t.
s_t : Probability of starting fishing at time t.
d_t : Mean duration of fishing trip starting at time t.
p_t : Probability of finding an angler on the beach at time t.
a_t : Step function.
N : Total number of surveyed anglers.
n_t : Number of surveyed anglers who started at time t.

Method

1. Calculate starting time distribution

$$s_t=\frac{n_t}{N} \qquad (1)$$

Note that

$$\sum_{t=0}^{23} s_t=0.1 \qquad (2)$$

2. Compute mean duration of fishing trip starting at time t. Add up the times of all fishing trips which started at time t (t=0,23) and divide by n_t.

3. Calculate probability of an angler being on the beach at time t.

$$p_t=\sum_{i=0}^{23} (s_i.a_i) \qquad (3)$$

$$a_i=1 \ \ if \ \ 0 \leq (t-i) \leq d_i \tag{4}$$

$$a_i=0 \ \ if \ \ 0 \leq d_i \leq (t-i) \tag{5}$$

$$a_i=1 \ \ if \ \ 0>(d_i-24) \geq (t-i) \tag{6}$$

$$a_i=0 \ \ if \ \ 0>(t-i)>(d_i-24) \tag{7}$$

4. Calculate daily total from instantaneous count.

$$A_d=\frac{O_{dt}}{p_t} \tag{8}$$

Note that the scaling factor is simply p_t^{-1}.

REFERENCES

AMESBURY, S.S., SHERWOOD, T.S. and DAVIS, G.W. 1991. Monitoring a tropical island reef fishery. *Am. Fish. Soc. Symp.* 12: 84-87.

ANDERSON, E.D. 1990. Fishery models as applied to elasmobranch fisheries. *NOAA Tec. Rep.* 90: 473-484

ANDERSON, L.E. and THOMPSON, P.C. 1991. Developing and implementation of the angler diary monitoring program for Great bear Lake, Northwest Territories. *Am. Fish. Soc. Symp.* 12: 457-475.

ANON. 1994. Creel survey underway. *Western Fisheries.* pp 7.

ANON. 1997. *South African tide tables 1997.* Hydrographer, South African Navy. Tokai, South Africa.

ATTWOOD, C.G. and BENNETT, B.B. 1995a. A procedure for setting daily bag limits on the recreational shore-fishery of the South-western Cape, South Africa. *S. Afr. J. mar. Sci.* 15:241-251.

ATTWOOD, C.G. and BENNETT, B.B. 1995b. Modelling the effect of marine reserves on the recreational shore-fishery of the south-western Cape, South Africa. *S. Afr. J. mar. Sci.* 16: 227-240.

BECKLEY, L.E. and VAN BALLEGOOYEN, R.C. 1992. Oceanographic conditions during three ichthyoplankton surveys of the Agulhas current in 1990/91. *S. Afr. J. mar. Sci.* 12: 83-93.

BENNETT, B.A. 1991. Long-term trends in the catches by shore anglers in False Bay. *Trans. Roy. Soc. S. Afr.* 47(4&5): 683-690.

BENNETT, B.A. 1993. The fishery for white steenbras *Lithognathus lithognathus* off the Cape coast, South Africa, with some considerations for its management. *S. Afr. J. mar. Sci.* 13: 1-14.

BENNETT, B.A., ATTWOOD, C.G. and MANTEL, J.D. 1994. Teleost catches by three shore-angling clubs in the south-western Cape, with an assessment of the effect of the restrictions applied in 1985. *S. Afr. J. mar. Sci.* 14:11-18.

BIDEN, C.L. 1948. *Sea-angling fishes of the Cape.* Juta and co. Ltd, Cape Town. 304pp.

BOOTH, A.J. and PUNT, A.E. (In prep.). Evidence for rebuilding in the pangs stock on the Agulhas bank, South Africa.

BOOTH, A.J. and BUXTON, C.D. (In prep). Management of the panga, *Pterogymnus laniarius* (Pisces; Sparidae) on the Agulhas bank South Africa. Using per-recruit models.

