AN ASSESSMENT OF THE SHORE-BASED AND OFFSHORE BOAT-BASED LINEFISHERIES OF KWAZULU-NATAL, SOUTH AFRICA

By

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ABSTRACT

The purpose of this study was to evaluate the current management effectiveness of the KwaZulu-Natal linefishery (i.e. the shore linefishery and the offshore boat-based linefishery). Methods used included a stratified-random creel sampling technique and an associated questionnaire survey for the shore-based linefishery and a random access-point technique and associated questionnaire survey for the offshore boat-based linefishery. Additional catch and effort data for the offshore boat-based linefishery was also obtained from Marine and Coastal Management's (MCM) Linefish Observer Programme. The study was undertaken between February 2009 and April 2010. Total participation within the two linefisheries ranged between 41283-68200 shore-anglers and 21220-28857 boat-fishers (2001-4445 boats). Excluding the increase in the number of boat-fishers that fish off charter vessels (i.e. charter clients), it seems that there have been relatively few new entrants into the marine linefishery of KZN since 1994-96. In contrast, total angler effort in both the shore (779382-1287548 angler-days.annum^{-1}) and offshore (39664 boat outings annum^{-1}) linefisheries has decreased substantially in the past 12 years.

Overall catch per unit effort (CPUE) for the KZN shore linefishery amounted to 0.18 ±0.3 fish.angler^{-1}.hour^{-1} or 0.07 ±0.13 kg.angler^{-1}.hour^{-1}. Eighty-four fish species, belonging to 39 families were recorded in catches of shore-anglers during the study period. Only five species accounted for 75% of the catch recorded along the coast (*Sarpa salpa* 34.8%, *Pomatomus saltatrix* 14.7%, *Diplodus capensis* 14.5%, *Pomadasys olivaceum* 6.5% and *Rhabdosargus holubi* 4.9%). The total annual catch for the KZN shore linefishery was estimated between 249.2 and 276.7 metric tonnes (mt).annum^{-1} (636589 - 706995 fish.annum^{-1}).

Overall CPUE was significantly different between the various sectors of the KZN offshore boat-based linefishery. The commercial boat sector had the highest CPUE both numerically ($p < 0.05$; 307.4 fish.outing^{-1}) and by weight ($p < 0.05$; 235.6 kg.outing^{-1}). Contrastingly, the recreational boat sector had the lowest CPUE both numerically ($p < 0.05$, 8.6 fish.outing^{-1}) and by weight ($p < 0.05$, 15.0 kg.outing^{-1}). The charter boat sector ($p < 0.05$, 26.6 fish.outing^{-1} or 41.6 kg.outing^{-1}), although far lower than commercials, had a CPUE slightly higher than the recreational boat sector. In total, 86 fish species, belonging to 27 families were recorded in catches of boat-fishers (all sectors) during the study period. The top five species that comprised the bulk of the commercial catch numerically included *Chrysoblephus puniceus* (66.0%), *Cheimerius nufar* (22.4%), *Lethrinus nebulosus* (4.6%), *Pachymetopon aeneum* (1.9%) and *Chrysoblephus anglicus* (0.9%). Similarly, recreational catch composition was dominated by *C.*

puniceus (33. 9%), *L. nebulosus* (9.0%), *Thunnus albacares* (7.4%), *Scomber japonicus* (5.3%) and *C. anglicus* (4.4%). The top five species in charter boat-fishers' catches comprised *C. puniceus* (34.4%), *L. nebulosus* (16.7%), *T. albacares* (13.1%), *C. anglicus* (8.1%) and *P. aeneum* (4.6%).

The socio-economic characteristics of the KZN shore and offshore linefisheries have changed very little since the last national linefish assessment conducted during 1994-96. Recreational (both shore and boat-based) and charter anglers generally agree with most of the linefishery regulations, with exception of the beach vehicle ban. However, knowledge and compliance with the current fishery regulations by recreational and charter anglers was limited. Commercial fishers had good knowledge of all the fishery regulations, but did not agree with the minimum legal size and daily bag limits that are in place on certain fish species. Subsequently, the majority of commercial skippers interviewed stated that they disobeyed these two regulations frequently. General policing of the KZN linefishery by EKZNW seems to be more focused on permit requirements rather than enforcing species-specific linefish regulations. Comparison of the catch and effort results of this study with the long-term monitoring data stored on the NMLS showed that while the NMLS data is limited by a number of biases, it still provides a valuable system for monitoring long-term trends in the KZN linefishery.

Analysis of overall CPUE, catch composition and total catch in both the shore and offshore linefisheries of KZN suggested that both fisheries are currently in a relatively stable condition and that little change has occurred in the past 12 years. However, comparisons of species-specific CPUE values from this study with recent literature suggest that some species (i.e. *Argyrosomus thorpei and Scomberomorus commerson*) are severely overexploited. Furthermore, in relation to the catches recorded throughout most of the 20th century, current catch trends suggest that linefish resources have been fished to very low levels which are only 'superficially' sustainable at current levels of fishing effort.

PREFACE

The experimental work described in this dissertation was carried out at the Oceanographic Research Institute, an affiliate of the University of KwaZulu-Natal, Durban, in the School of Biological and Conservation Sciences, from January 2009 to December 2010, under the supervision of Professor Rudy P. van der Elst and Bruce Q. Mann.

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

DECLARATION- PLAGIARISM

I,…………………………………………….……declare that

1. The research reported in this thesis, except where otherwise indicated, is my original research.

2. This thesis has not been submitted for any degree or examination at any other university.

3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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"There has long been a belief that the sea, at least, was inviolate, beyond man's ability to change and to despoil. But this belief, unfortunately, has proved to be naïve"

-Rachel Carson, The Sea Around Us, 1951

CHAPTER 1
INTRODUCTION

1.1. RATIONALE

Improved knowledge, together with accurate assessments and realistic interpretations of the impacts of fishing, are pre-requisites for protecting fish stocks and sustaining recreational, commercial and subsistence fisheries (Kearney 1994). With the growing human population and the increasing demand for food, many fisheries have been exploited to their maximum levels (FAO 2006), some have been overexploited (Pauly *et al.* 1998; Magnusson *et al.* 2001; Pauly *et al.* 2002; Myers and Worm 2003), and others have collapsed (Birnie *et al.* 1994; Myers *et al.* 1997; Jackson *et al.* 2001; Post *et al.* 2002; Baum *et al.* 2003; Pauly and Maclean 2003; Olsen *et al.* 2004; Fromentin and Powers 2005). It has been highlighted worldwide by over a century of fishery science that fishing is not only an important source of protein for people, but also a substantial economic benefit to local and national economies (Storey and Allen 1993; McGrath *et al.* 1997; Kirchner *et al.* 2000; Mann *et al.* 2001; Zeybrandt and Barnes 2001; Hilborn *et al.* 2003; Lamberth and Turpie 2003; Stage and Kirchner 2005; Cooke and Cowx 2006; Lewin *et al.* 2006; Napier *et al.* 2009).

Nowadays, nearly all fisheries are monitored in some way, on some scale. Linefishing is no different. Although not as destructive as trawling (Jones 1992; Watling and Norse 1998) or long lining (Myers and Worm 2003; Ward and Myers 2005), linefishing, by means of a handline or rod and reel, has accounted for many collapses in fish stocks and changes in species composition around the world. Previous research, as early as the 1960s, has recorded some decline or specific change in South African fish species composition (Ahrens 1964; van der Elst 1976; Joubert 1981a; Hecht and Tilney 1989; Penney *et al.* 1989; van der Elst 1989; Bennett 1991; Bennett *et al.* 1994; Birnie *et al.* 1994; Brouwer *et al.* 1997; Attwood and Farquhar 1999; Penney *et al.* 1999; Griffiths 2000; Brouwer and Buxton 2002; Fennessy *et al.* 2003; Pradervand 2004; Pradervand *et al.* 2007b). Although many of these declines were primarily attributed to commercial overexploitation, it has been shown that recreational linefishing can cause equivalent, if not greater, declines and changes in fish communities (Sigler and Sigler 1990; McPhee *et al.* 2002; Post *et al.* 2002; Coleman *et al.* 2004; Cooke and Cowx 2006; Lewin *et al.* 2006). Failure to recognise the impact that commercial, recreational (including charter fishing[*]) and subsistence fishing can have on fish resources creates a risk ecologically as well as economically (Coleman *et al.* 2004; Cooke and Cowx 2004; Arlinghaus and Cooke 2005; Pradervand and van der Elst 2008; Figueira and Coleman 2010).

In South Africa, linefishing is the largest fishery in terms of numbers of participants (Leibold and van Zyl 2008), and was estimated to contribute 1.3% of the Gross Geographic Product (GGP) of the coastal economies (McGrath *et al.* 1997). It is also a ‘people’s fishery’ since it is accessible to a wide variety of communities, ranging from subsistence and artisanal users to recreational (shore-angling, spearfishing, estuarine and offshore boat angling) and commercial operators. The diversity of users, coupled with the great diversity of species and methods of harvesting poses enormous challenges for effective management and sustainable development (van der Elst and Garratt 1984; Brouwer *et al.* 1997; Penney *et al.* 1997). Furthermore, the linefishery is difficult to monitor and is not managed on a quota basis (Griffiths *et al.* 1999). Currently, effort in the linefishery is controlled by limiting the size (i.e. total allowable effort) of the commercial component (commercial capping) and by species-specific daily bag limits, minimum legal size limits and closed seasons, for both recreational and commercial fishers (*see* section 1.2 below for an outline of the development of linefish management in KwaZulu-Natal (KZN)) (Griffiths *et al.* 1999). However, the lack of personnel to enforce regulations and monitor all linefish resources along the 3000 km coastline has confounded management to a large extent (Attwood *et al.* 1997; Singh 2004). Deterioration in the status of the linefishery presents substantial socio-economic hardships to a large sector of society, through compromised food security and employment opportunities (McGrath *et al.* 1997).

Although linefish management is a demanding and ongoing activity implemented by Marine and Coastal Management (MCM[†]) and its various provincial departments (e.g. Ezemvelo KwaZulu-Natal Wildlife (EKZNW)), management must be periodically evaluated and assessed in terms of management objectives. These objectives include inter alia implementation of regulations to rebuild depleted stocks; maintenance of stocks at optimum levels of production; ensuring user participation in the development and implementation of management measures; assessing public awareness of these management protocols; and lastly ensuring that the process of granting access to linefish resources is fair and equitable. Without periodic assessment of the efficacy of management, the management itself becomes compromised. Furthermore, management must periodically be adjusted to changing conditions and socio-economic issues

[*] Charter fishing is described as a linefishing activity where an angler, usually with no direct access to the boat-fishery, pays a fee to be allowed to fish from a vessel (*see* Pradervand & van der Elst (2008).
[†] Now known as the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries (DAFF).

relating to the linefishery. It was this fact that provided the rationale for the very successful 1994 to 1997 national survey of the South African linefishery (Brouwer 1997; Brouwer *et al.* 1997; Lamberth *et al.* 1997; Mann *et al.* 1997a; Mann *et al.* 1997b; McGrath *et al.* 1997; Sauer *et al.* 1997; Fennessy *et al.* 2003; Mann *et al.* 2003). This survey was unique since it moved away from traditional species directed studies, although these are still essential for reliable management recommendations to be made (Griffiths *et al.* 1999), and provided a comprehensive assessment of the levels of participation in all sectors of the South African linefishery (i.e. recreational shore fishing, recreational and commercial skiboat fishing, beach-seine & gill netting, spearfishing and estuarine fishing to a lesser extent). In particular, it generated information and recommendations that were valuable in improving management systems, particularly for sustainable development. In addition, it also captured vitally important information on fishers and their sociological characteristics, which few other studies had previously done. One notable recommendation emanating from this survey was that it should be repeated periodically (i.e. once every five years) to fine-tune management and accommodate changes in both the status of resources and stakeholders (Brouwer *et al.* 1997). Evaluation and 'ground truthing' of this type are a feature of many fisheries worldwide, including national surveys conducted in New Zealand, Canada, United States of America (USA) and Australia (Essig and Holliday 1991; Pollock *et al.* 1994; Hartill 2010).

Although it was originally planned to repeat the linefish survey every five years (Brouwer *et al.* 1997), it is now over 13 years since the completion of the first survey (1997) and significant changes have taken place in the linefishery (*see* section 1.2). Considering these changes and the current depressed status of linefish resources (Government Gazette No. 21949), it is of great importance that the survey be repeated without further delay. Failure to do so could compromise the resource and could expose the authorities to criticism over poor management strategies. Since KZN has its own unique and well-developed long-term monitoring programmes on the various linefisheries (i.e. National Marine Linefish System (NMLS), MCM's Linefish Observer Programme, and the Boat Launch Site Monitoring System (BLSMS)), it was strongly motivated that the next linefish survey be undertaken at a provincial level. The purpose of this study was therefore to undertake a major survey of the main sectors of the KZN linefishery in order to assess current management effectiveness. It forms part of an envisioned national programme to re-evaluate linefishery management along the South African coastline. The two main linefish sectors, namely the shore fishery (recreational* and subsistence) and offshore boat-based line fishery (recreational, charter and commercial†), formed the focus of the study.

The overall objective of this study was therefore to evaluate management effectiveness of the KZN linefishery. Specific aims included: (1) to determine total fisher participation and demographics; (2) to determine trends in catch composition, effort and catch per unit effort (CPUE); (3) to assess current fisher awareness of and attitudes towards linefish management; (4) to compare results with those obtained by means of long-term monitoring systems (i.e. NMLS); and (5) to make recommendations towards improving management of the KZN linefishery.

1.2. DEVELOPMENT OF LINEFISH MANAGEMENT IN KZN

Linefishing has a diversity of users associated with a plethora of target linefish species. Although several species (e.g. tuna (*Thunnus spp.*) and snoek (*Thyrsites atun*)) in the linefishery can be managed separately as it is possible to target them specifically, most linefishing, especially in KZN, is a ubiquitous activity characterised by a wide range of species, caught from both shallow and deep waters over a wide range of habitats (Penney *et al.* 1989). The management of the KZN linefishery is therefore complicated and much overlap, especially between recreational and commercial boat users, causes several management problems associated with conflicting motivations and goals (Penney *et al.* 1989).

In an attempt to control the continual decline of some linefish resources in KZN, certain fishing regulations have been in place since as early as the 1860s (van der Elst and Garratt 1984; van der Elst 1989). Other early regulations included the Coast Fisheries Act of 1906/07 and the Natal Ordinance of 1916, which subsequently consolidated all laws before it (van der Elst and Garratt 1984). The Natal Ordinance at its time was probably one of the fundamental stepping stones in marine resource conservation along the KZN coast (van der Elst and Garratt 1984). However, there was a major flaw in this Act. It focused only on intertidal resources (i.e. resources obtainable from the shore) and payed little attention to offshore resources. Finally, when the necessity for conservation of offshore resources was realised in 1939 (van der Elst and Garratt 1984), the Sea Fisheries Act of 1940 was promulgated (Table 1.1). It was however, not until 1973, after several additions and revisions of this act, that the more comprehensive Sea

* Although estuarine shore fishers and spearfishers diving from the shore could be included in the recreational shore fishing sector, due to time and logistical constraints they were not included in this study.

† Only participants in the traditional commercial linefishery were included in this study.

Fisheries Act No. 58 of 1973 was established, with a full suite of regulations being introduced (Table 1.1) (Penney *et al.* 1989; van der Elst 1989; Mann *et al.* 1997a). Before this, other than elf (*Pomatomus saltatrix*), snoek (*T. atun*) and kob (*Argyrosomus spp.*), there were few other restrictions on any fish species. Several management methods were implemented in terms of the Sea Fisheries Act and these included daily bag limits, minimum size limits, closed seasons and closed areas. Importantly, the Sea fisheries Act of 1973 specifically delegated inshore control of KZN fisheries to the Natal Conservation Ordinance.

Although legislation was now in place for the conservation of both inshore and offshore resources, the management of offshore resources in KZN was largely neglected. This was mainly because offshore resources were primarily managed by Sea Fisheries based in Cape Town, where most management attention was focused on larger commercial fisheries (van der Elst and Garratt 1984). The lack of management of offshore linefish resources in KZN during this period exacerbated the decline of a number of offshore fish stocks, such as seventy-four (*Polysteganus undulosus*) (van der Elst and Garratt 1984; Mann 2007). Effective conservation and management of offshore linefish species only really began in the early 1980s after research was conducted on several species of economic importance (e.g. *Cheimerius nufar* (Garratt 1985); *Chrysoblephus puniceus* (Garratt 1985)). Over the years, as new information on the linefishery has become available, especially with the implementation of the NMLS (*see* Chapter 6), the regulations have been modified accordingly. Specifically in 1984 (Government Gazette No. 9543), replaced in 1988 (Sea Fisheries Act No. 12) and further revised or amended several times there after up until 1997 (Table 1.1). The Smith Committee of Enquiry undertaken in 1979 and the nationwide linefish management framework that came about in 1984/5 were probably the most important steps towards a consolidated approach to linefish management in KZN (Table 1.1) (Smith Committee of Enquiry 1979; van der Elst and Garratt 1984; van der Elst 1989). The linefish management framework specifically formulated a management plan for the deep reef fishery, which included the standardization of minimum legal size limits, division of species into groups (i.e. protected list, critical list, restricted list, exploitable list, recreational list and bait list), division of linefish sectors and the capping of commercial effort at 1984 levels (Table 1.1) (Van der Elst & Garratt 1984). In addition, included in the capping of the commercial fishing effort was the introduction of a two-tiered licence system for full time (A category license) and part-time (B category license) commercial fishers. B-license holders were essentially recreational fishers who subsidised their fishing to some degree by selling their catch. In contrast to A-licence holders, they did not exclusively rely on the fishery itself and often had other sources of income. Overall, the management plans brought about by the linefish management framework still form the basis of the linefish protocol today (Griffiths *et al.* 1999).

Following the amendment to the Sea fisheries Act in 1992 (Sea Fisheries Amendment Act No. 57), the national assessment of the South African linefishery was carried out and several recommendations were made (*see* Brouwer *et al.* (1997); Lamberth *et al.* (1997); Mann *et al.* (1997a); Mann *et al.* (1997b); McGrath *et al.* (1997); Sauer *et al.* (1997); Fennessy *et al.* (2003); Mann *et al.* (2003)). Subsequent to this survey, in 1998 the Sea Fisheries Act was replaced by the Marine Living Resources Act (No. 18 of 1998), which was implemented on the 1 September 1998 (here on referred to as MLRA). This new act consolidated the Sea Fisheries Act and provincial Nature Conservation Ordinances, which previously regulated all marine resource utilisation in KZN. The MLRA was a revised system that classified stocks according to status, with associated regulations for each sector. There were a number of major changes that were brought about with the implementation the MLRA. One key change was the implementation of a compulsory national recreational license system for most all of marine fishing and harvesting. The primary aims of the licensing system were to enable determination of the number of recreational users, improve monitoring, enable better communication with resource users and to generate a source of funding for fisheries research and management. Prior to this, KZN had its own provincial marine licensing system, which was managed by the Natal Fisheries Licensing Board (FLB). Through this system, several licenses were made available and the funds generated through the sale of these licenses was managed by the FLB and largely used for marine conservation and management by the then Natal Parks Board (now known as EKZNW). Note that the original license system managed by FLB in KZN did not include a general angling permit and only included permits such as a ‘general bait’ licence (i.e. harvesting of marine bait organisms such as *Pyura stolonifera*) and a ‘spearfishing’ license. The national recreational permit system was therefore a follow on from this and had been proposed for a number of years before its actual implementation in 1998. For this reason, in the last national linefish assessment anglers had been asked if they were willing to pay for a general marine recreational angling permit. Surprisingly, 62% of the anglers interviewed in 1994-96 in KZN agreed to pay between R28 and R62 per annum (Mann *et al.* 1997a), although most stated that this was only on condition that the funds generated were used for fisheries conservation, research and management. Since its implementation the national recreational permit system has been met with mixed feelings by anglers and managers of South Africa’s marine resources. This has never been more evident than in 2010 where its function and applicability were heavily criticised following government proposals to increase license costs by up to 200% (Mann 2010). At the moment it still remains an ongoing issue with heavy debate concerning extreme licence fee increases, poor administration of the funds received and the failure to achieve any of the primary aims for which the licensing system was actually implemented to do.

Table 1.1- Changes that have occurred in linefish management between the years 1940 and 2010 (modified from Donovan (2010)).

Year	Changes to the Management Environment
1940	First regulations pertaining to offshore resources promulgated in terms of the new Sea Fisheries Act No. 10 of 1940
1973	Revised Sea Fisheries Act No. 58 of 1973 promulgated
1979	Smith Committee of Enquiry into the restrictions on the taking of shad (elf) in the nearshore waters of Natal was undertaken
1984	First suite of linefish regulations (i.e. minimum size limits, daily bag limits, closed seasons, closed areas, commercial capping, A- and B- licenses issued for commercial fishers) promulgated in terms of Sea Fisheries Act No. 58 of 1973 (Government Gazette No. 9543)
1988	Linefish regulations updated in terms of the new Sea Fisheries Act No. 12 of 1988
1992	Major revision of linefish regulations in terms of Sea Fisheries Act No. 12 of 1988 (Sea Fisheries Amendment Act No. 57 of 1992)
1998	Promulgation of Marine Living Resources Act No 18 of 1998- revision of linefish regulations, recognition of subsistence fishers and introduction of national permit system
1999	Development of Linefish Management Protocol (LMP), A- and B-commercial licenses abolished and introduction of annually allocated commercial fishing rights
2000	Linefishery declared in a state of emergency/crisis in terms of Marine Living Resources Act No 18 of 1998 (Government Gazette No. 21949)
2001	Once off "roll-over" of commercial fishing rights from the 1999/2000 fishing season
2002	Regulations promulgated under National Environmental Act (No. 107 0f 1998) to limit the use of off-road vehicles in the coastal zone (i.e. blanket beach vehicle ban), commercial effort reduced by 70% in KZN, medium-term commercial rights (four year tenure) allocated for the first time, revision of several catch restrictions
2005	New suite of linefish regulations promulgated in terms of Marine Living Resources Act No. 18 of 1998 (Government gazette no. 27453)
2006	Allocation of long-term commercial rights (8 year tenure), formation of crew register and issuing of subsistence permits in KZN (Government gazette no. 27843)

Despite the improved body of legislation that was brought about through the promulgation of MLRA, implementation of the Act with regard to the linefishery has been very poor (Griffiths *et al.* 1999; Mann *et al.* 2002b; Kleinschmidt *et al.* 2003; Pradervand *et al.* 2003; Witbooi 2006; Beckley *et al.* 2008). Furthermore, the Act has also been criticised for lacking quantitatively defined objectives and having inadequate provisions of reliable data for monitoring (Griffiths *et al.* 1999). Following two extensive workshops, one on the KZN reef-fishery (Harris 1997) and the other on the management and monitoring of the national linefishery (Penney *et al.* 1997), a new Linefish Management Protocol (LMP), in the form of a simplified Operational Management Procedure (OMP), was developed in 1999 (Table 1.1) (Griffiths *et al.* 1999). The LMP was basically a system designed to implement management plans for each important linefish species on a predetermined system of monitoring, assessment and revision of management regulations (Griffiths *et al.* 1999). Although in South Africa the concept of periodically collating and publishing scientific information on key linefish species is not new to management (Wallace and van der Elst 1983; van der Elst and Adkin 1991), the LMP contains more quantitative information, which includes biological reference points (e.g. spawner-biomass-per-recruit levels of 40% and 25% of pristine) and stock status indicators (e.g. CPUE <25% of historic value), which are essential in the drawing up of management plans (*see* Griffiths *et al.* 1999).