BROUSSEAU, C.S. and ARMSTRONG, E.R. 1987. The role of size limits in walleye management. *Fisheries.* 12(1): 2-5.

BROUWER, S.L., MANN, B.Q., LAMBERTH, S.J., SAUER, W.H.H. and ERASMUS, C.A survey of the South African shore angling fishery. In pres. *S. Afr. J. mar. Sci.* 18.

BUXTON, C.D. 1987. Life history changes of two reef fish species in exploited and underexploited marine environments in South Africa. Unpublished PhD thesis, Rhodes University. 220pp.

BUXTON, C.D. 1989. Protogynous hermaphroditism in *Chrysoblephus laticeps* (Cuvier) and *C. cristiceps* (Cuvier) (Teleostei: Sparidae). *S. Afr. J. Zool.* 24(3): 212-216.

BUXTON, C.D. 1992. The application of yield-per recruit models to South African sparid reef species, with special consideration to sex change. *Fish. Res.* 15: 1-16.

BUXTON, C.D. 1993. Life-history changes in exploited reef fishes on the east coast of South Africa. *Env. Biol. Fish.* 36: 47-63.

BUXTON, C.D. and ALLEN, J.C. 1989. Mark and recapture studies of two reef sparids in the Tsitsikamma Coastal National Park. *Koedoe.* 32(1): 39-45.

BUXTON, C.D. and CLARKE, J.R. 1986. Age, growth and feeding of the blue Hottentot *Pachymetopon aeneum* (Pisces: Sparidae) with notes on reproductive biology. *S. Afr. J. Zool.* 21(1): 33-38.

BUXTON, C.D. and CLARKE, J.R. 1989. The growth of *Cymatoceps nasutus* (Teleostei: Sparidae), with comments on diet and reproduction. *S. Afr. J. mar. Sci.* 8: 57-65.

BUXTON, C.D. and CLARKE, J.R. 1991. The biology of the white musselcracker *Sparodon durbanensis* (Pisces: Sparidae) on the Eastern Cape coast, South Africa. *S. Afr. J. mar. Sci.* 10: 285-296.

BUXTON, C.D. and CLARKE, J.R. 1992. The biology of the bronze bream, *Pachymetopon grande* (Teleostei: Sparidae) from the south-east Cape coast, South Africa. *S. Afr. J. Zool.* 27(1): 21-32.

CAPUTI, N. 1976. Creel census of amateur line fishermen in the blackwood river estuary, Western Australia, during 1974-1975. *Aust. J. Mar. Freshwater Res.* 27: 583-593.

CATANZANO, J. and MESNIL, B. 1995. Economics and biology used in fisheries research or when social and natural sciences try to depict together the objective of their research. *Aquat. Living Resources.* 8: 223-232.

CHARLES, A.T. 1995. Fishery science: the study of fishery systems. *Aquat. Living Resources.* 8: 233-239.

CHIPMAN, B.D. and HELFRICH, L.A. 1988. Recreational specialisations and motivations of Virginia river anglers. *N. Am. J. Fish. Man.* 8: 390-398

CLARKE, J.R. and BUXTON, C.D. 1989. A survey of the recreational rock-angling fishery at Port Elizabeth, on the south-east coast of South Africa. *S. Afr. J. mar. Sci.* 8:183-194.

CLAYTOR, R.R. and O'NIEL, S.F. 1991. Using small creel surveys and mark-recapture experiments to interpret angling statistics. *Am. Fish. Soc. Symp.* 12: 195-205.

COETZEE, P.S. and BAIRD, D. 1981. Catch composition and catch per unit effort of anglers' catches off St Croix Island, Algoa Bay. *S. Afr. J. Wildl. Res.* 11(1): 14-20.

COETZEE, P.S., BAIRD, D. and TREGONING, C. 1989. Catch statistics and trends in the shore angling fishery of the east coast, South Africa, for the period 1959-1982. *S. Afr. J. mar. Sci.* 8: 155-171.