Following the publication of detailed status reports on a number of South Africa's key linefish species brought about through implementation of the LMP (Griffiths *et al.* 1999; Mann 2000), the Minister of the Department of Environmental Affairs and Tourism (DEAT) declared a state of emergency in the linefishery in December 2000 (Government Gazette No. 21949 of December 2000) (Table 1.1). The notice called for a drastic reduction in the current level of commercial linefishing effort by approximately 70%. Thus, to manage the commercial linefishery sufficiently and to minimise socio-economic impacts that would be suffered with such a cut in effort, the Department (DEAT) divided the fishery into three commercial sectors, namely handline hake, tuna pole, and traditional linefishing[*] (note that this study only focuses on traditional linefishers in KZN). Between 1999 and 2001, A- and B-licences fell away and traditional linefishers operated under exemptions granted to them in terms of the MLRA (Table 1.1). Medium term fishing rights were allocated for the first time in 2002 and long-term rights were allocated in 2006 (Table 1.1). The long-term rights differed to previous management strategies since they were allocated for a period of 8 years with regular assessments against predetermined criteria (DEAT 2005). Importantly, these rights were not transferable or saleable. Furthermore, the South African linefishery was divided into three main regions (i.e. Port Nolloth to Cape Infanta; Cape Infanta to Port St Johns; and Port St Johns to Kosi Bay), of which rights holders could not move between (DEAT 2005). The TAE (total applied effort) for the traditional linefishery was therefore set at 450 vessels and 3 450 crew. Currently there are ca. 38 (of the 51 allocated) right holders that have activated their licenses in KZN for 2010 (Y. Snyders, 2010, MCM, pers. comm.). The criteria to obtain a commercial right remain rigorous with strict conditions and evaluative principles. This, coupled with decreasing catch returns over the years has raised many concerns and the actual number of full-time commercials operating remains relatively low in KZN (B. Mann, 2010, ORI, pers. comm.). For this reason, the original stipulation that commercial fishers must obtain 100% of their income from fishing has been relaxed and now only 50% of their gross annual income needs to be derived from commercial fishing (DEAT 2005).

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[*] Traditional linefishers are classified accordingly as fishers that use a handline or rod-and-reel, with a maximum of ten hooks per line, to catch mainly demersal (resident reef and soft substrate species) and pelagic gamefish fish species.

Overall, the allocation of rights was a major step in terms of the management of the entire commercial linefishery. It facilitated law enforcement and compliance to ensure conservation and management of marine resources. In addition, the rights allocation process also encouraged investment in the industry and job creation. The new rights system was also envisioned to allow transformation in the commercial linefishery allowing greater access to previously disadvantaged persons and more South Africans living in coastal communities to benefit from the fishery. In this regard all crew who intended working on traditional linefish boats had to register with the Department on the 'crew register/list' (Table 1.1). The crew register was specifically designed to help alleviate the shortage of crew for commercial boat operators and to allow them to choose more reliable crew members, who as a requirement of the registry needed to have shown a reliance on traditional linefishing and have passed a SAMSA (South African Maritime Safety Authority) safety training coarse. The crew register was also envisaged to provide crew with a recognised career path away from being casual labourers.

Other major changes that have occurred in the linefishery since the first national line fish assessment include the recognition and registration of subsistence linefishers, a national ban of vehicles driving on the beach, and the promulgation of new linefish regulations for several species in 2005 (i.e. a complete revision of minimum legal size and daily bag limits and closed seasons for both commercial and recreational fishers) (*see* Government Gazette 27453). Some important linefish species (relevant to KZN only) that have undergone changes in regulations since the last national linefish assessment are highlighted in Table.1.2.

The national beach vehicle ban (Regulation No. 1399 of 2001 in terms of section 44 of the National Environmental Management Act (1-7) 1998) has been highlighted as one the major factors that has contributed to the apparent decline in angler effort along the KZN coast since the previous linefish assessment (Mann *et al.* 2008). The ban, which became effective in January of 2002 (Table1.1), prohibits the recreational use of vehicles in the coastal zone[*], unless in a declared recreational use area (RUA) (Celliers *et al.* 2004). Prior to the implementation of the national beach vehicle ban, driving on the beach was managed by regional or local authorities through a permit system. Although beach access was particularly well controlled in KZN through EKZNW, several areas not under EKZNW jurisdiction simply failed to enforce and control beach utilization. The permit system therefore did not protect the sensitive areas for which it was initially intended, and several coastal environments were further degraded. This

[*] An area adjacent to the sea characterised by coastal landforms, and includes beaches, dunes, estuaries, coastal lakes, coastal wetlands, land submerged by the waters of the sea, or of any estuary, coastal lake or coastal wetland, boat-launching sites, proclaimed harbours and recreational use areas.

highlighted a need for national legislation along the whole of South Africa and the ‘blanket‘ beach vehicle ban was eventually promulgated. Therefore, since the previous survey, there has been a considerable change in areas that could previously be utilised by anglers and which are now inaccessible. Since the KZN coast has several areas of beach that stretch for many kilometres (especially along the north coast of KZN) with no or few access points, fishing effort and pressure may have been alleviated in these areas (Mann *et al.* 2008). However, with the associated alleviation of pressure in many areas, comes the increased pressure in easily accessible areas (Mann *et al.* 2008).

It is clear that the many changes in the linefishery have affected patterns of resource use along the KZN coast. Some recently introduced management systems have also tried to address many of the problems experienced in the past (i.e. Linefish Management Protocol). However, it has been several years since the efficacy of management has been evaluated. It is thus vital that an assessment of management of the KZN linefishery, such as the last one carried out between 1994 and 1996 (Mann *et al.* 1997a), be done to improve management and outline any problems that have or may arise.

Table 1.2- Important linefish species from KZN that have undergone changes (bold) in regulations since the first national linefish assessment was conducted in 1994-96 (Note these regulations are in terms of the Sea Fisheries Amendment Act No. 57 of 1992 and the Government Gazette No. 27453 of the Marine Living Resources Act No. 18 of 1998; refer to Table 1.1)

SPECIES	COMMON NAME	MIN SIZE		BAG LIMIT		CLOSED SEASON	
		1994-96	2009-10	1994-96	2009-10	1994-96	2009-10
Argyrosomus spp. (caught from a boat in KZN)	Kob/salmon	350	**400**	10[2]	**5 (but may only be in possession of one over 1100mm)[1]**	-	-
Argyrosomus spp. (caught from estuaries & from the shore east of Cape Agulhas)	Kob/salmon	400	**600**	10	**1**	-	-
Atractoscion aequidens	Geelbek	400	**600**	10[2]	**2[2]**	-	-
Cheimerius nufar	Santer	300	300	10[2]	**5[2]**	-	-
Chrysoblephus anglicus	Englishman	none	**400**	5[2]	**1[2]**	-	-
Chrysoblephus cristiceps	Dageraad	300	**400**	5	**1**	-	-
Class Chondrichthyes	(sharks/rays/skates /chimaeras)	–	–	10[2]	**1pppd[2]** (excluding *Charcarodon carcharias*)	-	-
Cymatoceps nasutus	Poenskop	500	500	2	**1**	-	-
Dichistius capensis[3]	Galjoen	350	350	5	**2**	15 Oct- last day of Feb	15 Oct- last day of Feb
Epinephelus andersoni	Catface rockod	400	**500**	5	5	-	-
Epinephelus marginatus	Yellow-belly rockcod	400	**600**	5	**1**	-	-
Lichia amia[3]	Garrick	700	700	5	**2**	-	-
Pachymetopon grande[3]	Bronze bream	300	300	5	**2**	-	-
Petrus rupestris	Red steenbras	400	**600**	2	**1**	none	**1 Sep- 30 Nov**
Polysteganus praeorbitalis	Scotsman	300	**400**	5	**1**	-	-
Polysteganus undulosus	Seventy-four	400	**Total ban**	2	**Total ban**	1 Sep- 30 Nov	**Total ban**
Pomadasys olivaceum	Piggy/pinky	none	**75**	none	10[2]	-	-
Pomatomus saltatrix	Shad/elf	300	300	5[2]	**4[2]**	2 Sep-30 Nov	**1 Oct-30 Nov[4]**
Sarpa salpa	Strepie	150	150	none	**10[2]**	-	-

[1] Argyrosomus spp. for commercials have an unlimited bag limit, but only one over 1100mm.
[2] Recreationals only, commercials have unlimited bag limit.
[3] Commercials are prohibited to catch these species.
[4] Commercials in KZN are not allowed to land or sell any *Pomatomus saltatrix*

1.3. STUDY AREA

The area under study, the KZN coastline, constitutes approximately 19% (564 km) of the South African coastline, and extends from the South African border at Ponto do Ouro (20°52' S; 32°55' E) in the north to Port Edward (31°06' S; 30°1' E) on the former Transkei Border (Eastern Cape) in the south (Fig. 1.1). KZN has a relatively straight coastline with few protected bays and is classified as a high-energy coastline (Penney *et al.* 1999). There is a fairly significant cape just south of St Lucia and a 150 km long bight, known as the Natal Bight, which is approximately 50km wide extending out to the 200m isobath between Port Durnford and Durban (van der Elst and Garratt 1984; Lutjeharms *et al.* 1989). The prevailing winds which govern most of the energy along the coast are usually from the south-west or north-east throughout the year. The shoreline of KZN is variable but is mainly characterised by sandy beaches interspersed with rocky outcrops (van der Walt 1995). There are 73 estuaries and coastal lagoons (Harrison *et al.* 2000), which although many remain closed for most of the year, are important nurseries for many juvenile inshore coastal fish species (Wallace and van der Elst 1975). The fact that the KZN coast represents a subtropical transition zone between the tropical Indo-Pacific biota (in the north-east) and warm-temperature biota (in the south) (Emanuel *et al.* 1992; Sink *et al.* 2005), is one of the reasons why it is regarded as a premier angling destination (Whibley and Garratt 1989).

The continental shelf exerts a strong influence on local circulation. According to the 200m isobath it ranges in width from 3-11 km north of St Lucia and south of Durban, but widens considerably to 50 km opposite the Tugela River (Lutjeharms *et al.* 1989; Penney *et al.* 1999; Sink *et al.* 2005). The oceanography of KZN is strongly influenced by the prevailing Agulhas Current, which flows in a south-westerly direction along the continental shelf edge (Schumann 1982). This current transports warm tropical water (22-27°C), which also accounts for the high diversity of fish species (Shannon 1989). Although the Agulhas Current is the dominant feature of this coast, the Natal Gyre, which is an elongated system of eddies flowing in the opposite direction to the main current, also has a strong influence on the oceanography of this region, especially between Richards Bay and Durban (Shannon 1989; Penney *et al.* 1999).

Over 120 different fish species (Penney *et al.* 1999), mostly of Indo-Pacific origin (van der Elst 1989), are caught in KZN waters, of which only a few comprise a large percentage of the catch (Mann 2000). The main target linefish species can be divided into two groups: demersal species and pelagic species. Pelagic Species can be subdivided into pelagic gamefish (e.g. scombrids and carangids) and billfish (e.g. istiophorids), while demersal species can be divided into reeffish (e.g. sparids and serranids) and soft-substrate species (e.g. haemulids and sciaenids) (Penney *et al.* 1999).

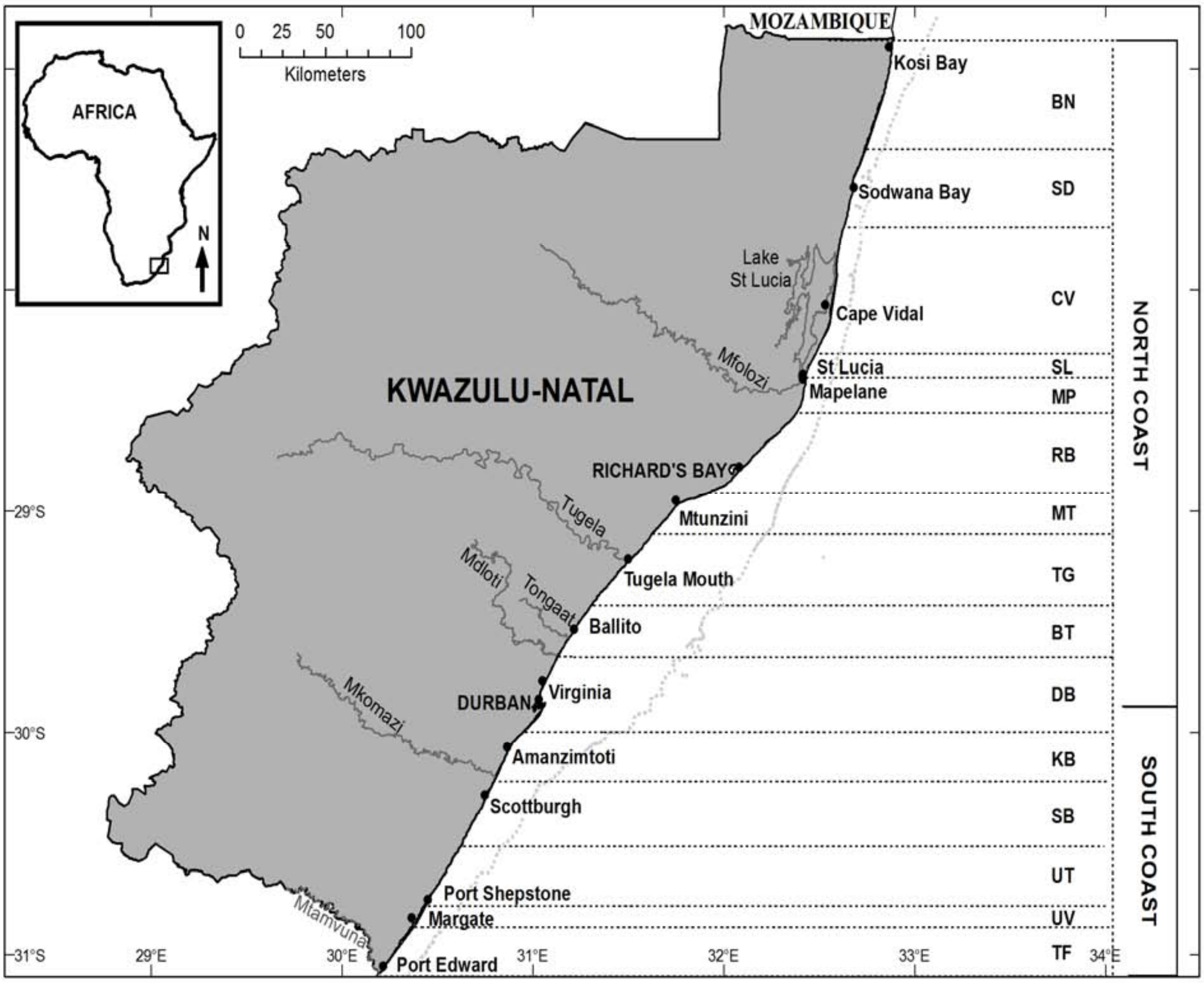


Figure 1.1- Map of the KZN coast divided into north and south coasts with the associated 15 EKZNW zones (BN=Banga-Nek; SD=Sodwana; CV=Cape Vidal; SL=St Lucia; MP=Mapelane; RB=Richards Bay; MT=Mtunzini; TG=Tugela; BT=Ballito; DB=Durban; KB=Kingsburgh; SB=Scottburgh; UT=Umtentweni; UV=Uvongo; TF=Trafalgar).

The topography and associated fishing pressure along the KZN coast is highly variable and detailed descriptions of the different region are given below:

The 145 km's of coastline between the Mozambique border (Ponto do Ouro) and Cape Vidal is declared as two contiguous marine protected areas (MPA), namely the Maputaland MPA and the St Lucia MPA. These MPAs form part of the iSimangaliso Wetland Park, a World Heritage Site proclaimed in 1999 (Fig. 1.1). Approximately 45 km of these two MPAs fall into no-take sanctuary areas where fishing is prohibited, while the rest has limited fishing where shore-anglers may catch any fish and skiboat and spear fishers may catch only pelagic gamefish species. This region is characterised by a warm sub-tropical climate with an annual rainfall of 1300-1400 mm that occurs throughout the year (Schultz 1997). The waters of this region are the only true tropical waters in South Africa and have one of the southernmost coral reef systems in the Indian Ocean, associated with deep, steep-sided submarine canyons located close offshore (Schleyer 1999). In addition to the large diversity of underwater life, there are extensive sandy beaches and interconnected lakes and estuaries (e.g. St Lucia estuary and lake) that make up more than 80% of the estuarine area in KZN (Harrison *et al.* 2000). This coastal region is extensively utilised by recreational and subsistence fishers in certain areas that are easily accessible (e.g. St Lucia, Cape Vidal, Sodwana, and Kosi-Bay). However, due to the limited access to the coast and the fact that it is declared and zoned as an MPA, the region has relatively low overall fishing pressure (Mann *et al.* 2008).

Between St Lucia and Tugela the continental shelf is further offshore (+-50km according to the 200m isobath) and the area forms part of the Natal Bight, which is dominated by northward flowing eddies of the Natal Gyre and more turbid conditions (Lutjeharms *et al.* 1989; Penney *et al.* 1999; Sink *et al.* 2005). The coastline is dominated by long sandy beaches with associated high dunes, rivers, coastal lakes, and wetlands. Along this stretch of coastline only seven estuaries enter the sea (Harrison *et al.* 2000). There is a wide diversity of fish species (i.e. reeffish, soft-substrate species, pelagic gamefish and billfish) that can be targeted by both shore and offshore linefishers in this region (Penney *et al.* 1999). The port of Richards Bay is particularly important in this area, and it provides boat linefishers with access to several productive reefs, especially the deeper reefs (100-200 m) to the north of the Tugela River (Penney *et al.* 1999). Up to 11 commercial linefishers are known to operate regularly out of the Richards Bay harbour (Jairam 2005). The shore fishery in this region is quite dispersed at only <2 anglers.km^{-1} (Mann *et al.* 1997a).

The 40 km stretch of coastline between the Zinkwazi and Tongaat River is a sub-tropical region with ample rain (1000-1200 mm) that falls mostly in summer (Fig. 1.1) (Schultz 1997). The coastline is dominated by sandy beaches enclosed between rocky outcrops. This coastline, as with the area further south of Tongaat River, has well-developed infrastructure and is a particular favourite for angling (Whibley and Garratt 1989; Mann *et al.* 1997a; Mann 2008). Shore fishing effort ranges between 1.5-4 anglers.km^{-1}, while several launch sites in the area are important to commercial, recreational and charter boat-fishers.

The area between the Umdloti River and Umkomaas River (52 km) has by far the highest angling pressure along the KZN coast (Fig. 1.1.) (Mann *et al.* 1997a). It is characterised by fairly long, coarse sandy beaches, which are separated by rocky outcrops (Celliers *et al.* 2004). There are nine estuaries that enter the sea here (Harrison *et al.* 2000). These estuaries, as well as the warm coastal waters, support and maintain a wide variety of linefish species. Shore fishing effort averages between 3-8 anglers.km^{-1}. *P. saltatrix* is of particular importance to the shore fisherman in this area (Mann *et al.* 1997a). The Durban area also has characteristically high boat usage, particularly from Durban harbour and the adjacent Durban Skiboat Club (Khumalo *et al.* 2010). The deeper reefs (100-200 m) to the south of Durban are of particular value to the boat-based fishery.

The remainder of the KZN coast (127km) is characterised by urban ribbon development and a high population density (Fig. 1.1) (van der Walt and Govender 1996). The coastline is made up of coarse, sandy beaches that are frequently interrupted by large rocky headlands and wave-cut platforms (ledges). The number of estuaries in this area is exceptionally high at 46 (Harrison *et al.* 2000). There are numerous rocky reefs offshore, such as the well known Aliwal Shoal off Umkomaas and the Protea Banks off Shelly Beach (Penney *et al.* 1999). The shore fishery in this region has an average of >2anglers/km, and is a premier fishing destination for holidaymakers and local fisherman (Whibley and Garratt 1989; Mann *et al.* 1997a). Several important subsistence communities also reside in this area (e.g. Umgababa and Mfazazana) (Clark *et al.* 2002).

1.4. STATISTICAL ANALYSIS

To determine if the assumptions of parametric data analysis were satisfied (i.e. normality and constant variance), data were tested using the Shapiro-Wilks and Levene's test respectively (Zar 1999). In most cases, the assumptions were not satisfied. For this reason, transformation procedures, such as log (X), were applied to the data but distributional assumptions were still not met (Zar 1999). It is well known that transformations are often ineffective when data sets contain a large numbers of zero values (Hall 2000; Fletcher *et al.* 2005; Martin *et al.* 2005; O' Hara and Kotze 2010), such as in the CPUE data. As is often the case, transformations only normalise the distribution of the non-zero values, while the high frequency of zero values are simply replaced by an equally high frequency of the value to which zero is transformed (Hall 2000). Consequently, non-parametric data analysis was applied to untransformed data throughout the analysis. Kruskal-Wallis One Way ANOVA on Ranks was used for multi-sample comparisons after which Dunn's method was used for *post hoc* multiple-pairwise comparisons. Mann-Whitney U tests were used for two sample comparisons. Note that the variability associated with mean values presented throughout the text was ± standard deviation.

Microsoft Excel (2007) and SigmaPlot (11) were used for all statistical procedures and a significance level (α) of 0.05 was applied throughout.

CHAPTER 2

CATCH AND EFFORT OF THE KWAZULU-NATAL SHORE LINEFISHERY

2.1. INTRODUCTION

The South African shore fishery can be traced back to the fishing activities of indigenous Khoi people (Penney *et al.* 1989; Poggenpoel 1996; Griffiths *et al.* 2004; Parkington 2006). However, more recent records of shore fishing in South Africa can be traced back to Van Riebeeck's time (mid 1600's), where certain residents in Rondebosch (an area in the now South Western Cape) were given permission to fish from the shore for food and not to sell (van der Elst 1989). Although other types of fishing, such as seine-netting, remained the principal fishing method in South Africa, by 1830 recreational linefishing from the shore was becoming an important past time in England and North America, with the simple casting of a roll of handline being modified into an organised activity with rod and reel. More organised fishing techniques, including advanced stout fishing rods and centre-pin reels, were soon adopted in KwaZulu-Natal (KZN) and from the period 1885 to 1949 the first angling clubs (e.g. Umgeni Angling Club and Isipingo Angling club) and fishing unions (e.g. Natal Coast Anglers Union[*]) were developed, some of which are still in existence today (van der Elst 1989). Many indentured labourers in KZN, specifically from India, also influenced the fishery at this time as they often substituted their food by catching fish from local waters (Desai and Vahed 2007). These days, recreational shore-angling has become the most prolific form of angling and contributes approximately 76% of the GGP attributable to the marine recreational fishery (McGrath *et al.* 1997).

Although subsistence fishing has been practised ever since the first line was cast from the shore into the sea, it is only in recent years that particular attention has been paid to this sector. As defined in the MLRA, subsistence fishers are poor people living within walking distance of the resource, fishing with low technology gear and generally using fish caught for own consumption, while some surplus is often sold locally. Prior to the implementation of the MLRA, subsistence fishers, who were often historically disadvantaged individuals, did not have legal access to linefish resources since they were managed under recreational fishing regulations. For the most part subsistence fishers were therefore classified as an informal sector, and most of their activities were deemed illegal or seen as poaching. Finally, in 1998 a Subsistence Fisheries Task Group (SFTG) was appointed. This group made recommendations

[*] Now known as the KwaZulu-Natal Coast Anglers Union (KZNCAU)

with regard to subsistence fishers and much headway has been made in identifying this group of fishers as a separate sector in the linefishery (Branch *et al.* 2002a; Branch *et al.* 2002b; Clark *et al.* 2002; Cockcroft *et al.* 2002; Harris *et al.* 2002). Currently, although there is a draft subsistence & small-scale fisheries policy (*see* Government Gazette No. 33530 of 03 September 2010) and there are several monitoring programmes and major funding from the government, the actual number of 'true' subsistence fishers in KZN is unknown. An evaluation of this sector and a comparison with the monitoring programmes, such as the subsistence fishery monitoring in KZN, will prove vital in future management of this small, but important sector of the linefishery.

Active management of the KZN shore linefishery has been ongoing since the 1970's (van der Elst and Garratt 1984). Management decisions have traditionally been based on research that focused on specific life-histories of the most important species. However, nowadays catch and effort data form an important part in assessing the efficacy of management and providing information for specific management regulations. For example, creel surveys are needed to set daily bag-limits, while CPUE data from such surveys provide information on stock size, trends in catch composition and distribution of catch between sectors (Griffiths *et al.* 1999). Furthermore, long-term monitoring of catch and effort can provide indications of possible overexploitation in a fishery and allow for subsequent management decisions to be made before any collapse occurs. In KZN, fishery monitoring is a requirement of law under the Marine Living Resources Act No. 18 of 1998 (MLRA). Currently, monitoring of the KZN shore fishery is conducted by the regional management authority (Ezemvelo KwaZulu-Natal Wildlife-EKZNW) through daily compliance orientated shore patrols carried out by trained staff (Mann *et al.* 2008). The information collected on such patrols is available in a central database known as the National Maine Linefish System (NMLS; *see* Chapter 6). However, this data is limited (e.g. no length frequencies are recorded and patrols are mainly compliance-orientated) and has been criticised as being biased (e.g. spatial and temporal biases) and therefore providing a relatively poor representation of the true nature of the shore linefishery in KZN (*see* Chapter 6) (Mann-Lang 1996; Penney 1997). For this reason, an independent research survey was conducted along the KZN coast in 1994-96 (Mann *et al.* 1997a) in order to produce unbiased estimates of catch per unit effort (CPUE) and the size structure of targeted fish populations. However, since this original survey several changes have taken place in the KZN shore linefishery (e.g. the capping of commercial fishing effort, the beach vehicle ban and the introduction of the national marine recreational license system; *see* Chapter 1). The primary aim of this chapter was therefore: (1) to determine total inshore fisher participation and annual fishing effort; (2) to describe current trends in CPUE; (3) to determine trends in catch composition and total catch; and (4) make comparisons with other similar independent assessments previously conducted along the South African coast and abroad.

2.2. MATERIALS AND METHODS

2.2.1 Roving-creel survey

Catch and effort data was obtained by means of a stratified-random roving-creel sampling technique, based on the techniques developed in South Africa (Joubert 1981a; Clarke and Buxton 1989; Brouwer *et al.* 1997; Mann *et al.* 1997a; Brouwer and Buxton 2002; Pradervand and Baird 2002; Mann *et al.* 2003; Beckley *et al.* 2008) and abroad (Malvestuto *et al.* 1978; Malvestuto 1983; Essig and Holliday 1991; Robson 1991; Pollock *et al.* 1994). The KZN coast was divided into 15 zones (zones 1-6 in the north from Mozambique border to Tongaat River and zones 7-15 in the south from Durban to Port Edward) according to the same zones that were patrolled by EKZNW in 2008 (Fig. 1.1). Each zone was then sub-divided into sample sites that were not equidistant. These sites were based on monthly aerial surveys of the KZN shore fishery (relevant to angler access points and popularity, *see* Mann *et al.* 2008) and the proportion of the zone that could be effectively patrolled in a four hour period by foot. Randomised monthly patrols were carried out in each of 13 zones (TF to CV), while the remaining two zones (SD and BN) were only sampled once in summer (December to February) and once in winter (June to August) because of substantially lower angler densities (Mann *et al.* 2008) and for logistical reasons. Where possible, within each sampling day three patrols were carried out in a zone and randomised according to choice of sampling site, time (06h00-10h00/ 10h00-14h00/ 14h00-18h00) and direction of the patrol (north/south). Night patrols were mostly avoided for security reasons. All identified sampling sites in each zone were sampled at least once during the sampling period. Sampling was stratified according to the ratio of 6 weekdays: 6 weekend days/holidays per month based on the ratio determined by Clarke & Buxton (1989) and Mann *et al.* (1997a). Peak school holidays (when the school holidays of all nine South African provinces coincided) and public holidays were also treated as weekend days. On each patrol, fishing conditions (weather and sea conditions ranked according to good, fair and poor), time spent, distance patrolled and presence of an EKZNW officer were recorded. All anglers encountered during a patrol were checked and questioned about the time spent fishing and what fish they had caught. Anglers less than 12 years old were not interviewed due to the complexity of some of the questions. In instances where a large number of anglers were encountered a sub-sampling routine was followed whereby every 10^{th} angler was checked. However, all anglers were counted during each patrol. In instance where a small group of anglers was encountered fishing together, the combined catch and effort for that group was recorded and divided by the number of people in the group. All fish caught were identified (to lowest taxonomic level), measured and weight was calculated using standard length/weight regressions (Froese & Pauly 2010; Mann 2000; Oceanographic Research Institute, unpublished data). For catches that were kept/retained but could not be measured (i.e. used for bait or taken to vehicle already), fish lengths (and thus weights) were estimated using the average recorded for that species or its closest relative during the study period.

In addition to catch and effort data, a sub-sample of shore-anglers was interviewed using a detailed questionnaire, the results of which are discussed in Chapter 3.

2.2.2. Estimation of total fisher participation

Total participation of anglers in the KZN shore linefishery was calculated using the total number of marine recreational angling permits sold in KZN during 2008 (excluding those exclusively used for boat angling; MCM unpublished data) and the club:non-club angler ratio (using club records for 2009 from KwaZulu-Natal Coast Anglers Union (KZNCAU) and Zululand Shore Angling Association (ZSAA). Note that the value calculated from the licence sales accounted for those shore-anglers that did not have/buy a licence in 2008. This was done by extrapolation using the total percentage of shore-anglers recorded without a licence during the questionnaire survey (i.e. 4.6% of those interviewed; *see* Chapter 3). A third method described by Pradervand *et al.* (2003) was also used. This method estimated total participation by apportioning indicated angler effort (in terms of the declared number of outings in 12 months prior to date of interview) obtained from the questionnaire survey (see Chapter 3) into distribution categories (*i*) as follows:

0-10 outings i = 1

11-20 outings i = 2

21-20 outings i = 3, etc.

and applying the equation:

$$N_T = \sum \frac{(b_i/c \times 100) \times E_{toutings}}{d_i}$$

where N_T is the total number of anglers, b_i is the number of interviewees in category *i*, *c* is the total number of interviewees, d_i is the average number of outings in category *i* and $E_{toutings}$ is the total number of angler outings.

2.2.3. Estimation of total annual angling effort

Total annual angling effort was determined from aerial surveys conducted in 2007/2008 (*see* Mann *et al.* 2008), the method of which has been discussed at length by Hoenig *et al.*(1993) and Pollock *et al.* (1994). The aerial surveys were conducted along the entire KZN coast on weekdays, weekends, and public holidays. A total of 36 flights were undertaken between March 2007 and February 2008, half along the north coast* and half along the south coast** of KZN (Mann *et al.* 2008). Date, direction of flight (north/south), day type (weekday/weekend/public holiday), duration of flight, weather conditions (poor/fair/good) and number of anglers counted were recorded on each flight (Mann *et al.* 2008). To validate the aerial surveys ground-truthing was also conducted, which showed 91% similarity of results (Mann *et al.* 2008). The total annual angling effort ($E_{outings}$) was calculated using the following formula:

$$E_{outings} = E_{w1} + E_{w2}$$

where E_{w1} and E_{w2} are the weekday and weekend estimates respectively, which are given by:

$$E_{wj} = \left(\frac{\sum_{i=1}^{n} e_i}{(d/p)}\right) \times l$$

where j is weekdays or weekends, 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 sampling days and l is the total length of the sampling area. North coast and south coast were calculated separately and then summed as aerial counts on the north and south coast were done on different days (Mann *et al.* 2008). Since this was an instantaneous estimate of the total shore-angling effort, angler turnover rate (rate at which anglers arrive and depart from fishing sites over a 24 hour period) needed to be taken into consideration. This was done by multiplying the total annual angling effort ($E_{outings}$) calculated above by the turnover rate as follows:

$$E_{Toutings} = E_{outings} \times \mathit{Turnover\ Rate}$$

Two values were used for the turnover rate, the first was the value determined by Brouwer *et al* (1997) (i.e. 2.48) and the second was calculated using the following formula derived from Pollock *et al.* (1994) and Everett (2004) where:

* North coast refers to the region north of Durban and includes the zones BT through to BN (Fig 1.1).
**South Coast refers to the region south of Durban and includes the zones DB through to TF (Fig 1.1).

$$Turnover\ rate = \frac{\sum_{i=1}^{n} (f_i/s_i)\ /d}{\sum_{i=1}^{n} (h_i)\ /\ n}$$

where f_i is the latest fishing trip finishing time on the *i*th day, s_i is the earliest fishing trip starting time on the *i*th day, *d* is the number of days sampled, h_i is the duration of the fishing trip by the *i*th angler, and *n* is the total number of anglers sampled. Since the current survey was conducted on a stratified random basis, with the day stratified into three time periods (06h00-10h00/ 10h00-14h00/ 14h00-18h00), the complete fishing day (i.e. the mean number of hours that anglers were either fishing or expected to be encounted while fishing in a 24 hour period)could be accurately calculated. Although night patrols were rarely carried out, anglers starting fishing late in the afternoon/evening and returning in the early morning were intercepted.

2.2.4. Estimation of total catch and catch per unit effort (CPUE)

Since anglers differ greatly in fishing ability and because there are a number of variables that can affect CPUE on a daily basis (e.g. weather, area and time of day; Bennett & Attwood 1991), overall CPUE was calculated by taking the average CPUE per sample day for the entire data set. The following formula was used:

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

where C_i is the total number or weight (kg) of fish retained on the *i*th day, E_i is the effort (i.e. total angler hours) expanded on the *i*th day and *n* is the total number of days sampled. Anglers that had fished for less than 0.5 hours were excluded from the CPUE calculation to avoid influencing the variance of the catch-rate estimator by extreme catch rates that arise by chance during short fishing trips (Pollock *et al* 1994). Released fish were not included in CPUE calculations because of the unreliability of angler reports (e.g. memory recall and prestige bias) (Claytor and O'Niel 1991; Brouwer *et al.* 1997).

Total annual catch was estimated by multiplying total annual effort by the CPUE as follows:

$$C_{total} = \text{CPUE x } E_{total}$$

2.3. RESULTS

2.3.1. Roving-creel survey

During the period 01 February 2009 to 31 January 2010, 406 roving-creel surveys (patrols) were undertaken, covering a total distance of 1 967 km and a total time of 474.6 hours. A total of 5 804 anglers was counted, of which 5 048 were checked for catch and effort information. On average, a patrol spanned 4.8 ±3.0 km for a period of 1.2 ±0.7 hours. From roving-creel surveys, average angling effort on the KZN coast was calculated at 3.8 ±4.8 anglers.km^{-1}. This was much higher than the angler density calculated during the aerial surveys (2.3 ±2.4 anglers.km^{-1}).

The number of shore-anglers encountered on a sample day was strongly influenced by weather and sea conditions (Kruskal-Wallis One -way ANOVA, $H = 21.07$, $df = 2$, $p < 0.001$). Dunn's test indicated that poor weather/fishing conditions were associated with lower angler numbers compared to fair ($p < 0.05$) and good ($p < 0.05$) weather/fishing conditions. Fair and good weather/fishing conditions had similar angler densities ($p > 0.05$), highlighting that anglers tolerated a reasonable range of fishing conditions. An analysis of CPUE showed that the number of fish (Kruskal-Wallis One-way ANOVA, $H = 0.17$, $df = 2$, $p = 0.88$) and size of fish (Kruskal-Wallis One-way ANOVA, $H = 0.15$, $df = 2$, $p = 0.90$) caught were not dependent on the weather/fishing conditions on any day. However, the high variation associated with CPUE values may account for there being no statistical differences between weather/sea conditions and CPUE.

On average, anglers had fished for 2.4 ±2.5 hours before being checked by an interviewer. Most angler outings recorded involved 2.1 ±1.4 anglers, however this ranged between one and 12 anglers fishing in a group at any given time.

2.3.2. Total fisher participation

The total number of anglers participating in the KZN shore linefishery during 2009-10 was estimated between 41 283 and 68 200 anglers (Table 2.1; also *see* Table 2.4 and Appendix I). This value included 354-585 true subsistence fishers and 1 220 competitive anglers[*] (Table 2.1). Using the number of non-local KZN anglers interviewed (based on questionnaire survey, *see*

[*] Recreational anglers that belong to a formal angling union (e.g. KwaZulu-Natal Coast Anglers Union) and who fish on a regular basis in organized competitive fishing events, ultimately for provincial and national recognition. These anglers often fish with the intention of scoring the maximum number of points on fish weight. In other words, they generally target larger fish than social anglers, such as sharks and rays.

Chapter 3), it is estimated that between 8 463 and 13 981 shore-anglers (20.5%) visit KZN annually from other provinces.

Table 2.1- Total participation and mean CPUE (fish.angler^{-1}.hour^{-1}) for each sector of the KZN shore fishery from roving creel surveys conducted from February 2009 to January 2010 (Note: CPUE for each sector was calculated from the questionnaire survey, while overall mean CPUE (*see* section 2.3.3) was calculated from the catch and effort survey).

Sector	Total participation	Mean CPUE	Standard Deviation	Reference
Subsistence	354 - 585	0.22	0.55	Permit compliance (this study)
Competitive	1220	0.35	0.72	KZNCAU members*
Social (non-competitive)	39563 - 56425	0.27	0.41	This study
Total	41283 - 68200	0.28	0.48	-

2.3.3. Total annual angling effort

Based on the results of the aerial survey, total annual shore-angling effort along the KZN coast was calculated at 350 084 angler-days.year^{-1} (Mann *et al.* 2008). Taking into account the angler turnover rate of 2.48 (Brouwer *et al.* 1997) and the value calculated in this study of 2.17 (*see* section 2.2.2), the best estimate of total annual shore-angling effort along the KZN coast was between 759 682 and 843 702 angler-days.year $^{-1}$.

2.3.4. Spatial and Temporal variation in fishing effort

Distribution of shore-angling effort along the KZN coast is shown in Figure 2.1. Shore-angling effort was not significantly different (Kruskal-Wallis One-way ANOVA, $H = 19.43$, $df = 12$, $p < 0.08$) between any of the zones (Fig. 2.1). However, variability was extremely high, especially in those zones with high angler densities. Only eight and two roving-creel surveys were conducted in BN and SD zones respectively. On account of the low survey effort in these two zones, their samples were not large enough for chi-square approximations to hold, and they were therefore excluded from the Kruskal-Wallis One-way ANOVA test. A further analysis of shore angler effort between the north and south coasts of KZN also revealed no significant differences (Mann-Whitney U test, $U = 19647.5$, $df = 404$, $p = 0.5$). In conclusion, angler density is highest around built up areas, i.e. Durban, and lowest in northern KZN (Fig. 2.1.) Popular fishing destinations, namely CV and SL, also showed high angler densities.

Shore-angling effort varied considerably according to the austral seasons (Kruskal-Wallis One-way ANOVA, $H = 17.39$, $df = 3$, $p = 0.002$; Fig. 2.2). According to Dunn's test, winter (June to August) had the highest peak in angler effort and differed significantly ($p < 0.05$) from summer

* D. Nisbet, 2010, KZNCAU secretary, pers. comm. & B. Tedder, 2010, ZSAA records officer, pers. comm.

(Dec-Feb). Autumn and spring had similar angler densities and were not significantly ($p > 0.05$) different from the other austral seasons.

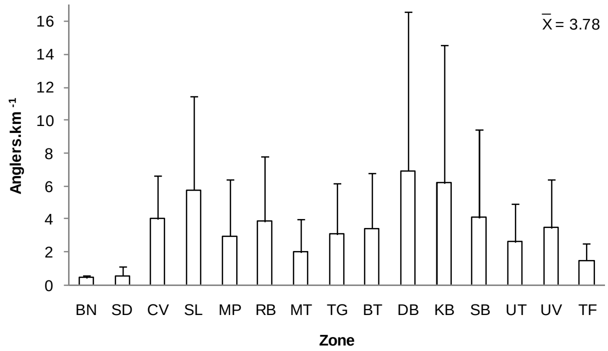


Figure 2.1- Spatial distribution of shore angler densities (mean + standard deviation) along the KZN coast as determined from 406 roving-creel surveys conducted between February 2009 and January 2010 (BN=Banga-Nek; SD=Sodwana; CV=Cape Vidal; SL=St Lucia; MP=Mapelane; RB=Richards Bay; MT=Mtunzini; TG=Tugela; BT=Ballito; DB=Durban; KB=Kingsburgh; SB=Scottburgh; UT=Umtentweni; UV=Uvongo; TF=Trafalgar).

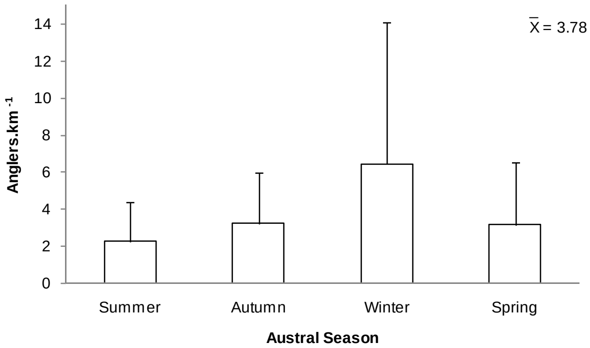


Figure 2.2- Seasonality of shore angler densities (mean + standard deviation) along the KZN coast as determined from 406 roving-creel surveys conducted between February 2009 and January 2010.

2.3.5. Catch per unit effort (CPUE)

During 13 370.6 hours of recorded fishing, a total of 4 933 fish was caught and 2 873 were kept/retained, constituting a total of 966.5 kg. Overall CPUE for the KZN shore fishery amounted to 0.18 ±0.3 fish.angler^{-1}.hour^{-1} or 0.07 ±0.13 kg.angler^{-1}.hour^{-1}. By taking the average angler day (4.6 ±2.7 hours), CPUE was 0.82 fish.angler-day^{-1} or 0.32 kg.angler-day^{-1}. CPUE differed between the different sectors of the shore linefishery (Kruskal-Wallis One-way ANOVA, $H = 8.318$, $df = 2$, $p= 0.016$), however, Dunn's test indicated this was only significant between subsistence and social anglers ($p < 0.05$, Table 2.1).

Spatial variation in CPUE along the KZN coast was clearly evident (Fig. 2.3). Several zones differed significantly in the number of fish (Kruskal-Wallis One-way ANOVA, $H = 45.22$, df =

12, $p < 0.001$) as well as the weight (Kruskal-Wallis One-way ANOVA, H = 36.85, df = 12, $p < 0.001$) of fish caught per angler per hour. For the most part, CPUE was higher on the south coast compared to the north coast in terms of CPUE by number. Overall, BT (026), DB (0.24), KB (0.21), UT (0.29), and UV (0.26) had the highest number of fish caught per angler per hour (Fig. 2.3a). The lower number of fish caught per angler per hour were mostly in the north coast zones, such as SD (0), CV (0.03), MP (0.01) and RB (0.15). Interestingly, BN (0.19) and SL (0.2) showed relatively high numbers of fish caught similar to zones on the south coast of KZN. TF had the lowest CPUE on the south coast at 0.1 fish.angler^{-1}.hour^{-1}. In terms of weight, SL (0.19) had the highest CPUE followed by TG (0.10), UT (0.10) and MT (0.09) (Fig. 2.3b). The lowest CPUE by weight was recorded in SD (0), MP (0), CV (0.03), TF (0.03) and RB (0.04) zones. Although BN, BT, DB, KB and UV had a high CPUE in terms of number of fish per angler per hour, the relative weight of those fish was small (Fig. 2.3b). The importance of a large number of smaller fish in catches along the KZN coast is quite evident, particularly along the south coast. The variance associated with CPUE calculations (*see* 2.2.4 above) is considerably high, as Figure 2.3a and 2.3b both highlight; this often confounds statistical analysis at a significant level (α) of 0.05. Note that for all CPUE calculations BN and SD zones were excluded from the Kruskal-Wallis One-way ANOVA since their samples were not large enough for chi-square approximations to hold.

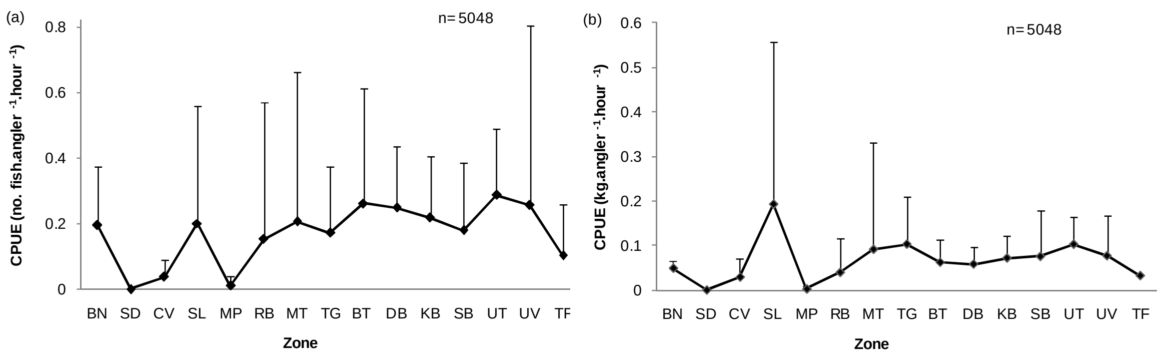


Figure 2.3-Spatial variation of mean (+ standard deviation) CPUE of shore-anglers according to (a) no. fish.angler^{-1}.hour^{-1} and (b) kg.angler^{-1}.hour^{-1} along the KZN coast from 406 roving-creel surveys conducted between February 2009 and January 2010 (BN=Banga-Nek; SD=Sodwana; CV=Cape Vidal; SL=St Lucia; MP=Mapelane; RB=Richards Bay; MT=Mtunzini; TG=Tugela; BT=Ballito; DB=Durban; KB=Kingsburgh; SB=Scottburgh; UT=Umtentweni; UV=Uvongo; TF=Trafalgar).

The seasonal trend in CPUE is shown in Figure 2.4. Overall, the number of fish per angler per hour was highest from July (0.4) to November (0.23), i.e. winter and spring months, and lowest from December (0.15) to June (0.18), coinciding with summer and autumn (Fig. 2.4a). However, an ANOVA of the monthly CPUE and between the different austral seasons (months combined into seasons) did not show any significant differences. In terms of weight, CPUE followed a similar trend as described above (Fig. 2.4b). Importantly, there was a peak in CPUE by weight in winter (July, 0.17 and August, 0.13) and late spring (November (0.13) and December (0.10)). The remainder of the year from February to June and September, October, and January, ranged between 0.03 and 0.06 kg.angler^{-1}.hour^{-1}. There was also no significant difference found between months and the different austral seasons and the weight of fish caught per angler per hour. High variation associated with CPUE may again account for there being no statistical differences.

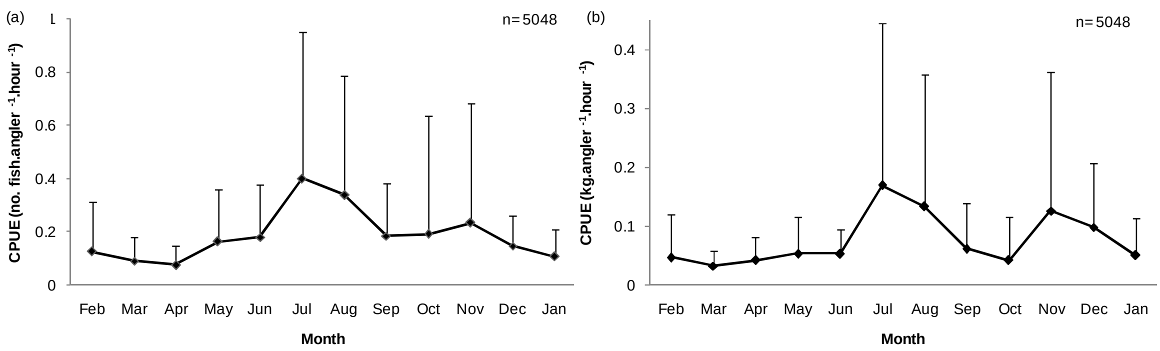


Figure 2.4- Monthly variation of mean (+ standard deviation) CPUE of shore-anglers according to (a) no. fish.angler^{-1}.hour^{-1} and (b) kg.angler^{-1}.hour^{-1} along the KZN coast from 406 roving-creel surveys conducted between February 2009 and January 2010.