COLE, R.A. and WARD, F.A 1994. Optimum fisheries management policy: angler opportunity versus angler benefit. *N. Am. J. Fish. Man.* 14: 22-33.

COMPAGNO, L.J.V and SMALE, M.J. 1989. Sharks and the Natal sharks board. *In*: *Oceans of life off Southern Africa.* A.I.L Payne and R.J.M. Crawford (Eds). Vlaeberg Publishers, Cape Town.198-208

CRIBB, A. 1994. The hole in Perths tailor fishery. *Western Fisheries.* 29-36.

CRAWFORD, R.J.M. and CROUS, H.B. 1982. Trends in commercial handline catches of redfishes along the southern Cape coast, Republic of South Africa. *Koedoe.* 25: 13-31.

DENT, R.J. and WAGNER, B. 1991. Changes in sampling design to reduce variability in selected estimates from a roving creel survey conducted on Pomme de Tarre Lake. *Am. Fish. Soc. Symp.* 12: 88-96.

DENTON, N.R., CLIFF, G. BOWMAKER, A.P. and THURMAN, G.D. 1987. The capture, transport and maintenance in captivity of large sharks for experimental purposes in the field. *Oceonog. Res. Inst. (Durban). Poster.* 2.

DEUEL, D.G. 1980. Survey methods used in the United States marine recreational fishery statistics program. *In: Allocation of fishery resources: proceedings of the technical consultation on* *allocation of fishery resources held in Vichy France, 20-23 April 1980*. J.H. Grover (Ed). Food and Agricultural Organisation of the United Nations. 82-86.

DITTON, R.B., FEDLER, A.J. and CHRISTIAN, R.T. 1992. The evolution of recreational fisheries management in Texas. *Oce. Coast. Man.* 17: 169-181.

EBBERS, M.A. 1987. Vital statistics of a largemouth population in Minnesota form electrofishing and angler-supplied data. *N. Am. J. Fish. Man.* 7: 252-259.

EDER, S. 1990. Angler use of black crappie and the effects of a tag reward programme at Jamesport community Lake, Missouri. *Am. Fish. Soc. Symp.* 7: 647-654.

EDWARDS, S.F. 1991. A critique of three "economics" arguments commonly used to influence fishery allocations. *N. Am. J. Fish. Man.* 11(2): 121-130.

ESSIG, R.J. and HOLLIDAY, M.C. 1991. Population and longitudinal surveys. Development of a recreational fishing survey : The marine recreational fishery statistics survey case study. *Am. Fish. Soc. Symp.* 12: 245-254.

FEATHERS, M.G. and KNABLE, A.E. 1983. Effects of depressurization upon largemouth bass. *N. Am. J. Fish. Man.* 3: 86-90.

FEDLER, A.J. and DITTON, R.B. 1994. Understanding angler motivations in fisheries management. *Fisheries.* 19(4): 6-13.

FERREIRA, A. 1993. A recreational anglers view of marine linefish management. *Oceanogr. Res.*

Inst. (Durban) Spec. Publ. 2: 182-185.

FIELDING, P.J., ROBERTSON, W.D., DYE, A.H., TOMALIN, B.J., VAN DER ELST, R.P., BECKLEY, L.E., MANN, B.Q., BIRNE, S, SCHLEYER, M.H. and LASIAK, T.A. 1994. Transkei costal fisheries resources. *Oceanogr. Res. Inst. (Durban) Spec. Publ.* 3: 175pp.

FISHER, W.L. and GRAMBSH, A.E. 1991. Measuring recreational fisheries economics from the national survey. *Am. Fish. Soc. Symp.* 12: 226-343.

FISHER, W.L., GRAMBSCH, A.E., EISENHOWER, D.L. and MORGANSTEIN, D.R. 1991. Length of recall period and accuracy of estimates from the national survey of fishing, hunting, and wildlife-associated recreation. *Am. Fish. Soc. Symp.* 12: 367-374.