2.3.6. Total catch and catch composition

Based on the estimate of total shore-angling effort and average CPUE, the total annual catch for the KZN coast was estimated between 249.2 and 276.7 metric tonnes (mt) per annum (636 589 - 706 995 fish per annum). Seventy teleost species, belonging to 35 families and 14 cartilaginous species representing four families were recorded in catches during the study period (Appendix III). The top five species that made up the majority (75%) of the catch numerically included *Sarpa salpa* (34.8%), *Pomatomus saltatrix* (14.7%), *Diplodus capensis* (formerly known as *Diplodus sargus capensis* 14.5%), *Pomadasys olivaceum* (6.5%) and *Rhabdosargus holubi* (4.9%). Similarly, by weight 66% of the total catch was made up of *P. saltatrix* (20.2%), *S. salpa* (14.0%), *Lichia amia* (13.5%), *D. capensis* (11.0%) and *Pachymetopon grande* (7.8%) (*see* Appendix III). Although *P. grande* (1.8%) and *L. amia* (0.8%) were caught in low numbers compared to other species, they still made up a substantial amount of the entire weight of fish kept due to their larger mean capture size. Generally, smaller fish that are more abundant play a significant role in both numbers and weight of the entire catch along the KZN coast. Catch composition for subsistence and competitive anglers was not analysed separately since the total number of fish recorded caught by these sectors was very low (i.e. 24 and 32 fish respectively).

Directed angling effort, described as angler preference (which species anglers described they were primarily targeting), showed that most anglers preferred to target *P. saltatrix* (26%), while *D. capensis* (15%), *P. grande* (11%) and *Argyrosomus japonicus* (7%) made up an additional 33% of the fish targeted (Table 2.2). Although *A. japonicus* was a popular angling species, it made up little of the total catch by both weight and number (*see* Appendix III).

Species	%
Pomatomus saltatrix	26
Diplodus capensis	15
Pachymetapon grande	11
Argyrosomus japonicus	7
Pomadasys commersonni	5
Rhabdosargus sarba	5
Sarpa salpa	5
Lichia amia	4
Trachinotus africanus	3
Carcharhinus spp.	3

Table 2.2- The top 10 angling species targeted by shore-anglers on the KZN coast from 1049 questionnaires conducted between February 2009 and January 2010.

In terms of species groups, anglers preferred to target reeffish (i.e. fish associated with rocky substrata in the surf-zone) and *P. saltatrix* (Fig. 2.5a). However, soft-substrate species (i.e. fish associated with sandy surf-zone) also made up an important percentage of directed effort. Interestingly, elasmobranchs were also specifically targeted by five percent of the anglers interviewed although these were primarily competitive anglers. Catch composition for the targeted species groups is described in Figure 2.5b and is very similar to the directed angling effort described above. Reef fish are, however, more important in catches than described by angler preference. Although many anglers preferred to target elasmobranchs, soft-substrate species and pelagic gamefish, few were actually recorded during the sampling period except for *P. saltatrix* (regarded as a pelagic gamefish). *P. saltatrix* was important in both preference and actual catch. It is thus clear that the majority of anglers prefer to target favourable species. However, when these species are absent they will adapt their techniques to fish for more abundant/available fish species.

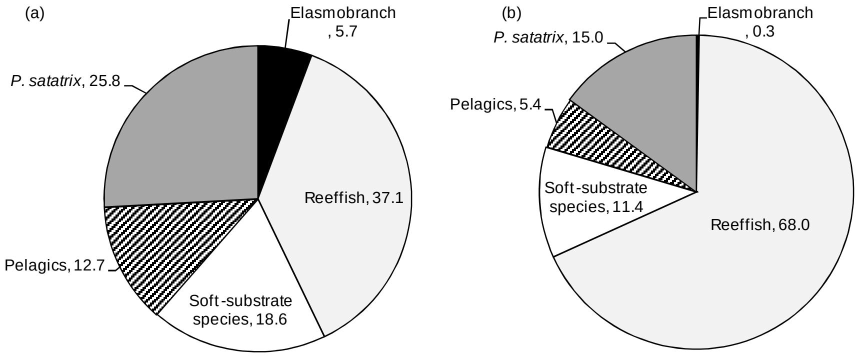
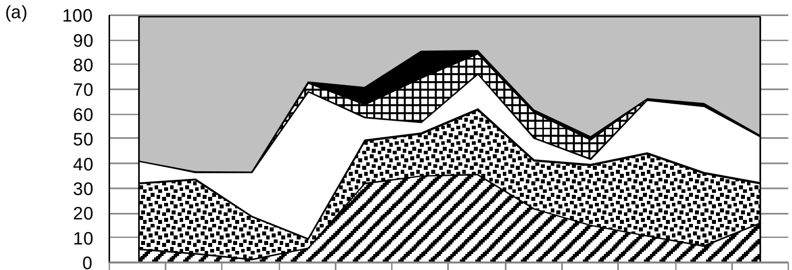
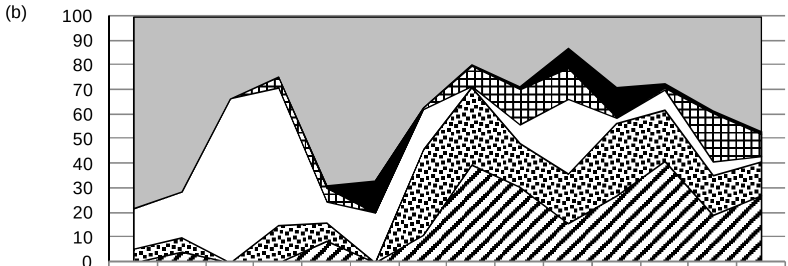


Figure 2.5- Percentage targeted shore-angling effort in terms of (a) angler preference and (b) actual catch by number directed at four target species groups and *P. saltatrix* found along the KZN coast from 406 roving-creel surveys conducted between February 2009 and January 2010.

The seasonal abundance of the top five species caught and kept by shore-anglers along the KZN coast is shown in Fig. 2.6a. Most notable is the general increase in abundance of *S. salpa*, *P. olivaceum* and *R. holubi* during winter (Jun-Aug). This increase in abundance is also associated with a decrease in the number of "OTHER" species caught, which highlights once again the change in directed effort by anglers to more abundant species at specific times of the year. *D. capensis* is relatively abundant throughout the year. *P. saltatrix* showed two distinct peaks in abundance, once during May and then another over a three month period (Nov-Jan). The month of May remained the only time during the year where *P. saltatrix* made up more than 50% of the catch. However, it should be noted that 2009 represented a comparatively poor catch of *P. saltatrix* which normally dominates the catches (31% of total catch) throughout the year (Mann *et al.* 1997a).



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
OTHER	58	63	63	26	29	14	14	38	49	33	35	48
CSTM	0	0	0	0	7	11	1	1	1	0	1	0
PGGY	0	0	0	4	5	18	8	11	8	1	0	1
ELF	9	3	18	59	9	4	15	9	2	21	27	19
BLTL	27	30	17	4	17	17	26	19	24	33	29	16
STRP	6	4	2	7	33	36	36	22	16	11	7	17



	BN	CV	SL	MP	RB	MT	TG	BT	DB	KB	SB	UT	UV	TF
OTHER	78	71	33	24	69	67	37	19	28	13	29	27	38	47
CSTM	0	0	0	0	1	13	0	1	1	8	12	2	1	1
PGGY	0	0	0	5	6	0	1	8	14	13	0	1	20	9
ELF	17	19	67	56	9	21	16	0	8	30	2	8	6	2
BLTL	6	6	0	15	7	0	35	31	18	20	29	21	16	14
STRP	0	4	0	0	9	0	11	40	31	16	27	41	19	27

Figure 2.6- The (a) monthly and (b) spatial species composition of the major species caught by shore-anglers along the KZN coast recorded during 406 roving-creel surveys conducted between February 2009 and January 2010 (STRP= *Sarpa salpa;* BLTL= *Diplodus capensis;* ELF= *Pomatomus saltatrix*; PGGY= *Pomadasys olivaceum*; CSTM= *Rhabdosargus holubi*; and OTHER= all other species) (BN=Banga-Nek; SD=Sodwana; CV=Cape Vidal; SL=St Lucia; MP=Mapelane; RB=Richards Bay; MT=Mtunzini; TG=Tugela; BT=Ballito; DB=Durban; KB=Kingsburgh; SB=Scottburgh; UT=Umtentweni; UV=Uvongo; TF=Trafalgar). Note SD zone was excluded since there were no fish recorded in this zone during roving-creel surveys.

The majority of the top five priority species (excluding *P. saltatrix*) were caught more on the south coast (south of BT) compared to the north coast (Fig. 2.6b). *P. saltatrix* made up a significant proportion of fish caught north of RB, especially in the MP and SL zones. There was however, a high number of *P. saltatrix* caught in the KB zone compared to the rest of the south coast. The number of ‘OTHER’ species caught was particularly high north of TG and comprised particularly of species such as *Trachinotus botla*, *Dinoperca petersi*, *Lichia amia*, *Pomadasys commersonni*.

The length frequencies of the five most important fish caught and kept by shore-anglers are shown in Figure 2.7. Both *S. salpa* and *P. olivaceum* were mainly caught above their minimum legal size limits. However, *P. saltatrix, D. capensis and R. holubi* all showed a wide range in size classes that were caught and kept by anglers. Worryingly, a substantial amount of *D. capensis* (25.5%) and *R. holubi* (21.8%) kept by anglers were under their minimum legal size limits. Ten percent of *P. saltatrix* kept fell under their minimum legal size limit of 30 cm (total length). Other important species that were commonly caught and kept by shore-anglers but that were generally smaller than their legal minimum size limits included: *Diplodus hottentotus* (93.3%), *Epinephelus marginatus* (85.7%), *Argyrosomus spp.* (84.2%), *E. andersoni* (58.3%) and *Pomadasys commersonii* (55.6%).

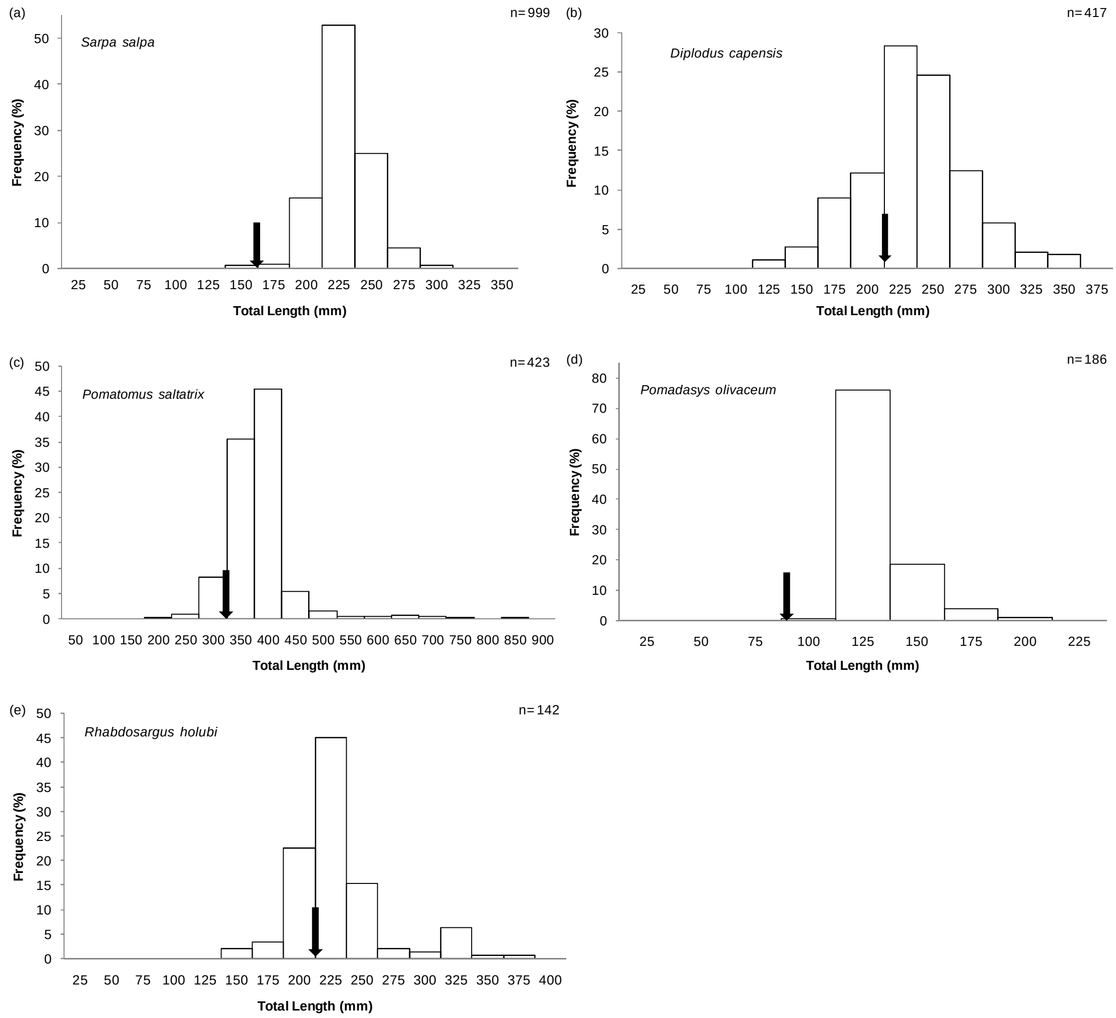


Figure 2.7- Length frequency distributions and minimum sizes (arrow) of the five most important angling species, (a) *Sarpa salpa*, (b) *Diplodus capensis*, (c) *Pomatomus saltatrix* , (d) *Pomadasys olivaceum* and (a) *Rhabdosargus holubi*, caught and kept by shore-anglers recorded during 406 roving-creel surveys conducted along the KZN coast between February 2009 and January 2010.

Taking the daily bag limits of the five most important fish species kept by shore-anglers into account, most anglers caught under their daily bag limits, while only a small proportion of anglers interviewed had actually caught their daily bag limits for the species they were targeting (Table 2.3). Few anglers also kept more than the daily bag limits of the fish they targeted (Table 2.3). Furthermore, at the time of the interview only 0.5% of all anglers checked had kept more than the overall cumulative daily bag limit of 10[*] fish per person per day (species that had a bag limit greater than 10pppd were excluded from this calculation).

Of all the fish recorded during roving-creel surveys, only *P. saltatrix* (1 October-30 November) and *Dichistius capensis* (15 October- last day of February in the following year) have a closed season. Considering these, 28 anglers had caught and kept 32 *P. saltatrix* during its closed season, while only one *D. capensis* was recorded in the entire study and it was also caught and kept during its closed season. During the aerial-survey conducted in 2007-08 there was a significant decrease in angler numbers throughout the closed season for *P. saltatrix* (Mann *et al.* 2008). This reflects the effectiveness of this regulation in reducing the overall fishing effort, particularly when *P. saltatrix* is at its most vulnerable (i.e. spawning along the KZN coast).

Table 2.3- Percentage of anglers that violated and complied with the daily bag limits of the five most important fish species caught and kept along the KZN coast from 409 roving-creel surveys (BL = daily bag limit for each species).

Species	% of anglers who had kept more than the bag limit	% of anglers who had attained the bag limit	% of anglers who had not attained the bag limit
Diplodus capensis	0.4	0.2	99.4
Pomatomus saltatrix	2.9	3.2	93.9
Pomadasys olivaceum	2.8	4.2	93.0
Rhabdosargus holubi	1.3	0.6	98.1
Sarpa salpa	0.8	0.3	98.8

2.4. DISCUSSION

2.4.1. Survey techniques

The roving-creel sampling technique has remained the most favourable technique among linefish scientists in South Africa for sampling shore fishing (Joubert 1981a; Clarke and Buxton 1989; Brouwer *et al.* 1997; Mann *et al.* 1997a; Brouwer and Buxton 2002; Pradervand and Baird 2002; Mann *et al.* 2003; Beckley *et al.* 2008). Similarly, internationally it remains one of the principle methods to obtain accurate catch and effort information in fisheries that are dispersed over large areas with multiple-users (Caputi 1976; English *et al.* 1986; Colvin 1991; Essig and Holliday 1991; Robson 1991; Kirchner and Beyer 1999; Hartill and Cryer 2000;

[*] In terms of the MLRA, there is an overall cumulative daily bag limit of 10 fish per person per day, irrespective of the species caught and provided that the limit does not apply to those species listed with no bag limit, and those with a bag limit exceeding 10.

Rangel and Erzini 2007). It is also an adaptable method that can be used in conjunction with other survey techniques, for example the questionnaire and aerial surveys, such as in the current study. Combined survey methods (companion methods) can also be highly effective in obtaining accurate data and minimizing several biases associated with a single survey technique (Hartill *et al.* 2010).

In general, the methods used in the current study to sample the KZN shore fishery were better designed and more comprehensive than the survey conducted in 1994-96 (Mann *et al.* 1997a) since it took into account many logistical and sampling biases suffered in the previous linefish survey sampling design. For example, the previous KZN shore fishery survey (Mann *et al.* 1997a) divided the coast into 18 relatively short patrol areas that were sampled monthly, whereas the current study attempted to cover most of the coastline in a random, stratified manner. Though there are inevitably still biases associated with the sampling design used in this study, there are few other ways of obtaining such “snapshot” information on a multi-user fishery without creating exorbitant budgets that few agencies can afford. Furthermore, by diluting the spatial sampling effort for the same budget, several statistical problems can arise (*see* Pollock *et al.* 1994).

The stratified sampling technique used in the current study was specifically designed to minimise possible sampling biases and is preferable since roving-creel surveys become ineffective when equal effort is spent sampling areas of high and low fishing intensity (Stanovick and Nielsen 1991). For example, it was for this reason that the BN and SD zones, which have very low fishing effort (Mann *et al.* 2008), were only sampled on two occasions, once in summer and once in winter. Other survey techniques, such as postal or telephone surveys, would not be effective in the KZN shore fishery since many shore-anglers are illiterate and cannot be contacted easily (i.e. no telephone or mail address) (Statistics South Africa Census 2001; Brouwer *et al.* 1997; McGrath *et al.* 1997). Furthermore, surveys that tend to intercept anglers (on site techniques) are also more accurate than those surveys that rely on simple angler-reporting of harvests since many biases associated with angler reporting are reduced (Mallison and Cichra 2004). Several advantages and disadvantages of certain survey methods are discussed at length by Pollock *et al.* (1997) and Phippen & Bergersen (1991). It is important that the choice of sampling techniques/methods should suite the objectives of the fishery being sampled.

2.4.2. Total fisher participation

The estimate of total participation in the KZN shore linefishery has changed relatively little compared to estimates made in 1994-96 (Brouwer *et al.* 1997; Mann *et al.* 1997a), even though several important changes have taken place in the linefishery. The introduction of the national marine recreational permit system in 1998 enabled the actual number of anglers participating in the marine fishery to be assessed and monitored for the first time. Historical permit sales data from KZN (MCM unpublished data) shows that there has been a decrease in angling permit sales during the past 10 years since the permit system was implemented (Table 2.4). The estimate calculated during 1994-96 (72 419 shore-anglers) could therefore have been an underestimation of shore fisher participation at that time. This is particularly evident since during the first year that the permit system was implemented (1998), only two years after the 1994-96 survey was completed, there were ~90 000 recreational angling permits sold for shore-angling (Table 2.4). Similarly, van der Elst (1989) estimated approximately 102 000 shore-anglers participating in KZN during 1987. However, the early permit sales data (i.e. 1999-2001) are misleading and are unlikely to reflect total angler participation since there were several biases associated with the licence system in its initial years (A. Cockcroft, 2010, MCM, pers. comm.). It is apparent therefore that shore angler numbers have probably remained fairly constant at around 65 000 between the years 1987 and 2001, despite a proposed annualised increase of 6% per annum (van der Elst 1993b). It must be noted that the license sales from EKZNW and the Post Office only refer to permits sold in KZN. Shore-anglers who purchase a license in another province were therefore excluded from the estimates of total participation. Taking into account this figure could increase the angler participation estimates, however, during the questionnaire survey it became apparent that only a relatively small percentage of non-local shore-anglers purchased a permit outside of KZN (*see* Chapter 3).

Table 2.4- Number of licenses sold to shore-anglers by the Post Office and EKZNW in KZN from 1999 to 2009 (note: these numbers do not include those fishers that bought a marine recreational fishing permit to fish off boats; *see* Chapter 5). Anglers that did not purchase a license were not included in these values.

Year	No. of licenses sold
1999	94115
2000	86125
2001	86014
2002	71724
2003	57627
2004	49804
2005	63865
2006	67833
2007	65295
2008	64415
2009	not available
Total	706817

The significant drop in angler numbers in 2002 recorded in the annual license sales data from EKZNW and the Post Office (Table 2.4) can partially be explained by the implementation of the beach vehicle ban (Regulation No. 1399 of 2001 in terms of section 44 of the National Environmental Management Act (1-7) 1998). This decline in angler numbers is also evident in the competitive shore linefishery, where the number of club anglers has decreased by 35% since 2002 (*see* Appendix II). The resultant impact of the beach vehicle ban has not only been a decrease in total participation, but has also resulted in a spatial shift in fishing effort to be more focused around beach access points (Mann *et al.* 2008). A similar spatial shift in angler effort was recorded by Mackenzie (2005) in the Eastern Cape. Since 2005, the number of anglers participating in the KZN shore linefishery has been fairly constant (Table 2.4), and it is believed that this trend is most likely to continue with the current depressed state of linefish stocks and the economic cost associated with shore-angling as a recreational activity. It is important to note that when certain fish stocks decline, fishing does not necessarily cease but rather switches to other species, and the previous target species become occasional catches (Brouwer and Buxton 2002). This is a well documented trend and has been referred to as 'serial overfishing' (Attwood *et al.* 1997).

The number of anglers estimated to be visiting KZN waters from other provinces in the current study (i.e. 8 463-13 981) was similar to the 10 000 estimated in 1987 (van der Elst 1989) and has remained fairly constant since 1994-96 (Mann *et al.* 1997a). From these results, it appears that these anglers are less affected by changes in linefish management. Furthermore, anglers that visit KZN from other provinces generally belong to the higher income quintiles (McGrath *et al* 1997; *see* Chapter 3) and are therefore less affected by economic limitations/pressures.

The number of subsistence fishers estimated to be participating in the KZN shore fishery in the current study (354-585) was lower than the total number of licensed subsistence fishers reported in 2008 (845 fishers; Mkhize 2009). However, if one takes into account those anglers that claimed to be subsistence fishers (i.e. said that they fished for food, livelihood, or to sell), but whom did not have a subsistence license, a total of 3 836 "subsistence fishers" was calculated. This value is however, likely to be a vast overestimation of the number of true subsistence fishers participating in the KZN shore linefishery, in terms of the current definition of a subsistence fisher in the Marine Living Resources Act No. 18 of 1998. This issue is discussed in detail by Branch *et al.* (2002a). The results quite clearly illustrate a common loophole that occurs when attempting to manage subsistence fishers. That is where many people parade as subsistence fishers, when in fact they are illegal recreational and commercial fishers (Clark *et al.* 2002). A further economic analysis of subsistence fishers is provided in Chapter 3.

Overall, the permit system remains a valuable tool that can be utilised by managers to track changes in angler participation. It is of vital importance though that these data are made available, possibly in the form of an annual report. Furthermore, the issue of compliance in purchasing a fishing permit is critical to knowing whether permit sales accurately reflect the number of participants. Fortunately, KZN shore-anglers are relatively compliant towards purchasing a permit; this issue is discussed further in Chapter 3.

2.4.3. Total annual angling effort

The overall average angler density for the KZN coast in this study (2.3-3.8 anglers.km^{-1}) was lower than the 1994-96 KZN linefish assessment (7.2 anglers.km^{-1}). This can be explained by the fact that the average distance patrolled in 1994-96 (1.8 km) was substantially lower than the current study (4.8 km) and patrols were more focused at access points in the previous study where angler densities were higher (Brouwer *et al.* 1997). Using randomised aerial surveys to obtain an instantaneous estimate of total shore-angling effort is far more accurate and less biased than normal roving-creel surveys (Pollock *et al.* 1994). This has been highlighted in EKZNW shore patrols that are also often biased towards access points and areas of higher fishing effort (spatially and temporally) due to their primary role of ensuring compliance and law enforcement (Mann-Lang 1996).

Total annual angling effort has changed considerably since 1994-96. According to Mann *et al.* (2008) there has been a 42.7% decrease in effort in KZN from 1994-96 (1 337 223 angler days.year^{-1}) to 2007-08 (759 682 -843 702 angler days.year^{-1}), and this is also associated with a spatial change in angler effort. The decrease in total shore-angling effort can be attributed to a number of reasons. The beach vehicle ban introduced in January 2002 has likely contributed significantly to this decline. Other reasons for the decrease in effort include security concerns, declining linefish catches, the increasing cost of fishing and many more. Reasons given by anglers interviewed in this study are discussed in Chapter 3.

Later statistical analysis of the data between the periods 1994-6 and 2007-8, using Generalised Linear Models (C. Attwood, 2009, University of Cape Town, pers. comm.) has, however, refuted those reported by Mann *et al.* (2008) due to the high variability in the count data. Overall, only day type (weekday or weekend) had a strong and significant effect (ANOVA, F =

11.06, df = 49, p = 0.002) on angler effort (C. Attwood, 2009, University of Cape Town, pers. comm.). There was no significant differences between the two different time periods (P1= 1994-96 or P2= 2007-08) and zones (North coast or South coast of KZN), nor were there any interaction effects (C. Attwood, 2009, University of Cape Town, pers. comm.). A closer inspection of the residuals shows that a difference in means between the two periods was driven by one very high measurement of angler numbers in P1 on a weekend day in good weather and coincidentally the last day of open *P. saltatrix* season (C. Attwood, 2009, University of Cape Town, pers. comm.). However, the model involving weather as a random effect did not suggest that either period or weather had significant effects (C. Attwood, 2009, University of Cape Town, pers. comm.).

Using the total number of anglers participating in the shore linefishery (i.e. 41 283 and 68 200) and the average number of times fished by an angler in 12 months (i.e. 8.7 times.annum^{-1}; *see* Chapter 3), another estimate of total annual angling effort was calculated at 359 162-593 340 angler-days.annum^{-1}. This value was similar to that which was calculated above from the aerial surveys conducted in 2007/2008 (i.e. 759 682 -843 702 angler days.year^{-1}), which therefore again highlights the fact that total annual angling effort has decreased since 1994-96.

Other than the estimates of total shore angler effort conducted by means of aerial surveys by Mann *et al.* (1997a) and Mann *et al.* (2008), there are no other reliable independent effort calculations for KZN. During 1994-96 KZN had the highest total annual shore-angling effort of all coastal provinces (Brouwer *et al.* 1997), however, with the marked decrease recorded in this study, it would be interesting to see if the same trends have occurred in the other costal provinces. Independent instantaneous effort calculations should be a fundamental part of the management and monitoring of any provincial shore fishery and should be conducted on a fairly regular basis of at least once every 5-10 years. It is thus strongly recommended that aerial surveys similar to those conducted by Mann *et al.* (2008) should be conducted in the other coastal provinces of South Africa in the near future.

2.4.4. Spatial and temporal variation in fishing effort

A range of factors determined the number of anglers fishing throughout the year. During the winter months, there was a marked increase in the angler densities along the KZN coast. This is a well-known trend that has been recorded in several studies (Joubert 1981a; van der Elst 1989; van der Walt 1995; Mann *et al.* 1997a; Mann *et al.* 2008), and can be attributed to the increased catch rates that occur when migratory spawning fish, such as *P. saltatrix* and *S. salpa*, move into KZN waters (Joubert 1981a; van der Elst 1989; van der Walt 1995; Mann *et al.* 1997a; Pradervand *et al.* 2007b; Mann *et al.* 2008) and the annual sardine run* (van der Lingen *et al.* 2010). Other noticeable increases in angler densities during the year can be attributed to the school or popular holiday periods, where many anglers from other provinces travel to KZN to come fishing. Spatially, areas that were easily accessible and in close proximity to metropolitan areas and/or were popular holiday fishing destinations, had the highest angler densities. This trend is recognised and also particularly evident in aerial surveys done by Mann *et al.* (2008) and creel surveys done by Mann *et al.*(1997a) and Joubert (1981a). A similar pattern was also recently recorded in part of the Eastern Cape shore linefishery, where the highest angler effort was recorded in or around urban and peri-urban areas (Mackenzie 2005). The Durban and south coast of KZN had the highest angler densities since most fishing areas are easily accessible (van der Walt and Govender 1996). Cape Vidal and St Lucia also had high peaks in angler densities since these are popular fishing destinations, also associated with several other tourist attractions. Although shore fishing appears to have declined in the iSimangaliso Wetland Park in recent years (Mann *et al.* 2002b; Mann and Pradervand 2007), it still remains a popular fishing and tourist destination.

While statistical analysis of angler densities across the KZN coast did not show any significant differences, the high variation in anglers.km^{-1} can account for this. On any given day, the probability around whether an angler will go fishing is extremely variable. This is clearly emphasised by the angler densities on different days (week, weekend or holiday) and by different weather conditions. During some “bad” weather days, angler densities were high, since the fish were ‘biting’, and on some excellent (good) weather days, angler numbers were low. Similarly, the time of day and tide also influenced angler density. Figure 3.4 accentuates the daily variation in starting and finishing times of anglers (*see* Chapter 3). Ultimately, there are a number of internal (perception of anglers own fishing skill, of fishing as an activity, and of people who fish), external (whether family and friends fish and their attitudes about fishing) and situational factors (i.e. fish availability, weather, time and season) that are all interrelated and can effect whether an angler will go fishing or not (Pollock *et al.* 1994). Furthermore, other factors such as the media (i.e. fishing television shows, newspaper articles and radio) also have a major influence on anglers perceptions of fishing.

* The annual migration of *Sardinops sagax* from the Agulhas Bank into KZN during winter.

2.4.5. Catch per unit effort (CPUE)

The present CPUE (numerically) on the KZN coast is similar to that reported by Joubert (1981a) and Mann *et al.* (1997a) (Table 2.5). CPUE by weight has also remained relatively constant since 1994-96 (Mann *et al.* 1997a), suggesting that over the past 12 years fish abundance and size has remained fairly stable. However, such a broad assumption needs to be carefully analysed. Current CPUE (numerically and by weight) values still show that catches in KZN are dominated by smaller fish, as described in several publications (Joubert 1981a; 1981b; van der Elst and Adkin 1988; Brouwer *et al.* 1997). The slightly lower CPUE values recorded during this study and by Joubert (1981a) could be a result of interannual variation in catches. Mann *et al.* (1997a) showed that variable abundances in *P. saltatrix* can account for extremely high and low annual catch rates. Since the KZN shore fishery is influenced by several migratory fish species that migrate up from Cape waters, such as *P. saltatrix*, *S. salpa*, *L. amia*, *A. japonicus*, *S. durbanensis*, etc. (Ahrens 1964; van der Elst 1976; Joubert 1981a; 1981b; Garratt 1988; Smale 1988; van der Walt and Govender 1996; Pradervand *et al.* 2007b), annual fluctuations in CPUE can be expected. Van Der Walt & Govender (1996) and Singh (2004) also showed the importance of 'alternate angling species' contributing to the overall CPUE when *P. saltatrix* abundances are low. This is also evident in the seasonal CPUE trends when "OTHER" fish species dominate the catches when the five top priority species are less abundant (Fig. 2.6).

Table 2.5- A comparison of mean CPUE of several important linefish species (arranged alphabetically) caught and kept by shore fishers from three independent linefish surveys conducted in KZN (Note: species were selected by their relative importance in the current study).

Species	1975-77 (Joubert 1981b)		1994-96 (Mann *et al.* 1997a)		2009-10 (This study)	
	CPUE #	CPUE kg	CPUE #	CPUE kg	CPUE #	CPUE kg
Argyrosomus japonicus	0.006	-	0.012	0.029	0.002	0.007
Dichistius multifasciatus	0.030	-	0.011	0.004	0.011	0.005
Diplodus capensis	0.100	-	0.103	0.016	0.143	0.036
Lichia amia	0.001	-	0.007	0.040	0.008	0.045
Neoscorpis lithophilus	0.090	-	0.049	0.011	0.029	0.013
Pachymetopon grande	0.004	-	0.001	0.001	0.017	0.026
Pomadasys olivaceum	0.210	-	0.035	0.001	0.064	0.002
Pomatomus saltatrix	0.250	-	0.285	0.129	0.145	0.067
Rhabdosargus holubi	0.008	-	0.024	0.007	0.049	0.008
Rhabdosargus sarba	0.010	-	0.027	0.025	0.002	0.004
Sarpa salpa	0.220	-	0.509	0.080	0.342	0.046
Overall mean*	1.090	-	1.200	0.460	0.820	0.320

CPUE # = fish.angler day^{-1}
CPUE kg = kg.angler day^{-1}
*Overall mean CPUE from each study. Measure of variability not applicable.

In contrast to this study, other similar studies done in South Africa have shown CPUE to have significantly declined over the years. Brouwer and Buxton (2002) for instance showed that in the Port-Elizabeth area (Eastern Cape), CPUE for sparids had declined in just over five years, while overall catch composition had remained the same since 1981. Several studies in South Africa have also noted a transitional change in species catch composition over time (Bennett 1991; Bennett *et al.* 1994; Brouwer *et al.* 1997; Attwood and Farquhar 1999; Brouwer and Buxton 2002; Pradervand 2004; Pradervand *et al.* 2007b), which is a common pattern that has been found in exploited fisheries worldwide (Pauly *et al.* 1998). Therefore, although the overall catch rates in KZN for the past two decades seem to have remained fairly constant, using Joubert (1981a) and Brouwer *et al.* (1997) as reference points, many important fish species caught in KZN have in fact shown substantial declines in CPUE that may be an indication of overexploitation. While care should be taken in comparing CPUE estimates from "snapshot" studies, some important species are discussed below with reference to the studies done by Joubert (1981b) and Mann *et al.* (1997) (refer to table to 2.4):

Pomatomus saltatrix

Current CPUE of *P. saltatrix* (0.145 fish.angler-day^{-1}) in KZN has decreased from estimates in 1975-77 (0.285 fish.angler-day^{-1}) and 1994-96 (0.250 fish.angler-day^{-1}) (Table 2.5), unlike the strong recovery described in several publications (van der Elst 1987a; 1987b; Brouwer and Buxton 2002). This could be a result of the new bag limit of four fish per person per day (pppd) imposed on this species in 2005 (Government Gazette No. 27453, April 2005); although, only 6.1% of anglers checked had caught four or more fish during the current study (Table 2.3). CPUE estimates of this species have however remained extremely variable in KZN (Mann *et al.* 1997a; Govender and Radebe 1999a), which has made management of this species difficult (Coetzee 1999). Generally, it is perceived that *P. saltatrix* has recovered from its overexploited levels in the early 1970's following the introduction of legislation in 1973 (van der Elst 1975). This species is the most important linefish caught in KZN (Mann *et al.* 1997a) and the Eastern and Western Cape (Brouwer *et al.* 1997). For this reason, CPUE trends need to be carefully monitored and a national stock assessment should be conducted as a matter of priority.

Sarpa salpa

S. salpa is one of the most important linefish species in the KZN shore linefishery (Joubert 1981a; 1981b; van der Walt and Govender 1996; Mann *et al.* 1997a). It has fluctuated in abundance over the years but current trends show a decline in CPUE from 1994-96 to the present (i.e. 0.509 to 0.342 fish.angler-day^{-1}) (Table 2.5). Prior to 2005, *S. salpa* was listed as a 'bait fish' and was unrestricted in terms of a bag limit. This changed in 2005 with the introduction of a species-specific bag limit of 10 fish pppd (Government Gazette No. 27453, April 2005). It is likely that this limitation has reduced the overall CPUE of this species and the decline therefore may not be as a result of decreased abundance. However, since this species is still heavily utilised in the shore fishery both for bait and as a food source (subsistence and recreational), levels of harvesting should continue to be carefully monitored.

Diplodus capensis

Current CPUE of *D. capensis* (0.142 fish.angler-day^{-1}) in KZN has increased from estimates in 1975-77 (0.1 fish.angler-day^{-1}) and 1994-96 (0.103 fish.angler-day^{-1}) (Table 2.5). Similarly, CPUE by weight has doubled since 1994-96 (0.016 to 0.036 kg.angler-day^{-1}) (Table 2.5). This could be a sign that current management regulations implemented for this species (i.e. daily bag limit of five fish pppd and a minimum legal size of 20 cm) (Government Gazette No. 27453, April 2005) are effective. This corresponds with Attwood & Bennett (1995), who predicted a positive CPUE response from a decreased daily bag limit on *D. capensis*. However, in this study a large proportion of shore-anglers had kept undersize fish. *D. capensis* is a generalist species and it is possible that it has adapted to heavy fishing pressure along the KZN coast for the past ±50 years by reducing size/age at maturity (Mann 1992). Nevertheless, a stock assessment is urgently needed to determine the stock status of this important linefish species.

Pomadasys olivaceum

Although catches of *P. olivaceum* declined between 1975-77 and 1994-96 (0.210 to 0.064 fish.angler-day^{-1})(Joubert 1981a; Mann *et al.* 1997a), estimates from the current study (0.064 fish.angler-day^{-1}) show a potential 'recovery' (Table 2.5). This recovery is important since *P. olivaceum* is known to be an important prey species (van der Elst 1993a) and as an additional protein source for many subsistence fishermen (Mann *et al.* 2000). This species was also subject to the introduction of a bag limit of 10 fish pppd in 2005 (Government Gazette No. 27453, April 2005), having previously been listed as a 'bait species'. Much of the adult *P. olivaceum* stock is known to occur in subtidal waters offshore and is not targeted to any great extent (van der Elst 1993a; Mann *et al.* 2006). The observed changes in CPUE are therefore more likely to reflect annual changes in recruitment success of this species or changes in directed effort partly caused by the recently introduced bag limit.

Rhabdosargus holubi

Catches of *Rhabdosargus* species suggest that. *R. holubi* is increasing in abundance (Table 2.5) This is somewhat surprising as *R. holubi* is an endemic, estuarine-dependent species (Wallace and van der Elst 1975) subject to high fishing pressure throughout its distribution (Cowley *et al.* 2004). It is thus possible that current management measures (i.e. daily bag limit of five fish pppd and a minimum size of 20 cm- Government Gazette No. 27453, April 2005) are providing adequate protection for this species. However, the many undersize fish recorded in catches by KZN shore-anglers in the current study is of concern. A similar trend was also observed in several estuaries in the Eastern Cape (Cowley *et al.* 2004; Nsubuga 2004). The fact that the bulk of estuarine nursery areas for this species are located south of KZN (Wallace and van der Elst 1975) where estuaries are generally in a better ecological condition (in terms of water quality suitable for aquatic life) (Harrison *et al.* 2000) means that this species is less vulnerable to overexploitation. Changes in targeting and declining catches of other important linefish species may also have contributed to the increased CPUE described in the current study. Nevertheless, little is known about the life history of this species (i.e. age, growth rate and reproductive style) and it should be prioritised for more research.

Rhabdosargus sarba

By comparison, *R. sarba* catches have changed drastically over the years, showing a decline since 1994-94 (0.027 to 0.002 fish.angler-day^{-1}) (Table 2.5). Although CPUE increased between 1975-77 and 1994-96 (0.010 to 0.027 fish.angler-day^{-1}) (Table 2.5), this was because of sampling bias since more north coast beaches were sampled in the latter study where this species is commonly caught by anglers (Mann and Radebe 1999). Declining catches have also been reported for this species in northern KZN associated with the prolonged drought and subsequent closure of the St Lucia estuary mouth since 2002. This has resulted in poor recruitment of this species (Mann and Pradervand 2007; Lamberth *et al.* 2009). Furthermore, it is also likely that the poor ecological health of many of the estuaries in KZN (Harrison *et al.* 2000), which *R. sarba* is dependent on for nursery areas (Wallace and van der Elst 1975), are acting as a life-history bottleneck for this species. Low catch rates of *R. sarba* have already been recorded in the St Lucia (Cyrus and Vivier 2006), Durban Harbour (Pradervand *et al.* 2003) and Mgeni (Pradervand *et al.* 2003) estuary systems. The poor ecological health status of many estuaries in KZN needs to be addressed as soon as possible. Stricter regulations, possibly marine and estuarine protected areas (*see* Chapter 7), might be the only solution to rebuild depleted stocks of *R. sarba* and other similar estuarine-dependent fish.

Neoscorpis lithophilus

Catches of *N. lithophilus* by shore-anglers in KZN declined between 1975-77 (0.09 fish.angler-day^{-1}) and 1994-96 (0.049 fish.angler-day^{-1}), and this trend has continued up to now (0.002 fish.angler-day^{-1}) (Table 2.5). From these results, it would appear there has been a decrease in abundance of *N. lithophilus* over the years. However, this may be a result of sampling bias between the various surveys and not because of a change in stock abundance (Mann *et al.* 2002a). Furthermore, the catchability of this species is low due to its herbivorous diet (Joubert 1981b) and most anglers use sardine (*Sardinops sagax*) as bait (Mann *et al.* 2002a). A recent stock assessment in KZN by Mann *et al.* (2002a) showed that the spawner-biomass-per-recruit is 46.1% , thus indicating that the stock is being sustainably exploited in KZN. This point is emphasised by the fact that many individuals of *N. lithophilus* are often seen in shallow, turbulent surf, close inshore while diving. With increasing pressure on marine resources, especially by subsistence fishers, stock abundance of *N. lithophilus* should be carefully monitored.

Dichistius multifasciatus

CPUE declined from 0.03 fish.angler^{-1}.day^{-1} in 1975-77 to 0.004 fish.angler^{-1}.day^{-1} in 1994-96 (Table 2.5). This is probably as a result of sampling bias as discussed above. Current values show no change in catch rate from 1994-96 (Table 2.5). *D. multifasciatus* was previously categorised as an intensively exploited species (Joubert 1981b); however, recent CPUE data show it has dwindling importance. This may be a result of traditional overexploitation (as evident from declining CPUE) or because few anglers are actually targeting this species. Only 0.57% of shore-anglers interviewed directly stated that they targeted this species, which favours the latter explanation. Furthermore, since the majority of fish caught are relatively small and it is generally a difficult species to catch, it may have little importance to most anglers. As with other teleosts discussed, this species forms an important alternate source of protein when priority species are less abundant, particularly to subsistence fishers (Mann and Radebe 1998). Comprehensive data on the biology of this species are lacking and further investigation of the status of this species is needed.

Argyrosomus japonicus

The catch rate (number and size) of *A. japonicus* has decreased considerably over the past 30 years throughout its distribution and the stock is considered to have collapsed (Joubert 1981a; Griffiths 1997; 2000). Similarly, catch rates have declined in KZN between 1994-96 (0.012 fish.angler-day^{-1}) and present (0.002 fish.angler-day^{-1}) (Table 2.5). Although, catch rates seemed to have increased in KZN between 1975-77 (0.006 fish.angler-day^{-1}) (Joubert 1981a) and 1994-96 (Mann *et al*. 1997a) (Table 2.5), this is most likely due to sampling bias. Long-term catch statistics on this species are, however, unreliable since *A. japonicus* was previously misidentified as *A. hololepidotus* and confused with another closely related species, namely *A. thorpei* in KZN (Griffiths and Heemstra 1995). More recent estimates by Griffiths & Lamberth (2002) put the spawner biomass-per-recruit between 1.0 and 4.5% of the pristine value. Thus, although current CPUE levels are similar to 1994-96, they are considered to be at a minimum level. During this study many anglers also misidentified *A. japonicus* as *Otolithes ruber*, which has no size limit and a bag limit of 10 pppd. However, *O. ruber* is relatively easy to identify due to its four large, canine-like teeth. Therefore, many anglers may have known that they had in fact caught a juvenile *A. japonicus*, but because they feared prosecution, they claimed it was *O. ruber*. Such confusion between the identification of similar species can cause problems for management. The fact that there are several closely related sciaenid species, which all look similar, has made management of these species extremely difficult. Furthermore, it was also observed that many anglers were confused between the different catch restrictions that apply to *Argyrosomus spp*. caught from a boat compared to those caught from the shore in KZN (*see* Appendix X). Although the current regulations on *Argyrosomus spp.* are difficult for anglers to understand (*see* Appendix X), it is up to the management agencies to enforce the regulations strictly and educate both compliance personnel and anglers on the rationale behind the regulations. Alternatively, catch restrictions on *Argyrosomus spp* could be revised, especially since multi-species regulations are disadvantageous in several respects (Adams 1980; Pauly 1982; Attwood and Bennett 1995).

Pachymetopon grande

Out of all fish recorded, *P. grande* has shown an exceptional increase in CPUE (Table 2.5). Only two fish were recorded during 1994-96 (0.001 fish.angler-day^{-1}), compared to the 51 recorded in the current study (0.017 fish.angler-day^{-1}). Interestingly, Joubert (1981a) recorded 28 fish (0.004 fish.angler-day^{-1}). The current high CPUE was in direct contrast with the declining CPUE for *P. grande* recorded in the Port Elizabeth area (Clarke and Buxton 1989; Brouwer *et al.* 1997; Brouwer and Buxton 2002). Current values may therefore reflect a period of good recruitment coming through into KZN waters or possibly a result of a change in targeted effort by anglers. The latter is more likely since during 1994-96 *P. grande* was directly targeted by only 1.1% of anglers, compared to 11.15% in the current study. A similar change in targeted effort for *P. grande* was also recorded by Coetzee *et al.* (1989). In the former Transkei, *P. grande* is also a favoured target species and forms an important component of the shore linefishery (Mann *et al.* 2003). The change recorded in directed effort in the current study for this species could have been facilitated by popular angling programmes that are regularly aired on national television, such as ESA (Extreme Sports Angling), which have shown anglers where and how to target *P. grande* successfully. Previously, only specialised anglers knew how to target *P. grande,* which is an exceedingly timid fish with a herbaceous diet (Buxton and Clarke 1992; van der Elst 1993a). Since declines in CPUE have been recorded in several other areas around South Africa, current positive CPUE trends should not soften the management recommendations for this species. Its slow-growth and subsequent vulnerability to overexploitation underline the need for effective conservation measures (Booth 1999).

Lichia amia

L. amia has showed a remarkable increase in CPUE compared to 1994-96 and 1975-77 (0.001 to 0.008 fish.angler-day^{-1}) (Table 2.5). This is despite the implementation of a reduced daily bag limit (i.e. from five fish pppd to two fish pppd- Government Gazette No. 27453, April 2005) in 2005. Similarly, CPUE was higher in the current study (0.008 fish.angler-day^{-1}) than that reported by Smith (2008) for the period 1985 to 2006 determined from EKZNW shore patrols. However, Smith (2008) reported that for three sectors of the KZN linefishery that target this species (i.e. shore, boat and spear fishers) there has been an overall decrease in CPUE in each sector. Thus, although CPUE was high during the current study period, an overall decrease in CPUE may still have taken place. High interannual variation as well as effort-creep[*] could explain the increase in CPUE during 2009. The spawner-biomass-per-recruit for *L. amia* was estimated at 14% of pristine levels (Smith 2008), which suggests that the adult stock has collapsed and stringent measures are needed to rebuild the stock.