GARRATT, P.A. 1986. Protogynous hermaphroditism in the slinger, *Chrysoblephus puniceus* (Gilchrist and Thompson, 1908) (Teleostei: Sparidae). *J. Fish. Biol.* 28:297-306.

GARRATT, P.A. 1988. Notes on seasonal abundance and spawning of some important offshore linefish in Natal and Transkei waters, Southern Africa. *S. Afr. J. mar. Sci.* 7: 1-8.

GARRATT, P.A. 1993. Slinger- the final analysis? *Oceanogr. Res. Inst. (Durban) Spec. Publ.* 2: 14-18.

GIGLIOTTI, L.M. and PEYTON, R.B. Values and behaviours of trout anglers and their attitudes toward fishery management, relative to membership in fishing organisations: a Michigan case study. *N. Am. J. Fish. Man.* 13: 492-501.

GLASS. R.D. and MAUGHN, O.E. 1984. Angler compliance with length limits on largemouth bass in an Oklahoma reservoir. *N. Am. J. Fish. Man.* 4:457-458.

GOVENDER, A. 1996. *Pomatomus saltatrix*: review of the biology, fishery, regulations, stock assessment and relevant databases in South Africa. *Oceanogr. Res. Inst. (Durban)* Unpublished report. 124: 1-19.

GOVENDER, A., BULLEN, E. and VAN DER ELST, R. 1995. Tagging news. *Oceo. Res. Inst.* 11: 12pp.

GRAMBSCH, A.E. and FISHER, W.L. 1991. Improving surveys: Lessons form the national survey. *Am. Fish. Soc. Symp.* 12: 5-12.

GREENWOOD, C. and CLARKE, D.I. 1994. Time series of monthly mean sea temperature around the South African coast. *Internal report Sea fisheries research institute.* 124: 36pp.

GRIFFITHS, M.H. 1988. Aspects of the biology and population dynamics of the geelbek *Atractoscion aequidens* (Cuvier) (Pisces: Sciaenidae) off the South African coast. Unpublished MSC. thesis. Rhodes University. 149pp.

GRIFFITHS, M.H. and HECHT, T. 1995. On the life-history of *Atractoscion aequidens*, a migratory sciaenid off the east coast of southern Africa. *J. Fish Biol.* 47: 962-985.

GRIFFITHS, M.H. and HEEMSTRA, P.C. 1995. A contribution to the taxonomy of the marine fish genus *Argyrosomus* (Perciformes: Sciaenidae), with descriptions of two new species from southern Africa. *Ichthy. Bull.* 65: 40pp.

GUASTELLA, L. and VAN DER ELST, R.P. 1990. Trends in marine recreational angling in Natal. *S. Afr. Assoc. Mar. Biol. Res. Bull.* 18: 25-27.

HAAS, R.C. 1990. Effects of monetary rewards and jaw-tag placement on anglers reporting rates for walleyes and smallmouth bass. *Am. Fish. Soc. Symp.* 7: 655-659.

HAYNE, D. 1991. The access point creel survey: Procedures and comparison with the roving-clerk creel survey. *Am. Fish. Soc. Symp.* 12:123-138.

HECHT, T. and BUXTON, C.D. 1993. Catch trends in the Transkei commercial linefishery. *Oceanogr. Res. Inst. (Durban) Spec. Publ.* 2: 127-133.

HECHT, T. and TILNEY, R.L. 1989. The Port Alfred fishery: a description and preliminary evaluation of a commercial linefishery on the South African east coast. *S. Afr. J. mar. Sci.* 8: 103-117.

HEGGENES, J. 1987. Random stratified creel surveys in three Norwegian rivers with low fishing intensities. *N. Am. J. Fish. Man.* 7: 363-368.

HENRY, G. and VIRGONA, J. 1984. Why is angling so popular? *Australian Fisheries.* 43(5): 32-33.

HILBORN, R. 1985. Fleet dynamics and individual variation: why some people catch more fish than others. *Can. J. Fish. Aquat. Sci.* 42: 2-13.

HILBORN. R. 1992. Current and future trends in fisheries stock assessment and management. *S.*

Afr. J. mar. Sci. 12: 975-988.

HOENIG, J.M. and GRUBER, S.H. 1990. Life-history parameters in the elasmobranchs: implications for fisheries management. *NOAA Tec. Rep.* 90: 1-16.

HOEING, J.M., ROBSON, D.S., JONES, C.M. and POLLOCK, K.H. 1993. Scheduling counts in instantaneous and progressive count methods for estimating sport fishing effort. *N. Am. J. Fish. Man.* 13: 723-736.

HUGHES, G. S. 1989. Total effort evaluation for the recreational line-fishery on the Natal coast, with recommendations for future data collection and patrol frequencies in various zones. Unpublished report to SANCOR.

HUTCHINGS, L. 1994. The Agulhas bank: a synthesis of available information and a brief comparison with other east-coast shelf regions. *S. Afr. J. Sci.* 90: 179-185.

ILLGNER, P.M. 1996. Coastal Features. *In: The geomorphology of the Eastern Cape.* G.A. Lewis (Ed). Grocott and Sherry, Grahamstown. 52-70.

JOUBERT, C.S.W. 1981. A survey of shore anglers ' catches at selected sites on the Natal Coast, South Africa. *Invest. Rep. Oceanogr. Res. Inst.* (Durban). 52: 1-15.

LOOMIS, D.K. and DITTON, R.B. 1987. Analysis of motive and participation differences between saltwater sport and tournament fishermen. *N. Am. J. Fish. Man.* 7: 482-487.

LUBKE, R.A., GESS, F.W. and BRUTON, M.N. 1988. *A field guide to the eastern Cape.* Wild life society of Southern Africa. 519pp.

MACKENZIE, C. 1991. Comparisons of northern pike catch and harvest rates estimated from uncompleted and completed fishing trips. *Am. Fish. Soc. Symp.* 12: 47-50.

MALVESTUTO, S.P. 1983. Sampling the recreational fishery. *In. Fisheries techniques.* L.A. Nielsen and D.L. Johnson (Eds). American Fisheries Society, Bethesda, Maryland. 397-419.

MALVESTUTO, S.P. and HUDGINGS, D. 1996. Optimum yield for recreational fisheries management. *Fisheries.* 21(6): 6-17.

MALVESTUTO, S.P., DAVIES, W.D. and SHELTON, W.L. 1978. An evaluation of the roving creel survey with nonuniform probability sampling. *Trans. Am. Fish. Soc.* 107(2):255-262.

MANN, B. and BUXTON, C. 1993. The biology and management of blacktail (*Diplodus sargus capensis*) and zebra (*Diplodus cervinus hottentotus*) off the southeastern Cape coast. *Oceanogr. Res. Inst. (Durban) Spec. Publ.* 2: 26-27.

MATLOCK. G.C. 1991. Overview use of surveys in decision making. *Am. Fish. Soc. Symp.* 12:1-4.

MATLOCK. G.C., OSBURN, H.R., RIECHERS, R.K. and DITTON, R.B. 1991. Comparison of response scales for measuring angler satisfaction. *Am. Fish. Soc. Symp.* 12: 413-422.

MCGRATH, M., HORNER, C., BROUWER, S., MANN, B., LAMBERTH, S. and SAUER, W. An economic valuation of the South African linefishery. In pres. *S. Afr. J. mar. Sci.* 18.

MCNEISH, J.D. and TRIAL, J.G. 1991. A cost-effective method for estimating angler effort from interval counts. *Am. Fish. Soc. Symp.* 12: 236-243.

NEPGEN, C.S. 1977. The biology of the hottentot *Pachymetopon blochii* (Val.) and the silverfish *Argyrozona argyrozona* (Val.) along the Cape south-west coast. *Invstl. Rep. Div. Sea Fish. Rep. S. Afr.* 105: 1-35.