Other teleost and elasmobranch species

Catches of the other commonly caught species, though not discussed independently, are listed in Appendix III. For the most part, catches of these species were not recorded independently in other similar studies, or are caught too infrequently to evaluate in any detail. A prime example of this is with *Sparodon durbanensis*, which was not recorded in the survey of KZN in 1994-96 (Mann *et al.* 1997a), but was found to have a similar catch rate as the current study by Joubert (1981b). Mann *et al.* (2003) also found *S. durbanensis* to be less important in the Transkei shore fishery, whereas Brouwer *at al.*(1997) showed it to be an important component of catches in the

[*] Increased catch rates caused by improved/better fishing technology, e.g. targeting *L. amia* using non-return slides and live bait; refer Pradervand *et al.* (2007b) for explanation of technological advancements that have taken place in the KZN shore fishery.

southern region of the Eastern Cape. Other commonly caught teleost species that have increased in CPUE include *Diplodus hottentotus*, *Kuhlia mugil*, *Lithognathus mormyrus*, *Monodactylus spp.*, Mugilids, *Trachinotus bolta*, *T. baillonii* and *Pagellus bellottii natalensis*.

Several species recorded during the sample period were discarded (released) by anglers and can be viewed, in a sense, as 'by-catch'. These included unpopular species such as *Amblyrhynchotes honckenii*, *Galeichthyes trowi* (previously misidentified as *G. feliceps*; Kulongowski 2010), *Gymnothorax spp.* and *Plotosus nkunga*. Unfortunately, during this study it was found that many anglers simply killed fish (discarded them on the beach or rocks) that they had no use for. These were mostly catches of A. *honckenii*, however, several undersize (juvenile) fish that are of high target value were also discarded. The reason for this behaviour is not entirely understood, but it may stem from the fact that many anglers believe if 'nuisance' fish are killed off, they may catch more desirable/larger fish. This is an issue of concern and the only solution is to promote angler awareness programs to stem this behaviour. The majority of *Dinoperca petersi*, *Lutjanus rivulatus* and *Pomadasys furcatum* caught by shore-anglers were released, however, this was because these fish were caught during a once off competition that was encountered during the survey (Senior Nationals Competition, South African Shore Angling Association (SASAA)) where all fish caught are measured and released as part of competition rules.

Elasmobranchs were generally not caught in sufficient abundance for comparisons to be made. This is a common trend found in fisheries that are predominantly non-competitive (social) in nature (Joubert 1981a; Brouwer *et al.* 1997). Furthermore, since many anglers fish for elasmobranch species more for sport (catch and release) than for consumption, and released fish were not included in the CPUE estimates, little CPUE data for elasmobranchs were recorded in this study. The standard length-weight conversion tables that have been developed by ORI and the competitive angling organizations have also facilitated the catch and release of most elasmobranchs. During past angler competitions, elasmobranchs, including teleosts, were kept and weighed at the end of the competitions. Nowadays, most elasmobranchs are simply measured (and thus weight calculated) and quickly returned back to the water with minimal handling and stress caused to the fish.

Overall, although CPUE can be used as a useful stock status indicator (i.e. >75% decline in CPUE), it should not replace reliable stock assessments methods such as per-recruit analyses and/or age-structured production modelling (Hilborn 1992; Griffiths *et al.* 1999). Importantly, CPUE trends should only be used to develop management recommendations in situations where comprehensive stock assessments have not been performed. Furthermore, studies such as this one and those by Joubert (1981a) and Mann *et al.* (1997a) are "snapshot" assessments that need to be compared with long-term catch and effort data sets, such as the NMLS (*see* Chapter 6). Nonetheless, the current study has still provided valuable catch and effort information that can be used to improve management of the shore linefishery as whole (*see* Chapters 6 and 7).

2.4.6. Total catch and catch composition

Total annual catch in the KZN shore linefishery (249-277 mt) has dropped considerably from the estimates made in 1994-96 (615 mt) (Mann *et al.* 1997a). However, since total catch is proportional to total annual angling effort this result reflects a drop in effort rather than catch rate. It must be pointed out that although effort has dropped in the last ten years as described above, total participation has remained constant. It must be noted, though, that changes in catch composition over time is another measure which can be used as a stock status indicator (Griffiths *et al.* 1999).

Of the 84 species of fish recorded during the current survey of the KZN shore linefishery, nine individual species contributed 2% or more (numerically) to the total catch. Similar results were also recorded in KZN during 1975-77 by Joubert (1981a) and 1994-96 by Mann *et al.* (1997a). Similar catch compositions to those described in KZN have also been found in the shore linefisheries of the Transkei (Mann *et al.* 2003) and southern regions of the Eastern Cape (Brouwer and Buxton 2002).

Catch composition for the KZN shore linefishery in 1975-77 was dominated numerically by *Pomatomus saltatrix* (23%), *Sarpa salpa* (20%), *Pomadasys olivaceum* (20%), *Diplodus capensis* (9%) and *Neoscorpis lithophilus* (8%) (Joubert 1981a). Similarly, *Sarpa salpa* (43%), *Pomatomus saltatrix* (24%), *Diplodus capensis* (9%), *Neoscorpis lithophilus* (4%) and *Pomadasys olivaceum* (3%) dominated the catches (numerically) in 1994-96. Catch composition in both these studies was therefore very similar to the current study (*Sarpa salpa* 34.8%, *Pomatomus saltatrix* 14.7%, *Diplodus capensis* 14.5%, *Pomadasys olivaceum* 6.5% and *Rhabdosargus holubi* 4.9%). Alarmingly, *P. saltatrix* seems to have declined in importance over the years. However, such a decline may be a result of the decreased bag limit (i.e. 4 pppd) imposed on this species (*see* Chapter 1). Since this species is the most important linefish caught in KZN, a national stock assessment should be conducted as a matter of priority. *N. lithophilus* was also less important in catches in the current study. However, this difference is more likely as a result of sampling bias between the various surveys and not because of a change in stock abundance. Overall, although differences in catch that are recorded between studies are generally a sign of decreasing abundances of traditionally targeted species (Bennett *et al.* 1994), they may also reflect a change in targeting and fishing techniques used by anglers (Bennett 1991). However, the differences in sampling techniques between the three studies are most likely to be responsible for the differences observed. Trends in catch composition were generally mirrored in the spatial-temporal CPUE of the species caught.

Although 84 species were recorded in the catches of shore-anglers along the KZN coast, apart from a few important species (i.e. *A. japonicus*, *Argyrosomus thorpei*, *Epinephelus marginatus* and *E. andersonii)*, shore-anglers generally do not catch species targeted by skiboat-fishers in KZN. A similar trend was observed by Brouwer (1997). It must be noted that there is considerable overlap between the different sectors within the offshore boat-based linefishery (i.e. commercial, charter and recreational; *see* Chapter 4). Ostensibly, this overlap exits in the shore linefishery between the subsistence, competitive and social sectors; however, catch composition between the different sectors of the KZN shore fishery were not analysed since not many fish were recorded for subsistence and competitive anglers. Importantly, there is some overlap between species taken in the spearfishery and those in the shore linefishery, particularly *Lichia amia* and *Pachymetapon grande* (Mann *et al.* 1997b). Thus, it is important that the spearfishery continues to be carefully monitored by EKZNW, especially since KZN historically has the highest spearfishing effort in South Africa (Mann *et al.* 1997b).

The general differences in targeted effort and the actual fish caught are quite evident. This discrepancy has been recorded in several studies (Clarke and Buxton 1989; Brouwer *et al.* 1997; Mann *et al.* 2003), and is a result of targeting of prime species contributing to the decline of those fish. Smaller less ‘desirable’ teleost species, such as *S. salpa*, *D. capensis*, *R. holubi*, *P. olivaceum* and mugilids, together form a significant part in the overall fishery and must not be ignored in the broader scale of sustainable utilisation and management thereof (*see* Chapter 6).

2.4.7. Conclusion

While total participation appears to have remained fairly constant, total annual angling effort in the KZN shore fishery has declined in recent years. This is important since KZN historically has had substantially higher fishing effort than elsewhere in South Africa and a fishery that was considered to be under great pressure (Brouwer *et al.* 1997). Analysis of overall CPUE, catch composition and total catch in the shore linefishery of KZN suggests that this fishery is in a relatively stable condition and that little change has occurred in the past 12 years. However, comparisons of species-specific CPUE values from this study with recent literature suggest that some species (e.g. *Argyrosomus japonicus and Rhabdosargus sarba*) are overexploited. It is thus suggested that current catches could be reflecting a gradual transition in landings from long-lived, high trophic level, piscivorous fish (e.g. *A. japonicus*) to more short-lived, low trophic level species (e.g. *S. salpa*). The results therefore suggest that present exploitation levels may not be sustainable for certain species. Furthermore, since many of the regulations that currently exist are based on 'crisis management' (van der Elst and Garratt 1984), where only once catches have exceeded their sustainable limits are counteractive measures considered (e.g. *P. saltatrix* (van der Elst 1987a; 1987b)), many fish species may in fact be heavily overexploited or even collapsed in terms of the Linefish Management Protocol (Attwood *et al.* 1999). Recommendations are discussed in Chapter 7.

CHAPTER 3

SOCIO-ECONOMICS OF THE KWAZULU-NATAL SHORE LINEFISHERY

3.1 INTRODUCTION

Fisheries systems are extremely complex, involving dynamic interactions within and between the linefish resources and the people who utilise and manage them (Hoggarth *et al.* 2006). Unlike commercial fishing, recreational angling in South Africa has suffered from a lack of information and understanding of its extent, impacts and systematic relationships concerning fish resources, societal role and economic contributions (Leibold and van Zyl 2008). For example, previous linefish management plans, such as those that were implemented in 1984 (*see* Chapter 1), were developed mainly on species-specific biological data and failed to take fisher behaviour into account. In contrast, socio-economic surveys have been a part of management protocol in North America (Grambsch and Fisher 1991; National Research Council 2006) and New Zealand (Hartill 2010) for some time, with angler behaviour often being considered before any regulations were implemented or amended. Fortunately, nowadays in South Africa, fishery management systems are understood to include an understanding of how sociological, economic and ecological forces, in combination with management decisions, affect the distribution of fishing opportunities over time and space (Brouwer 1997; McGrath *et al.* 1997; Griffiths *et al.* 1999). This is particularly important since issues relating to equity and access to certain fisheries play an important role in shaping the direction of fisheries management policy in South Africa (McGrath *et al.* 1997).

Studies by Brouwer *et al.* (1997) and McGrath *et al.* (1997) highlighted the magnitude and importance of the shore linefishery in South Africa. They provided invaluable data and management recommendations based not only on biological data, but on socio-economic data as well, which few other studies in South Africa had done before. These two studies have proved as a vital reference point and guideline for a number of subsequent studies done in South Africa (Penney *et al.* 1999; Mann *et al.* 2002b; Mann *et al.* 2003; Pradervand *et al.* 2003; Pradervand and Govender 2003; Everett 2004; Pradervand 2004; Pradervand *et al.* 2007b; Pradervand and Fennessy 2009), assessing management decisions, angler attitudes and compliance. Ultimately, the successful management of any fishery cannot be solely based on biological data, but needs to understand fishing practices and the dynamic responses of anglers and fish to variations in fishing pressure and conditions. The primary aim of this chapter was therefore: (1) to determine shore angler demographics and associated socio-economics; (2) to determine current shore angler awareness, attitude and compliance towards linefish regulations; and (3) to make comparisons with other similar independent assessments previously conducted in South Africa and abroad.

3.2 MATERIALS AND METHODS

With the aid of a short questionnaire, socio-economic information was collected from a sub-sample of anglers intercepted during roving-creel surveys (*see* Appendix IV). An attempt was made to randomly interview at least ten anglers on each sampling day, which consisted of three randomly stratified roving-creel surveys (*see* Chapter 2). No questionnaires were conducted at night for security reasons. Zulu speaking anglers were interviewed with the assistance of an interpreter. Although catch and effort of all shore-anglers intercepted was captured during the roving-creel surveys, it was also recorded during the questionnaire survey to ascertain individual CPUE. Anglers that were younger than 12 years of age were not interviewed due to the complexity of some of the questions. In instances where anglers were fishing in a group (i.e. two or more anglers), the group was requested to nominate one representative to answer the questionnaire. Where the total catch for the group was shared, an attempt was made to separate individual catches from the overall groups catch. As in the roving-creel surveys, all fish caught were identified (to lowest taxonomic level), measured and weight was calculated using standard length/weight regressions (Froese & Pauly 2010; Mann 2000; Oceanographic Research Institute, unpublished data). For catches that were kept but could not be measured (i.e. used for bait or taken to vehicle already), fish lengths (and thus weights) were estimated using the average recorded for that species or its closest relative. Anglers that were encountered again during patrols and that had previously been interviewed, only had catch and effort information recorded as part of the roving-creel survey. The questionnaire was divided into five sections (*see* Appendix IV). Section A and E dealt with general information such as locality, ethnic group[*], angler age, bait type, and general angling questions. Section B dealt with catch and effort data, including trip length and the number of years spent fishing. Section C referred to anglers attitudes to management and certain questions dealing with new regulations and the permit system. The different species targeted and the knowledge of current linefish regulations was also dealt with here. Section D was the economic section and dealt with travelling distances, residency, expenditures and other economic questions. All questions were based on those used by Brouwer *et al.* (1997) and McGrath *et al.* (1997) for comparative reasons, while

[*] Note that questions relating to angler demographics were considered for comparative reasons, particularly since economic forces and political inequalities suffered in the past have played a major role in determing angler participation.

additional questions were added to consider changes that have occurred in the shore fishery since the last national linefish assessment was carried out in 1994-96 (Mann *et al.* 1997a). For the purpose of this study, economic data were analysed at a relatively simple level.

3.3 RESULTS

3.3.1 Socio-economics

A total of 1049 shore-anglers were randomly interviewed in all 15 zones along the KZN coast, although the number interviewed in each zone and per month differed for several logistical reasons. Shore-anglers varied between four ethnic groups (Fig. 3.1). Sixty percent of the anglers were from the Indian community, while the remainder was made up of White (30.9%), black African (6.1%), Coloured (2.4%), and Asian (0.1%) anglers. Only 177 (17%) of the shore-anglers checked were female. The mean age of respondents was 43.4 ±13.4 years old, with a range between 12 and 86 years old (Fig. 3.2). Interestingly, a relatively high proportion (11.2%) of shore-anglers were over 60 years of age.

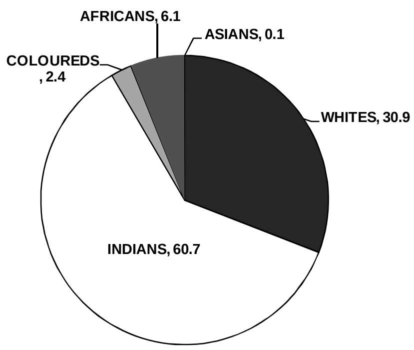


Figure 3.1- Ethnic composition of shore-anglers interviewed along the KZN coast during a questionnaire survey conducted between February 2009 and January 2010.

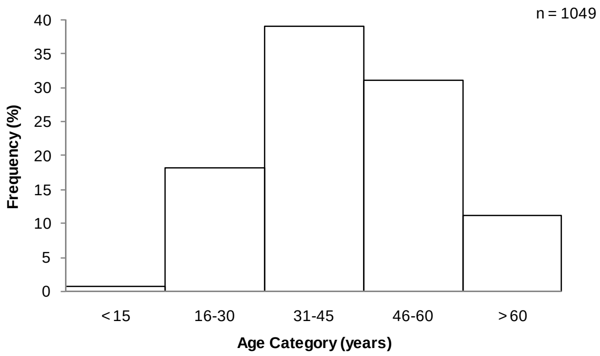


Figure 3.2- Frequency Distribution of the age structure of shore-anglers interviewed along the KZN coast during a questionnaire survey conducted between February 2009 and January 2010.

Generally, shore-anglers were mainly day visitors (i.e. local residents), while 31% were on holiday or staying overnight. The majority of shore-anglers that were interviewed resided in KZN (79.5%), while anglers from Gauteng (11.5%) and Mpumalanga (4.7%) comprised the main visitors from other provinces (Fig. 3.3). Only eight shore-anglers interviewed lived overseas and only two of them were not originally South African citizens. On average, anglers travelled 19.6 ±34.0 km to a fishing destination, however the distance ranged from less than 0.1 km up to 350 km one-way. Taking into account trip duration (i.e. day/overnight/holiday trip) (Kruskal-Wallis One-way ANOVA, $H = 152.87$, $df = 2$, $p < 0.001$), anglers on holiday ($p < 0.05$) or staying overnight ($p < 0.05$) travelled far less than anglers on a day trip (Table 3.2). These values are based on where anglers were staying on the day of their angler outing and did not include where they had come from if they were on holiday or staying overnight.

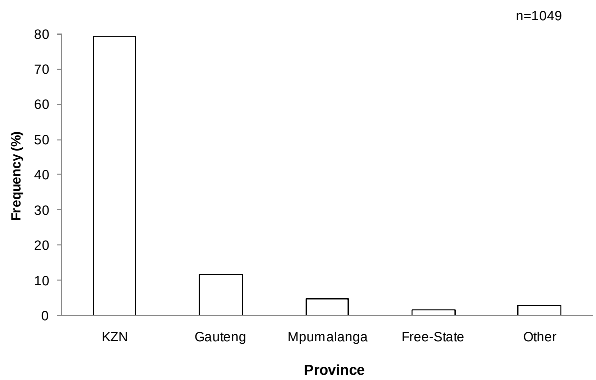


Figure 3.3- Domicile of 1049 shore-anglers interviewd along the KZN coast during a questionnaire survey conducted between February 2009 and January 2010.

The frequency distribution of shore-anglers' starting and finishing times are shown in Figure 3.4. Most anglers preferred to start fishing in the early morning between 05h00 and 9h00, with a gradual decrease throughout the rest of the day. There were some anglers that started fishing in the afternoon, but very few were recorded starting later than 16h00. Most angler outings ended around midday (between 11h00 and 14h00), however many anglers that had started fishing in the afternoon, fished into the dark as late as 21h00. Fig. 3.4 highlights the importance of midday (between 10h00 and 14h00) shore patrols in capturing most anglers either finishing or starting their fishing trips. However, early morning and late evening patrols are also essential to capture those anglers fishing at night. Forty-eight percent of shore-anglers did claim to fish at night with a regularity of 12.3% ±21.8 of their outings. Most anglers fished for approximately 4.6 ±2.7 hours, while a complete fishing day was assumed to be 9.9 ±2.5 hours long (this was calculated by subtracting the earliest starting time from the latest expected end time for each day for the entire data set). On average, anglers fished with a regularity of 56.7 ±64.7 times (days) a year. However, this was subject to avidity bias where anglers that fish often were more frequently intercepted during the roving-creel surveys. By accounting for avidity according to the equation developed by Thompson (1991):

$$\text{Correction bias} = \frac{n}{\sum(1/T_i)}$$

where *n* is the sample size and T_i the number of angler trips taken annually by angler *i*. A new value of 8.43 trips per annum was calculated. The difference between these two values can probably be explained by the high variance in angler avidity associated with the roving-creel sampling technique (*see* Thompson (1991)). Trip duration also significantly influenced the number of times an angler went fishing in a year (Kruskal-Wallis One-way ANOVA, H = 250.22, df = 2, p = < 0.001). Anglers that were on holiday ($p< 0.05$) or staying overnight ($p< 0.05$) fished far more infrequently than local anglers (i.e. anglers on a day trip) did. The experience of each angler varied considerably and this is evident in how many years an angler had been fishing. The range included from as little as a few days to as long as 76 years. On average however, anglers claimed to have been sea fishing for approximately 23.5 ±15.7 years. Only 31 anglers interviewed were members of a club belonging to KZNCAU (KwaZulu-Natal Coast Anglers Union) or ZSAA (Zululand Shore Angling Association), while a further 43 anglers belonged to either social clubs or clubs not registered to any formal KZN angling unions.

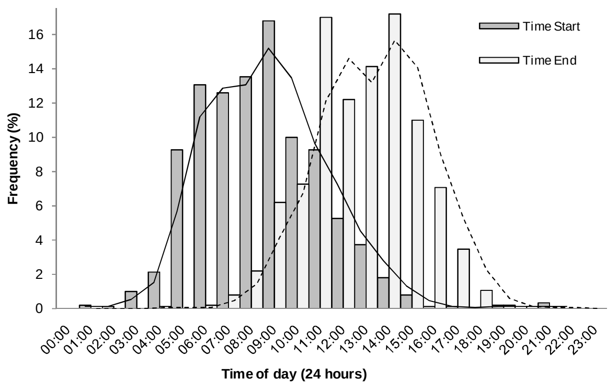


Figure 3.4- Frequency distribution of shore-anglers (n=1049) fishing trip starting and finishing times over a 24-hour period from a questionnaire survey conducted between February 2009 and January 2010 along the KZN coast.

A large proportion (25.8%) of shore-anglers interviewed were *unemployed and economically inactive* and/or *retired* (Table 3.1). Anglers that were employed came from a large spectrum of the working group (Table 3.1), with the bulk either falling under the *professional/semi and technical* (13.4%) or the *artisan, apprentice or related* (12.5%) occupational categories. Many anglers also just referred to themselves as being “*self-employed*”, which could have fallen into any of the occupational categories described in Table 3.1.

The average expenditure on bait per fishing trip was calculated to be R53.40 ±R66.26 (Table 3.2). Anglers also claimed to own on average R6 967.83 ±R11 482.18 worth of fishing tackle (Table 3.2). There were variable differences between anglers expenditure on bait and the trip duration (Kruskal-Wallis One -way ANOVA, H = 7.32, df = 2, p= 0.026). Anglers that were on holiday had a significantly ($p < 0.05$) higher expenditure on bait than those that were on a day trip (Table 3.2). However, trip duration did not influence the amount of tackle a shore angler owned (Kruskal-Wallis One -way ANOVA, H = 0.76, df = 2, p= 0.69; Table 3.2).

Table 3.1- The percentage of shore-anglers interviewed that fell into different occupational categories in KZN based on a questionnaire survey conducted between February 2009- and January 2010 (occupational categories modified from McGrath *et al.* 1997).

Occupational category (n= 1049)	%
Professional/semi and technical	13.4
Artisan, apprentice and related	12.5
Self-employed	10.7
Managerial/executive and administrative	9.8
Services	5.6
Clerical and sales	5.0
Foremen, supervisor and mining	4.4
Operators and semi-skilled	4.4
Labourers	3.2
Students/scholars	2.8
Transport and related	1.4
Minister, father, priest, church related	0.6
Skilled agricultural and fishery workers	0.3
Full time Charters, no other jobs	0.1
Unemployed and not economically active	14.5
Retired	11.3

Table 3.2- Average shore angler expenditure (Rand) per angler outing in KZN according to trip duration from a questionnaire survey conducted between February 2009- and January 2010. Standard deviation is given in parentheses

Parameter	Day	Overnight	Holiday	Average
Distance travelled (km)	24.14 (36.37)	7.02 (33.95)	10.32 (27.00)	19.62 (33.98)
Bait cost (per trip)	46.72 (36.37)	60.89 (66.20)	70.55 (96.08)	53.40 (65.23)
Tackle (total net worth)	7030.79 (12035.16)	6531.97 (11471.24)	6917.79 (10680.8)	6967.83 (11482.18)

* Reflects distance travelled on the day of the fishing outing (one-way)

3.3.2 Subsistence fishers

An analysis of anglers that claimed to fall into the subsistence sector (i.e. 3 836 “subsistence fishers”, estimated from those anglers interviewed that had a subsistence permit or claimed to fish for food, livelihood and/or to sell; *see* Chapter 2) showed that they had relatively good fishing equipment, which they valued at an average of R1 265.39 ±R1609.91. Of all the subsistence fishers checked, only two were using self-collected marine organisms for bait, while the rest had purchased bait for approximately R23.10 ±R22.00. The average angler day (4.7 ±1.9 hours) for subsistence fishers was similar to that found overall (*see* above), while the average distance that subsistence fishers travelled to go fishing was 7.8 ±9.3 km one way. Travelling distance ranged between 0.2 and 40 km one way. Twenty of the so-called subsistence fishers had also in fact purchased annual recreational permits, while two of those also had additional mollusc (general-bait) permits. Two fishers with subsistence permits issued to them by EKZNW were also permanently employed, while another was recently retired. From these results, it is clear that there are relatively few 'true' subsistence fishers participating in the KZN shore linefishery.