O'MALLEY, M.F. and CRAWFORD, B. Getting to know our free fishing weekend clientele. *Fisheries.* 20(7): 6-8.

OZUNA, T. and STOLL, J.R. 1991. The significance of data collection and econometric methods in estimating non-market resource values. *Am. Fish. Soc. Symp.* 12: 328-335.

PENNEY. A. and WILKE, C. 1993. The red steenbras: a species under siege? *Oceanogr. Res. Inst. (Durban) Spec. Publ.* 2: 32-35.

PETERSON, G.L. and CORDELL, H.K. 1991. Estimating recreational demand functions: experience with the public area recreation visitor survey. *Am. Fish. Soc. Symp.* 12: 316-327.

PHIPPEN, K.W. and BERGERSEN, E.P. 1987. Angling definitions and their effects on the accuracy of count-interview creel survey harvest estimates. *N. Am. J. Fish. Man.* 7: 488-492.

PHIPPEN, K.W. and BERGERSEN, E.P. 1991. Accuracy of a roving creel survey's harvest estimate and evaluation of possible sources of bias. *Am. Fish. Soc. Symp.* 12: 51-60.

PILFOLD, S.J. and PAMPALLIS, A 1993. The Natal commercial linefishery. *Oceanogr. Res. Inst.*

(Durban) Spec. Publ. 2: 118-121.

POLLOCK, K.H., JONES, C.M. and BROWN, T.L. 1994. Angler survey methods and their applications in fisheries management. *Am. Fish. Soc. Spec. Pub.* 25: 371pp.

PROPST, D.B. and GAVRILIS, D.G. 1987. Role of economic impact assessment procedures in recreational fisheries management. *Trans. Am. Fish. Soc.* 116: 450-460.

RICKER, W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Can.* 191: 1-382.

RIECHERS, R.K., MATLOCK, G.C. and DITTON, R.B. 1991. A dual survey approach for estimating the economic aspects of fishing. *Am. Fish. Soc. Symp.* 12: 344-355.

ROBINSON, G.A. 1989. Marine reserves. *In: Oceans of life off southern Africa.* A.I.L. Payne and R.J.M. Crawford (Eds). Vlaeberg Publishers Cape Town. 380pp.

ROHRER, R. L. 1986. Creel surveys from a kayak on the Henry's Fork of the Snake river, Idaho. *N. Am. J. Fish. Man.* 6: 294-295.

RORKE, D. 1996. What a load of. *Ski-boat.* 7-9.

ROSS, G.J.B. 1988. Coastal hydrography. *In: A field guide to the eastern Cape.* R.A. LUBKE, F.W. GESS and M.N. BRUTON (Eds). Wildlife society of Southern Africa: 31-32.

SANTUCCI Jr, V.J. and WAHL, D.H. 1991. Use of a creel census and electrofishing to assess centrachid populations. *Am. Fish. Soc. Symp.* 12: 481-491.

SAUER, W.H.H., ERASMUS. C., MANN, B.Q., BROUWER, S.L., LAMBERTH, S.J. and STEWART, T. Validation of the NMLS and an evaluation of fisher attitudes towards current management in the South African boat based linefishery. In pres. *S. Afr. J. mar. Sci.* 18.

SCHMIED. R.L. 1980. Development of marine recreational fisheries in the southeastern United States: problems and some solutions. *In*: *Allocation of fisheries resources: proceedings of the technical consultation on allocation of fishery resources held in Vichy France, 20-23 April 1980.* J.H. Grover (Ed). Food and Agricultural Orginisation of the United Nations. 333-345.

SCHUMANN, E.H., PERINS, L.-A. and HUNTER, I.T. 1982. Upwelling along the south coast of the Cape province, South Africa. *S. Afr. J. Sci.* 78: 238-242.

SCHUMANN, E.H., ROSS, G.J.B. and GOSCHEN, W.S. 1988. Cold water events in Algoa Bay and along the Cape south coast, South Africa, in March/April 1987. *S. Afr. J. Sci.* 84: 579-584.

SHINDLER, J. 1994. Literacy statistics in South Africa . *EduSource data news.* (7): 1-6

SMALE, M.J. 1988. Distribution and reproduction of the reef fish *Petrus rupestris* (Pisces: Sparidae) off the coast of South Africa. *S. Afr. J. Zool.* 23(4): 272-287.

SMALE, M.J. and BUXTON, C.D. 1985. Aspects of the recreational ski-boat fishery off the Eastern Cape, South Africa. *S. Afr. J. mar. Sci.* 3: 131-144.

SMITH, S.S. 1995. Social implications of changes in fisheries regulations for commercial fishing families. *Fisheries*. 20(7): 24-26.

SPENCER, P.D. 1993. Factors influencing satisfaction of anglers on lake Miltona, Minnesota. *N. Am. J. Fish. Man.* 13: 201-209.

SPENCER, P.D. and SPANGLER, G.R. 1992. Effect that providing fishing information has on angler expectations and satisfaction. *N. Am. J. Fish. Man.* 12: 379-385.

STORER, J.A. 1992. Marine resource management international experience and aspects. *Am. Fish. Soc. Symp.* 13: 39-45.

SWANSON, C.S. and MCCOLLUM, D.W. 1991. Application of economics to recreational fisheries management: an overview. *Am. Fish. Soc. Symp.* 12: 299-315.

TARRANT, M. A., MANFREDO, M.J., BAYLEY, P.B. and HESS, R. 1993. Effects of recall bias on self-reporting estimates of angling participation. *N. Am. J. Fish. Man.* 13: 217-222.

THOMPSON, C.J. 1991. Effects of the avidity bias on survey estimates of fishing effort and economic value. *Am. Fish. Soc. Symp.* 12: 356-366.

VAN DE BOONSTRA, H.G. 1995. South African commercial fisheries review. Government printer, Cape Town. 51pp.

VAN DEN AVYLE, M.J. 1986. Measuring angler effort, success and harvest. *In*: *Reservoir Fisheries Management strategies for the 80's*. G.E. Hall and M.J. Van Den Avyle, (Eds). American Fisheries Society. Bethesda, Maryland. 57-64

VAN DER ELST, R. 1987a. Joint action resulting in better shad fishing. *Natal news from NPB*.3: p3.

VAN DER ELST, R. 1987b. A happy ending. *Our living world.* 9: p2.

VAN DER ELST, R. P. and ADKIN, F. 1991. Marine linefish priority species and research objectives an southern Africa. *Oceanogr. Res. Inst. (Durban) Spec. Publ.* 1: 132pp.

VAN DER ELST, R.P. and DE FREITAS, A.J. 1988. Long term trends in Natal marine fisheries. *S.Afr. Nat. Sci. Prog. Rep.* 157: 76-84.

VAN DER HEEVER, P. 1997. Statistical report, provincial statistics (part 2) - Eastern Cape. [On-line]. *Http://www.css.gov.za/reports/general/00_90_02.htm.*

VAN DER WALT. B.A. 1995. Biology ans stock assessment of the coastal fish, *Sarpa salpa* (Sparidae) off the KwaZulu-Natal coast, South Africa. Unpublished MSC. thesis, University of Natal. 106pp.

WALTER, J.P. and EBERT, D.A. 1991. Preliminary estimates of age of the bonze whaler *Carcharhinus brachyurus* (Chondrichthyes: Carcharhinidae) form Southern Africa, with a review of some life history parameters. *S. Afr. J. mar. Sci.* 10: 37-44.

WEITHMAN, A.S. and HAVERLAND, P. 1991. Comparability of data collected by telephone and roving creel surveys. *Am. Fish. Soc. Symp.* 12: 67-73.

WINCH, G. 1990. Goodbye, red rhino! *Ski-boat.* 6(1): 13.

ZALE, A.V. and BAIN, M.B. 1994. Estimating tag-reporting rates with postcards as tag surrogates. *N. Am. J. Fish. Man.* 14: 208-211.