3.3.3 Bait utilization

Ninety-eight percent of the shore-anglers interviewed were using some sort of bait to capture fish rather than artificial lures. A total of 28 different bait types were recorded, which was made up of mostly locally purchased or self-collected marine organisms (Table 3.3). The three most commonly used baits were pilchard/sardine (*Sardinops sagax* 44.2%), Pink-Prawn (*Haliporoides triarthrus.* 18.2%) and Squid (*Loligo spp.* 16.5%). Four-hundred and sixteen anglers, 239 without bait permits, admitted they self-collected marine organisms for bait. The three most common were mole-crabs (*Emerita spp.* & *Hippa ovalis* 28.2%), red-bait (*Pyura stolonifera* 17.7%) and mussels (*Perna perna* 16.0%).

Table 3.3- Percentage contribution of the bait types used by shore-anglers from a questionnaire survey conducted between February 2010 and January 2009. Bait types are arranged alphabetically by common name.

Common Name	Scientific Name	%
Artificial lure	-	1.5
Crab*	*Ocypode ryderi*	1.6
Japanese mackerel	*Cololabis spp.* & *Scomberesox spp.*	0.9
Live bait*	Unspecified type	3.7
Mackerel	*Scomber japonicus*	2.4
Mussel*	*Perna perna*	2.2
Pilchard/sardine	*Sardinops sagax*	44.2
Pink prawn	*Haliporoides triarthrus*	18.2
Red bait*	*Pyura stolonifera*	2.0
Red-eye sardine	*Etrumeus teres*	1.0
Sand Prawn*	*Callianassa kraussi*	1.2
Mole-crab*	*Emerita spp.*& *Hippa ovalis*	1.7
Squid	*Loligo spp.*	16.5
OTHER	-	2.9

*indicates bait species that are usually self-collected

3.3.4 Angler attitudes towards current management measures

In general, the majority (87.8%) of anglers agreed with the current linefish regulations, with minimum legal size limits receiving the strongest support (92.6%, Table 3.4). However, 50.9%

of the anglers disagreed with the current ban on driving on the beach. This is quite surprising bearing in mind that the number of shore-anglers that own an off-road vehicle (4x4) is probably less than 50%. Although the majority of shore-anglers agreed with current linefish regulations, a high number admitted to disobeying them (Table 3.4). Forty-six percent of anglers stated they had knowingly kept undersize fish, however 18.6% of those anglers said it was only for live bait and not for personnel consumption. Similarly, 23.0% of shore-anglers claimed to have kept over their daily bag limit, while 18.3% of anglers admitted to having kept certain species of fish (e.g. *Pomatomus saltatrix*) during the closed season for that species. Only 9.2% of anglers admitted that they had fished in a marine protected area where fishing was prohibited. Although more than half the anglers disagreed with the beach vehicle ban, only a small group (6.0%) admitted to driving on the beach. Fourteen percent of anglers (excluding permitted subsistence fishers) also admitted to substituting their income by selling fish illegally, with an average regularity of 11 times a year.

When questioned about the fishing regulations on the three most important species of fish they were targeting, shore-anglers generally had a fairly poor knowledge of the legislation (Table 3.4). Specifically, 65.2% of shore-anglers did not know the minimum legal size limits of the fish they were targeting, while a further 62.3% of the shore-anglers did not know the daily bag limits for the same species. The closed seasons for certain fish species (e.g. *P. saltatrix*) were relatively well known.

Most shore-anglers (56.5%) stated that EKZNW had informed them of the linefish regulations either by direct (verbal) or indirect communication. The latter being through measuring rulers (stickers) and/or brochures and pamphlets that are made available at tackle shops and EKZNW offices. The remainder claimed to have either learnt about the regulations over the years (i.e. by word of mouth) or through various other media (e.g. signboards, internet, newspaper, television shows and magazines).

Eighty-six percent of the shore-anglers interviewed had been checked at least once by an EKZNW officer or fishery inspector since they had started sea fishing, with a regularity of 5.08 ±16.8 times (corrected for avidity, *see* above) in the last 12 months. Interestingly, EKZNW patrol officers/inspectors were only encountered 28 times during the current questionnaire survey. Thirty-three percent of the shore-anglers interviewed expressed unhappiness with the manner in which the shore linefishery was managed by EKZNW. Most of them believed that there were insufficient personnel to control or implement effective management along the coast.

Additionally, 24.5% of the anglers that criticised management said EKZNW did not police the shore fishery correctly, while a further 29.1% stated that corruption and racism were major problems affecting good management. Similar observations were made by Govender (1999) in a study of shore angler attitudes to law enforcement methods along the KZN coast.

Table 3.4- Percentage of shore-anglers (n=1049) that agree with, admitted to disobeying and knew the current linefish regulations for their target species during a questionnaire survey conducted in KZN between February 2009 and January 2010.

Regulation	Agree	Disobey	Knowledge
Minimum Size	93	28	35
Daily bag limit	82	23	38
Closed season	89	17	69
Marine reserves	88	9	-
Beach ban	49	6	-

Of the 1049 shore-anglers interviewed, 95.4% claimed to have an annual (recreational or subsistence) fishing permit, but 13.8% of these did not have it in their possession. The Post Office remained the most common place to purchase an angling permit (75.6%), while some permit holders had bought their licenses through EKZNW outlets (19.2%). In addition to general angling permits, 299 of the shore-anglers interviewed had also purchased other marine permits including a “mollusc” or general bait permit (code 09; 177 permits purchased), castnet permit (code 03; 62 permits purchased), east-coast rock lobster permit (code 07; 61 permits purchased) and others. An individual shore angler thus had anything from only a general angling permit to up to six additional marine recreational permits in her/his possession.

The majority of anglers interviewed generally fished for recreational purposes, while only 3.2% of anglers claimed to fish for a livelihood. Seventy-nine percent of anglers enjoyed eating the fish they caught, while a surprising 16.5% of anglers interviewed fished purely for fun and released their catch. More than half the anglers interviewed (57.0%) practiced other types of fishing. The most common were freshwater (39.7%), estuarine (29.5 %) and skiboat (19.3%) fishing.

More than half the anglers interviewed (53.0%) that had been fishing for 10 years or more stated that they fished less frequently nowadays. ‘Work/family commitments’ (37.9%) and ‘poorer catches’ (24.0%) were the main reasons given for this reduced frequency of fishing. Other responses, such as the ‘cost’ and ‘security’ involved in fishing (13.5%), featured prominently in angler responses. A further 6% of anglers stated that changes in the ‘regulations’ (including the beach vehicle ban) had prevented them from fishing as often as they used to.

The majority (83.8%) of anglers believed that fishing along the KZN coast had deteriorated and felt that general overfishing (21.5%), trawling (17.8%), pollution (14.3%) and climate change[*] (14.0%) were the main reasons for the poorer catches over the years. Some anglers (13.5%) were also concerned about the general lack of compliance towards linefish regulations and the poor enforcement of these regulations by EKZNW. Other interesting answers to decreased catches included the ‘salamis’[†]experienced in 2007, as well as too many jellyfish, dolphins and sharks.

The questionnaire survey provided a unique opportunity to check the recapture and reporting rates of fish tagged in the ORI Tagging Project. Briefly, only 117 (11.2%) of the shore-anglers interviewed reported that they had caught a tagged fish during their lifetime. Of those anglers, a surprising (and worrying) 55 (47.0%) had just released the fish without recording the tag number or had simply not bothered to report it. In other words, nearly half of the tagged fish recaptured by shore-anglers interviewed along the KZN coast were not reported to the Tagging Officer at ORI. Of the remaining 62 anglers (53.0%) that had “reported” catching a tagged fish, only 44 (71.0%) stated that they had received feedback from ORI about the fish. So again, some of this “reported” recapture information may also have gone unrecorded. Several anglers, particularly the ill informed, did not know about the Tagging Project run by ORI and were under the impression that tagged fish belonged to someone else and they could not keep such fish.

3.4 DISCUSSION

3.4.1 Socio-economics

Shore-anglers interviewed represented a wide spectrum of society, from those that fish purely for recreation, to those that rely on the fishery as an additional source of protein or income. The ethnic composition of anglers has changed considerably in the last decade. Mann *et al.* (1997a) found that Whites made up 50% of the shore-anglers along the KZN coast, with Indians (41%), Coloureds (3%) and black Africans (5%) making up the remainder. However, the current ethnic composition has shown a shift with a greater proportion of Indian anglers and a considerably lower White component. Such a shift may be explained by changes that have occurred in the management of the shore linefishery since 1994-96 (e.g. beach vehicle ban); however, it is more

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[*] Climate change in the current study is referred to as the long-term significant change in the weather patterns of a particular area.

[†] Anglers often referred to the specific storm-sea event that occurred during March 2007, where surf conditions were amplified by several storms, strong winds and an extra high spring tide (highest tidal range in 18 years), as a ‘salami’ or ‘tsunami’.

likely because the results of the 1994-96 survey were slightly biased in terms of the areas sampled (B. Mann, 2010, ORI, pers. comm.). For example, the previous KZN shore fishery survey (Mann *et al.* 1997a) divided the coast into 18 relatively short patrol areas that were sampled monthly, whereas the current study attempted to cover most of the coastline in a random, stratified manner. This bias is emphasised by the fact that Joubert (1981a) found a similar ethnic composition to the current study. The numbers of black African and Coloured anglers has remained fairly constant since 1994-96, despite a predicted increase in the former group described in several publications (Brouwer 1997; Brouwer *et al.* 1997; Mann *et al.* 1997a). In general, the current study, and those by Joubert (1981a) and Mann *et al.* (1997a), all show a distorted ethnic composition that is not representative of the population of KZN as a whole (Statistics South Africa Census 2001). This is likely explained by the fact that recreational fishing is more popular among higher income groups (Clarke and Buxton 1989; Brouwer 1997; McGrath *et al.* 1997) and KZN inherently has a high unemployment rate in black African and Coloured population groups (Statistics South Africa Census 2001). Furthermore, it could be argued that the majority of black African people living in KZN are Zulus who traditionally did not eat fish or harvest food from the sea (Merrett and Butcher 1991). They are therefore not culturally dependent on fishing, unlike the amaPondo people of the former Transkei (Siegfried *et al.* 1985; Robertson and Fielding 1997; Mann *et al.* 2003).

The age structure of shore-anglers in the current study was similar to other studies done in South Africa (Clarke and Buxton 1989; Brouwer 1997; Mann *et al.* 1997a; McGrath *et al.* 1997; Mann *et al.* 2003; Beckley *et al.* 2008) and abroad (Gigliotti and Peyton 1993; Miller and Galinat 2003; Ormsby 2004). The high number of anglers interviewed over the age of 60 years can be explained by angler avidity. Most anglers above 60 years of age are retired and therefore have the opportunity to fish more frequently. Contrastingly, few anglers below 15 years of age were interviewed. This was primarily for logistical reasons (*see* methods) and because in most cases the adults that accompanied them conducted the interview. In general, angling is a sport or pastime in which most participants begin young and continue throughout their lives (McGrath *et al.* 1997). Angler experience in the current study was also high, which confirms this point.

In contrast to the age-structure, the sex-ratio of shore-anglers has changed considerably since 1994-96. In the 1994-96 survey the number of females interviewed in the shore fishery was only 1.1%, whereas in the current study it was 17%. This is a substantial increase and is likely a result of shift in gender equality in the sporting environment, such as those that have been described in soccer and other traditionally male dominated sports (Pelak 2005; 2006).

As expected, the majority of anglers interviewed were day visitors that resided in KZN. Visitors to KZN from other provinces (20.1 % of 1049 shore-anglers interviewed) do however form an important part of the shore fishery (McGrath *et al.* 1997). Although holiday/overnight anglers fish less frequently than day trip anglers (Table 3.2), they contribute significantly more to the local economy, particularly during popular holiday periods. McGrath *et al.* (1997) also showed a twofold difference for money spent per day between local and overnight anglers in 1994-96. Furthermore, holiday/overnight anglers have other expenditures not directly related to fishing, which includes unanticipated expenses, that are often not included in economic assessments (Pollock *et al.* 1994; McGrath *et al.* 1997). Seventy-six percent of fishing trips are also made in the company of other people who do not fish; this also incurs further expenses during most fishing trips (Brouwer 1997). Overall, taking inflation into account, differences in expenditure between day and overnight anglers was similar to that recorded in the 1994-96 shore linefish survey (McGrath *et al.* 1997).

The mean duration of angler outings (4.6 ±2.7 hours) in the current study was very similar to that recorded in 1994-96 (4.7 hours) (Mann *et al.* 1997a), but was slightly higher than that recorded in the Richards Bay Harbour (4.1 hours) (Beckley *et al.* 2008), Mgeni (3.7 hours) (Pradervand *et al.* 2003) and Durban Harbour (4.3 hours) (Pradervand *et al.* 2003) estuarine shore fisheries. As shown in Fig. 3.4, most anglers either started or finished fishing during daylight hours, with very few anglers recorded fishing after 21h00 or before 03h00. Although half of the anglers interviewed stated that they had fished at night, the regularity of night fishing was very low. It must be noted that survey patrols during this study were only conducted during daylight hours for security reasons. This is unfortunate since CPUE, catch composition and angler motivations at night may well differ from those during the daytime. Nonetheless, in an attempt to curtail this problem in the current study, patrols were started as early as possible (06h00) and ended as late as possible (18h00). In this way anglers that had started a fishing outing at dusk or just before, or ended it at dawn or just after, were intercepted. This procedure minimised most of the biases associated with only sampling during daytime hours. However, future studies should strive to include nocturnal fishing effort. Possibly motion activated CCTV cameras could be put up at several popular fishing venues (e.g. on fishing piers), which could monitor anglers as they come and go (*see* Donovan 2010). Alternatively, survey patrols could be carried out simultaneously with nocturnal EKZNW compliance patrols, such as those carried out in the MT and BT zone (*see* Chapter 6).

Turnover rate of anglers (i.e. arrivals and departures of anglers from angling sites over a 24 hour period) is an important factor for estimating total participation in a fishery from instantaneous angler counts. The last national linefish survey conducted in 1994-96 estimated a turnover rate of 2.48 (Brouwer *et al.* 1997). Although this value has remained one of the best estimates of turnover rate of anglers in KZN (and the rest of South Africa), a new value of 2.17 was calculated in the current study (*see* Chapter 2). Importantly, the methods used in the current study differed from those described in Brouwer *et al.* (1997) and were based on methods described by Pollock *et al.* (1994) and Everrett (2004). Despite the different methods used, the turnover rates are very similar and the value estimated in the current study provides a valuable contribution to calculating annual fishing effort in KZN.

3.4.2 Subsistence fishers

Continuing from Chapter 2 and the above-mentioned results, it is quite evident that there are many people unscrupulously posing as subsistence fishers, when in reality they are nothing more than opportunistic recreational fishers. The estimated total number of 'true' subsistence fishers (i.e. 354-585 subsistence fishers; *see* Chapter 2) in the KZN shore linefishery is therefore a realistic value; however, even this could be an overestimation. Although in South Africa there are many anglers on the lower end of the income scale that do require some sort of support to survive (McGrath *et al.* 1997; Clark *et al.* 2002), any special dispensation or even special concessions given to these fishers quite easily becomes a loophole for poachers (Clark *et al.* 2002). There are several criteria that are useful in defining exactly what constitutes a subsistence fisher (Branch *et al.* 2002a). However, great care must be taken not to define subsistence fishers too broadly since this will ultimately compromise the sustainability of the resources on which they depend (Clark *et al.* 2002). Many subsistence fishery resources are already fully utilised or even overharvested (Siegfried *et al.* 1985; Dye 1992; Tomalin and Kyle 1998), while few other opportunities, barring several possible small-scale bait fisheries (Mackenzie 2005; Pradervand and Fennessy 2009) (*see* below), exist for subsistence fishers to harvest new resources (Harris *et al.* 2002). Although this sector of the fishery has historically been neglected by management, in recent years with the help of several researchers working together with managers, there have been several developments in communication, data gathering and compliance. Management between recreational anglers and subsistence fishers should ideally be balanced between the needs of the fishers themselves and the limits of sustainability. Unsustainable harvesting by either sector could compromise the fishery for all stakeholders that rely so heavily on it. For this reason, it might be beneficial for management to return most of its focus back onto recreational anglers who comprise the majority of linefish resource users in KZN (96.8%), while at the same time continuing with current management protocols/programs (i.e. subsistence fishery monitoring in KZN) that have been so rigorously designed for the subsistence sector (Cockcroft *et al.* 2002; Harris *et al.* 2002).

3.4.3 Bait utilisation

A high proportion of KZN shore-anglers preferred to use bait organisms rather than artificial lures (including fly and drop shot[*] fishing) to capture fish. This was expected and a similar trend was observed in the province during the last national linefish assessment conducted in 1994-96 (Mann *et al.* 1997a; Pradervand and Fennessy 2009) and in an estuarine shore-based recreational angling survey conducted in Richards Bay (Beckley *et al.* 2008). Similar bait usage was also observed in the Eastern Cape (Brouwer 1997; Mann *et al.* 2003; Mackenzie 2005); however, few other publications describe bait usage outside of KZN.

The most commonly used bait organisms in the KZN shore fishery were those that were commercially available from bait retailers and wholesalers[†] (i.e. pilchard/sardine, pink-prawn and squid). Pradervand & Fennessy (2009) estimated that 3400 tonnes of the most popular bait organisms (sardine and squid) are used annually in the KZN line fishery. Furthermore, yearly expenditure on bait organisms by shore-anglers in KZN, by taking the total number of outings estimated per year and extrapolating, was calculated at ~R40 million. It is clear that the buying and selling of bait organisms in KZN contributes significantly to the local economy (*see* Chapter 5 for yearly expenditure on bait organisms by boat-fishers). High expenditures on bait organisms have also been recorded in the Richards Bay Harbour (Beckley *et al.* 2008), Durban and Mgeni (Pradervand *et al.* 2003) estuarine shore fisheries. Interestingly, it is possible that the amount of bait organisms used in the shore linefishery exceeds the total catch made by this fishery (*see* Chapters 2 & 5). However, such a statement needs further investigation.

Since the 1994-96 linefish assessment in KZN (Mann *et al.* 1997a), the number of different bait organisms recorded has doubled from 14 to 28 in the current study. A number of reasons can account for this. Firstly, Pradervand & Fennessy (2009) state, red-eye sardine (*Etrumeus teres),* chub mackerel (*Scomber japonicus*) and other locally-harvested small pelagic fishes, which were traditionally only used by offshore boat anglers while targeting pelagic gamefish, are now highly-desired by shore-anglers as bait. For this reason, they are mostly sourced illegally by

[*] A form of artificial lure fishing originally used in freshwater, whereby lures mimic various bait organisms, both in smell and appearance.
[†] Suppliers of bait to specialist (fishing tackle outlets, etc.) and non-specialist retailers (e.g. general dealers, cafés, chain stores, etc.), which sell bait directly to anglers.

retailers directly from recreational offshore boat-fishers (Pradervand and Fennessy 2009). Many studies have often ignored the importance of these bait species; however, they form an important component of the entire shore and offshore linefisheries. For this reason, suitable legal methods of accessing these bait species needs to be developed to alleviate this problem. Secondly, in recent years many bait organisms that were traditionally self-collected by anglers under specific permit conditions hare now become commercially available. For example, red-bait (*P. stolonifera*) and octopus (*Octopus vulgaris*) can now be easily bought in and around Durban from specialist retailers. The accessibility of these bait species in bait shops has brought the legality of the permit system into question as anglers can now be in possession of such bait organisms without having to have a permit. This issue needs to be addressed to prevent increased illegal harvesting and subsequent overexploitation of these species. Thirdly, and to a lesser degree, in some areas of KZN many bait organisms can be bought illegally from local subsistence fishers. The most well known is the long-standing illegal trade of sand prawn (*Callianassa kraussi*) in the Durban harbour (Pradervand & Fennessy 2009). Other similar illegal bait trades have also been identified in the Eastern Cape (Robertson and Fielding 1997; Mackenzie 2005). In this regard the opportunity possibly exists to develop some small-scale, localised bait fisheries, so long as these are undertaken on a well managed and sustainable basis (*see* Mackenzie 2005).

During patrols many anglers were found to be using bait organisms that were illegal (e.g. seaworms[*]) and/or not in line with current regulations (i.e. under size, over the daily bag limits and/or without fishing permits). Stricter enforcement by EKZNW is required to keep this activity in check and better training of EKZNW patrol staff in the various bait types and concurrent regulations is needed. This is of particular importance since a large proportion of anglers were observed self-collecting bait organisms without permits.

3.4.4 Angler attitudes towards current management measures

The current regulations (with the exception of the beach vehicle ban) seem to have the support of the majority of shore-anglers. Similar trends were observed by Brouwer *et al.* (1997), Mann *et al.* (2002b), Mann *et al.* (2003), Pradervand *et al.* (2003), Mackenzie (2005) and Beckley *et al.* (2008). Although the lack of support towards the beach vehicle ban is of concern, the fact that very few anglers admitted to driving on the beach suggests that most anglers do abide by this law. Furthermore, policing of this regulation is relatively simple since any vehicle driving

[*]All marine species of the phyla Platyhelminthes, Nemertea, Sipunculida and Annelida (e.g. wonder worm (*Eunice spp.*) and mussel worm (*Pseudonereis variegata*)), are not allowed to be harvested in KZN.

on the beach can be easily detected from its tyre tracks. Despite the general support for the fishery regulations, most anglers had relatively poor knowledge of the regulations, while a large proportion admitted to disobeying them. This is in contrast to the results recorded by Mann *et al.*(1997a) and Brouwer *et al.* (1997), who found comparatively high levels of knowledge of the fishery regulations in KZN compared to the other coastal provinces. The most likely reason for the change is that during the current questionnaire survey, shore-anglers were questioned on their knowledge of the regulations of their three main target species and not on just *P. saltatrix* and *S. salpa* as was the case in the original survey. The actual number of anglers that disobey the regulations may in fact be higher than that recorded in this study since many anglers fear prosecution and deny disobeying the regulations during face-to-face interviews. An obvious link can be made between the lower catch rates of some fish species and the high violation of linefish regulations. Since catches of several important shore-angling species have decreased over the years (*see* Chapter 2), many shore-anglers are willing to break the law when the opportunity arrises. For instance, during many interviews anglers often expressed frustration with the regulations stating that few fish are ever caught, however, when they are 'on the bite', they (anglers) are only allowed to keep a few because of species-specific daily bag limits. The fact that relatively few anglers are prosecuted for breaking fishery regulations and because the associated fines are relatively small further compromises this problem. Furthermore, as is often the case, magistrate courts are overburdened with more serious crimes such as murder and rape, which leads to environmental crimes being subsequently considered less important (Moolla 2008). It is also quite possible that the lack of compliance recorded in this study is related to mistrust, false perceptions, misinformation and a lack of appreciation of the principles of environmental conservation (Govender 1999).

The fact that the regulations are so poorly known is of great concern. Many anglers are disobeying the regulations without actually knowing that they are. This point can probably also explain the high percentage of anglers that agree with the regulations since few actually know them well. Similar trends of non-compliance have been recorded elsewhere in South Africa (Bennett 1992; Attwood and Bennett 1995; Brouwer *et al.* 1997; Sauer *et al.* 1997; Mann *et al.* 2002b; Mann *et al.* 2003; Pradervand *et al.* 2003; Mackenzie 2005; Beckley *et al.* 2008) and abroad (Paragamian 1984; Gigliotti and Taylor 1990; Schill and Kline 1995; Henry and Lyle 2003; Byers and Noonburg 2007; King and Sutinen 2010). Since regulations on certain fish species have changed several times in the past decade (*see* Chapter 1), a well designed angler education programme should be implemented as soon as possible, possibly through fishing tackle shops and/or the Post Office where angling permits are sold. Although EKZNW has developed several brochures and pamphlets to facilitate information sharing and improved awareness of the fishing regulations, these initiatives currently appear to have had limited success, partly because of relatively high levels of social illiteracy.

Although it is often believed that implementation of an angling permit system will reduce angling effort (Pollock *et al.* 1994; O'Malley and Crawford 1995), results from Brouwer *et al.* (1997), McGrath *et al.* (1997) and the current study suggest otherwise. The introduction of the national marine recreational permit system in 1998 has been very successful in KZN. More than 95% of anglers exhibited compliance with the requirement for a fishing permit, which was considerably higher than the 67.1% of anglers who were willing to pay for an annual license fee in the 1994-96 linefish survey in KZN (Mann *et al.* 1997a). These results of permit compliance are similar to those recorded elsewhere in KZN, namely in the Richards Bay Harbour (94%) (Beckley *et al.* 2008), Mgeni (84%) (Pradervand *et al.* 2003) and Durban Harbour (86%) (Pradervand *et al.* 2003) shore estuarine fisheries. This high level of permit compliance is directly accounted for by the high number of inspections/patrols conducted by EKZNW staff. Brouwer *et al.* (1997) also recorded a similar correlation between angler compliance and inspection frequency in KZN, which was higher than any other coastal province in South Africa. It must be noted that some anglers regard a visible presence of EKZNW officials as being inspected. Nonetheless, despite the high inspection frequency recorded, many anglers continue to disobey many of the fishery regulations (except the requirement of a permit). It is apparent therefore that compliance-orientated shore patrols are severely biased towards checking for a permit and not checking for discrepancies in catch. Thus, although there is intensive policing by EKZNW, traditional problems, such as incorrect fish identification and absence of measuring fish, continue to undermine effective management of the fishery. The fact that a large proportion of anglers stressed that policing by EKZNW was ineffective (*see* below), reiterates this point. It is suggested that EKZNW continues with their current shore patrol system, but that they invest in better training of responsible staff, teaching them to identify common angling species correctly and ensuring that they have a thorough knowledge of the associated fishing regulations. It is also recommended that current management problems are brought to the attention of EKZNW staff and that these be dealt with in the respective training programmes. For further recommendations, see Chapters 6 & 7.

The questionnaire survey provided a unique opportunity to assess whether anglers fish less often nowadays than before and for what reasons. Mann *et al.* (2008) proposed that a number of changes, such as the beach vehicle ban, the poor security on the beaches and the depressed status of linefish stocks, may have been responsible for the apparent decrease in shore angler participation and effort since 1994-96. However, in the current study most anglers stated that 'work/family commitments' had prevented them from going fishing as much as they used to. This response may be explained by the economic recession that has affected the South African economy since 2007 (Arieff *et al.* 2010). However, it is also likely that many anglers now have alternate entertainment (i.e. increased availability of sport on television; Mann *et al.* 2008) and/or arrangements (i.e. family outings) that are more important than fishing, especially since catches have declined so drastically over the years leading to angler dissatisfaction (*see* Pollock *et al.* 1994). The fact that the second most common response to why anglers fish less often nowadays was because of the poor fishing and low catch rates confirms this point. Furthermore, when shore-anglers were directly asked if fishing had deteriorated over the years, the majority (83.8%) believed that catches had indeed declined. A similar trend was observed in the last national linefish assessment in KZN (Brouwer *et al.* 1997; Mann *et al.* 1997a)

Although general reasons for a decline in catches varied widely amongst anglers, there seems to have been a mind-set shift in KZN since 1994-96 (Mann *et al.* 1997a). In 1994-96 anglers stated that pollution (40.25%) was the most important reason for the decline in catches (Mann *et al.* 1997a). However, in the current study overfishing (21.5%) and trawling (17.8%) were the most common responses. These responses might be related to the greater public awareness of overfishing and the damaging effects that trawlers have on the oceans fish stocks. Interestingly, climate change also featured prominently in responses, which may also be accounted for by greater public awareness of this phenomenon in the last decade. A large proportion of anglers were also concerned by the general non-compliance of many anglers to the linefish regulations and the lack of effective management control by EKZNW. This again questions the efficacy of management.

3.4.5. Conclusion

In general, the socio-economic characteristics of the KZN shore linefishery have changed very little since the last national linefish assessment in 1994-96. The fact that anglers general perceptions are that the linefish stocks are overexploited and that there has been no recovery, coupled with the decrease in total fishing effort described in Chapter 2, is reason for concern. This correlates directly with the lower CPUE values recorded for several important linefish species and the change in catch composition recorded in this study (*see* Chapter 2). Although conventional stock assessment methods (i.e. per-recruit analyses and age-structured production models) provide valuable tools to assess the status of certain linefish stocks, the use of several less reliable stock status indicators, such as the degree of public concern, CPUE trends and changes in catch composition, can also provide a useful guide for management action (Griffiths *et al.* 1999). In this chapter, taking the public concern indicator (i.e. more than 75% of the survey respondents class the stock/s as over-exploited; Griffiths *et al.* 1999), it is quite clear that management has failed to provide a reasonable measure of resource protection, either because of poor enforcement or because the regulations themselves were not limiting (this aspect will be discussed in more detail in Chapter 6). This is further exacerbated by the fact that overall compliance levels by anglers are low and anglers generally have a poor public conscience and responsibility for the fishery regulations. If most of our linefish stocks are at their limits of protection, the only next option for sustainable management of resources must be fishery closure or the introduction of several Marine Protected Areas (*see* Chapter 7).

CHAPTER 4

CATCH AND EFFORT OF THE KWAZULU-NATAL OFFSHORE BOAT-BASED LINEFISHERY

4.1. INTRODUCTION

In comparison to the Western Cape where linefish have been exploited since the 18th century (Griffiths 2000), the offshore linefish resources of KwaZulu-Natal (KZN) have only been exploited for the past ±100 years (Garratt 1988; Penney *et al.* 1999). At first these resources were only accessed through a limited number of large lineboats (14-20 m in length) that operated out of the Durban Harbour (Mann-Lang *et al.* 1997). However, with the development of the skiboat after 1945 that could be launched through the surf (Penney *et al.* 1999), offshore fishing effort expanded along the KZN coast. Although the distance range of skiboats was minimal (< 25 nautical miles) compared to the above mentioned lineboats (Mann-Lang *et al.* 1997), the number of skiboats operating off KZN increased rapidly. Skiboats were compact, trailable, beach-launched vessels 4-6m long, powered by twin outboard engines and were more affordable, fuel efficient and cheaper to run than large harbour-based vessels (Penney *et al.* 1999). One of the key aspects brought about by skiboats was the fact that anglers could now launch from just about any reasonably protected beach (including river mouths) and access many productive fishing grounds that had previously not been exploited and had thus acted as refugia for resident reef fish.

The KZN boat-based linefishery is the largest of its kind in terms of capital investment, accounting for approximately 35% of the total capital value of all fisheries in the province (Penney *et al.* 1999). It also produces an estimated 40% of the total annual weight of fish landed in KZN (Penney *et al.* 1999). Furthermore, in terms of number of participants, it is the second largest marine fishery after shore linefishing (Brouwer *et al.* 1997). Currently, within the KZN offshore boat-based linefishery there are three sectors that compete directly with each other for the same fish resources using similar vessels and fishing equipment. These are namely recreational, charter and commercial boat-fishers. Although not fully recognised as a separate facet of the offshore boat-based linefishery in past literature and in the Marine Living Resources Act (No. 18 of 1998), charter boat fishing has become increasingly popular in KZN and has been shown to be driven by recreational and commercial objectives (Pradervand and van der Elst 2008). For this reason it was included as a separate sector in the current study. Considering the strong overlap in motivations between these three sectors and the fact that offshore boat linefishing is a ubiquitous activity characterised by a wide range of species, caught from both shallow and deep waters over a wide range of habitats, sector-specific management measures have been difficult to develop (Sauer *et al.* 1997; Penney *et al.* 1999).

Although catch and effort data has been collected on the offshore boat-based linefishery sporadically over the past 100 years (Penney *et al.* 1999), management decisions for this fishery have traditionally been based on research that focused on specific life-histories of the most important species (Sauer *et al.* 1997; Brouwer and Buxton 2002). For example, a study by Ahrens (1964) on *Polysteganus undulosus* eventually (20 years later!) resulted in several catch restrictions (i.e. a minimum size of 250 mm, bag limit of five fish per person per day and a 3-month closed season from 1 September to 30 November each year) being implemented for this species in 1984 (*see* Chapter 1). However, in the last 30 years catch and effort data has formed an important component for assessing the efficacy of management and providing information for specific management actions and subsequent regulations (Sauer *et al.* 1997; Griffiths *et al.* 1999). Furthermore, long-term monitoring of catch and effort has provided indications of important trends in the fishery and has allowed for better informed management decisions to be made.

Although catch and effort data from the National Marine Linefish System (NMLS) (*see* Chapter 6), has been used to motivate offshore linefish management recommendations, the NMLS has also been heavily criticised as being biased (e.g. error in data sources) and inaccurate (e.g. lacks coverage of certain sectors). For these reasons the NMLS was thought to provide a relatively poor representation of the true nature of offshore linefishing in KZN (Mann-Lang 1996; Penney 1997; Sauer *et al.* 1997). It is not surprising therefore that management measures that were implemented over the years based on this system have attracted much criticism. In light of the criticism revolving around the NMLS and based on requests for a revision of linefish management measures, a comprehensive survey on the offshore linefishery was conducted in 1994-96 (Mann *et al.* 1997a). This survey provided a comprehensive assessment of the levels of participation in all sectors of the KZN offshore boat-based linefishery (i.e. recreational and commercial skiboat fishing). In particular, it generated information and recommendations that were valuable in improving management systems, particularly for sustainable development. From this study it was realised that management must be periodically evaluated and assessed in terms of management objectives. Without periodic assessment of the efficacy of management, the management itself becomes compromised. It was therefore proposed that independent research surveys, such as that conducted in 1994-96, be carried out regularly (i.e. every 5 years) to evaluate the linefishery. However, while there have been a few surveys conducted focusing on certain aspects of offshore fishing in KZN since 1994-96 (Jairam 2005; Pradervand and van der Elst 2008), no large scale evaluations assessing fishery metrics, such angler participation, fishing effort, catch composition and CPUE, have been carried out. Furthermore, several changes have also occurred in the offshore boat-based linefishery over the years (*see* Chapter 1). Therefore, the primary aim of this chapter was to: (1) determine total boat-based fisher participation and annual fishing effort; (2) describe current trends in catch per unit effort (CPUE); (3) determine trends in catch composition and total catch; and (4) make comparisons with other similar independent assessments conducted along the South African coast and abroad.

4.2. MATERIALS AND METHODS

4.2.1. Access-point survey

Catch and effort data was obtained using a stratified-random access-point technique, based on the techniques developed in South Africa (Smale and Buxton 1985; Hecht and Tilney 1989; Mann *et al.* 1997a; Sauer *et al.* 1997; Brouwer and Buxton 2002; Fennessy *et al.* 2003; Pradervand *et al.* 2003; Everett and Fennessy 2007; Pradervand and van der Elst 2008) and abroad (Robson 1960; Robson and Jones 1989; Hayne 1991; Jones and Robson 1991; Wagner *et al.* 1991; Pollock *et al.* 1994; Pollock *et al.* 1997; Steffe *et al.* 2008). As pointed out by Stanovick & Nielsen (1991), sampling all potential launch sites (access-points) uniformly may cause the access-point design to become ineffective as areas of low and high fishing intensity will be sampled equally. The survey design therefore focused on launch sites[*] with high fishing effort to minimise the sampling bias; this information was obtained from launching effort along the KZN coast recorded in 2008 (*see* Khumalo *et al.* 2009). All launch sites were apportioned into zones according to the same zones that were patrolled by EKZNW in 2008 (Fig. 1.1). All sampling was stratified according to the same 6 weekdays: 6 weekend days as for the shore fishery, which was based on the ratio determined by Clarke & Buxton (1989) and Mann *et al.* (1997a). Peak school holidays (when the school holidays of all nine South African provinces coincided) and public holidays were also treated as weekend days. However, as the boat fishery is far more weather dependent, boat sampling was confined to areas and days when boats had gone to sea. All boats and their associated skippers that were encountered on a return trip were checked and questioned about the time spent fishing, crew size and demographics, area fished and what fish they had caught. Where large catches were made, such as on commercial vessels,

[*] During 2008-09 there were 45 registered boat launch sites along the KZN coast (15 of them were under the jurisdiction of the National Ports Authority (Durban and Richards Bay harbours) and the iSimangaliso Wetland Park Authority).

all fish caught were counted but only a sub-sample of fish was measured and the total catch weight was estimated by using published length/weight regressions (Froese & Pauly 2010; Mann 2000; Oceanographic Research Institute, unpublished data) and scaling up. In instances where large numbers of boats were encountered, a sub-sample routine was followed whereby boat skippers were checked randomly. However, all boats that were not checked were counted and apportioned into the different boat sectors (i.e. commercial, charter or recreational) according to their vessel registration number[*]. In instances where fish were kept but measurements of all fish could not be taken (i.e. uncooperative anglers), the species types and numbers caught were recorded and the length (and thus weight) was estimated using averages recorded for that species or its closest relative during the study period. Larger, harbour-based commercial linefishing vessels that operate at sea for extended periods and have freezing facilities or ice on board were not checked during this study as very few of these vessels currently operate in KZN waters. Furthermore, few boats that launched in the evening and returned at night were sampled for logistical and safety reasons.

Due to the large number of launch sites and spread of effort along the KZN coast, additional catch and effort data was also obtained from random access-point surveys carried out by trained observers as part of Marine and Coastal Management's (MCM) Linefish Observer Program. This programme has been running for the past three years (2007-2009) and records boat-based catch and effort data at a few of the major launch sites on the north coast (i.e. Richards Bay Skiboat Club, Meerensee Skiboat Club and Richards Bay Small Craft Harbour) and lower south coast (i.e. Port Edward Skiboat Club, Ramsgate Skiboat Club, Glenmore Skiboat Club and Shelly Beach Skiboat Club). Data from the programme were extracted for the period October 2008-September 2009 since subsequent to this period the observer programme ceased for three months (Oct-Dec 2009). Data from the access-point surveys carried out by the author for the period January 2009-September 2009 was therefore pooled with MCM's Linefish Observer Program data and used for the catch and effort analysis. In addition to catch and effort data, a sub-sample of boat skippers were interviewed using a detailed questionnaire (*see* Appendix VIII), the results of which are discussed in Chapter 5.

[*] In terms of the South African Maritime Safety Authority/Regulations for small vessels (Shipping Registration Act, No. 58 of 1998) all seagoing vessels must have a registration number (made up of text and a unique number). This number can be used to distinguish them into the different sectors of the KZN offshore boat-based linefishery. For example, "N123" would be a commercial linefishing boat, while "DTD122" or "DTR122" would be a vessel registered with the Department of Transport (DOT) in Durban or Richards Bay and would normally be a charter boat. Although, some recreationals do have a "DTD" or "DTR" number as well, the majority have a number according to the skiboat club they belong to (e.g. WSC125=Warner Beach Skiboat Club; INJ125= Injambili Skiboat Club; etc.).

4.2.2. Estimation of total fisher participation

Total annual effort in the South African commercial boat-based linefishery is monitored and regulated through rights allocations by MCM under the Marine Living Resources Act No. 18 of 1998 (MLRA). Total Allowable Effort (TAE), in terms of number of vessels was set at 52 vessels and 356 crew members for KZN during the long-term rights allocation process in 2006 (*see* Chapter 6). Not all these rights are activated each year and information on the number of active commercial vessels along the KZN coast during the study period was obtained from MCM (Y. Snyders, 2010, MCM, pers. comm.). In contrast, participation in the charter and recreational boat fisheries is currently of an open access nature. For this reason, four different methods were used to calculate total participation for the recreational boat sector. Firstly, as a requirement of the MLRA, all skippers of recreational vessels (and charter vessels for that fact) must be in possession of a code 10 recreational skippers permit (note this permit type is an extra permit only required by the skipper of a vessel, which is in addition to the general recreational angling permit required by all anglers). For this reason total participation was calculated using the number of code 10 skipper permits sold in KZN during 2008 by the Post Office/EKZNW (MCM unpublished data) and scaling up using the average crew size recorded for recreational boats (i.e. 3.13; Table 4.1). Note that this value was adjusted by taking into account the percentage of skippers that did not buy a code 10 skippers permit in 2008 (*see* Chapter 5). The second method calculated total participation of recreational boat-fishers by taking the total number of registered boats in KZN from the Natal Deep Sea Angling Association (NDSAA) and the South African Light Tackle Boat Anglers Association (SALTBAA) and multiplying this by the average crew size of the recreational boat sector. The third method used calculated total participation by taking the total number of launches recorded in 2009 by recreational boat-fishers (*see* below; Khumalo *et al.* 2010) and dividing it by the average number of times fished in a year (adjusted for avidity after Thompson (1991)) obtained from the questionnaire survey (*see* Chapter 5).

The fourth method, after Pradervand *et al.* (2003), estimated total participation by apportioning indicated angler effort (in terms of the declared number of outings in 12 months prior to date of interview) obtained from the questionnaire survey (*see* chapter 5) into distribution categories (*i*) as follows:

0-10 outings i = 1
11-20 outings i = 2
21-20 outings i = 3, etc.

and applying the equation:

$$N_T = \sum \frac{(b_i/c \times 100) \times E_{toutings}}{d_i}$$

where b_i is the number of interviewees in category *i*, c_i the total number of interviewees, d_i the average number of outings in category *i* and $E_{toutings}$ is the total number of outings (i.e. total annual angling effort; *see* below). This value was then multiplied by the average crew size for the recreational boat sector.

Total participation for the charter boat sector was obtained from Pradervand & van der Elst (2008). It is important to note that a high majority of anglers that fish off chartered boats (i.e. charter clients) are not regular anglers and in most cases pay to fish on a once-off basis. Thus, by taking the proportion of charter boat-fishers interviewed by Grljevic (1995) that were fishing on a charter boat for the first time (i.e. 41%), a more realistic representation of total participation in terms of number of anglers in the charter boat sector was obtained.

4.2.3. Estimation of total annual angling effort

In January 2002, all small craft launch sites (except those within registered ports) had to be licensed in terms of environmental considerations under the National Environmental Management Act (Act No. 107 of 1998; Khumalo *et al.* 2008). Through extensive stakeholder participation, this licensing initiative introduced a mandatory launch and catch register, known more commonly as the Boat Launch Site Monitoring System (BLSMS) register (Khumalo *et al.* 2008). This register was part of the Environmental Management Plan (EMP) developed for each successfully licensed small craft launch site, and it allowed managers of these launch sites a unique opportunity to collect valuable data on launch and catch statistics (Khumalo *et al.* 2008). Since skippers are obliged to record several aspects (e.g. date, launch time, beach time, crew number and purpose of trip; refer to Khumalo *et al.* 2010) for each boat outing in the BLSMS register, angler effort (i.e. number of launches/outings per annum) was determined by analysis of these records.

4.2.4. Estimation of total catch and catch per unit effort (CPUE)

Since anglers differ greatly in fishing ability and because there are a number of variables that can influence CPUE (i.e. weather, area and time of day.; Bennett & Attwood 1991), CPUE was calculated per boat outing and then averaged for the entire data set. The following formula was used:

$$\text{CPUE} = \frac{\sum_{i=1}^{n}(C_i)}{n}$$

where C_i is the number or weight (kg) of fish retained by the *i*th boat outing, and n is the total number of boat outings sampled. Boat outings that had a duration of less than 0.5 hours were excluded from the CPUE calculation to avoid influencing the variance of the catch-rate estimator by extreme catch rates that arise by chance during short fishing trips (Pollock *et al* 1994). Released fish were not included in CPUE calculations because of the unreliability of angler reports (Claytor and O'Niel 1991; Brouwer *et al.* 1997).

Total annual catch was estimated by multiplying total annual effort by the CPUE as follows:

$$C_{total} = \text{CPUE} \times E_{total}$$

4.3. RESULTS

4.3.1. Access-point survey

A total of 390 access point surveys was carried out at 32 of the ~45 registered skiboat launch sites along the KZN coast between 1 October 2008 and 30 September 2009. In all, 1 318 boats were inspected, which consisted of 561 recreational, 234 charter and 523 commercial boat outings. The numbers of boats inspected per month and per zone are shown in Figure 4.1. Temporally, sampling effort for recreational, charter and commercial boat-fishers was evenly distributed throughout the year (Fig. 4.1a). Spatially, the majority of the boat inspections were conducted on the high-usage lower-south (UV and TF zones) and mid-north (RB zone) coastal zones of KZN (Fig. 4.1b). However, boat inspections were also conducted at other popular launch sites, such as in the CV, SL, TG, DB and SB zones. Most charter boat-fishers were inspected at popular (high-usage) launch sites (i.e. St Lucia (SL), Rocky Bay (SB), Shelly Beach (UV) and Port Edward (TF)), while all commercial operators were inspected in the RB, UV and TF zones (Fig. 4.1b). RB had the highest commercial boat sampling effort at 316 outings inspected. Recreational boat-fishers were inspected in 12 of the zones along the KZN coast (Fig. 4.1b).

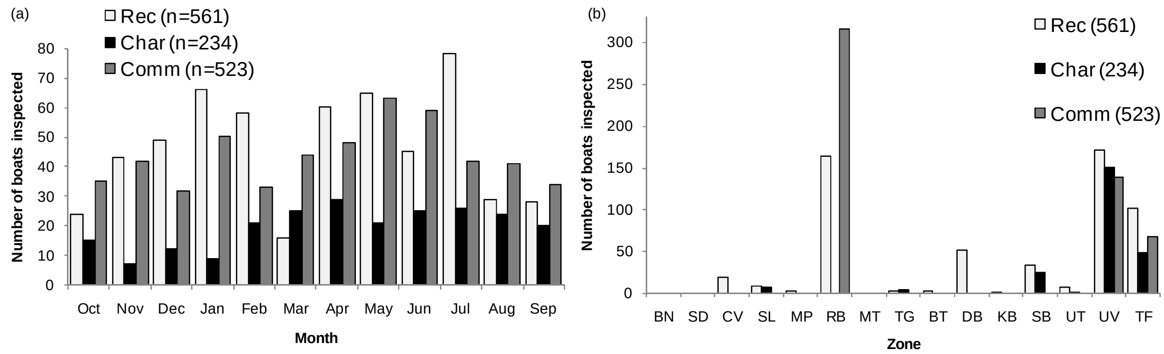


Figure 4.1- Summary of the total (a) temporal and (b) spatial survey effort along the KZN coast from 390 access point surveys conducted between October 2008 and September 2009 (BN=Banga-Nek; SD=Sodwana; CV=Cape Vidal; SL=St Lucia; MP=Mapelane; RB=Richards Bay; MT=Mtunzini; TG=Tugela; BT=Ballito; DB=Durban; KB=Kingsburgh; SB=Scottburgh; UT=Umtentweni; UV=Uvongo; TF=Trafalgar; Rec= recreational, Char= charter, Comm= commercial).

There was a significant difference (Kruskal-Wallis One-way ANOVA, H = 674.99, df = 2, p= <0.001) in the average number of crew per boat between the sectors (Table 4.1). However, according to Dunn's test, charter (6.2 ±2.2 crew members) and commercial (5.8 ±1.1 crew members) boat-fishers had on average a similar number of crew per vessel (p > 0.05), while recreational boat-fishers (3.1 ±1.4 crew members) generally had fewer crew. The number of crew ranged from 1-10 for recreationals, 2-10 for commercials and 2-12 for charters. It should be noted that the high crew range recorded for recreational vessels might be overestimated since some charter outings, which generally have a higher crew number, were recorded as recreational outings in MCM's Linefish Observer Programme.

The average fishing trip duration (i.e. time spent fishing at sea) per sector was also significantly different (Kruskal-Wallis One-way ANOVA, H = 412.39, df = 2, p= <0.001; Table 4.1) between the sectors. Commercial boat-fishers (7.2 ±1.5 hours) spent the longest period fishing at sea, whilst recreationals fished for the shortest period at only 5.1 ±1.6 hours. However, this ranged from 1-12 hours for recreationals, 1-11 hours for commercials and 1-10 hours for charter boat-fishers. There are obvious factors (i.e. fishing conditions and economics) that influence the duration of fishing trips.

Table 4.1- Average crew size and daily fishing hours from 1 318 boat inspections conducted along the KZN coast between the period October 2008 and September 2009. Standard deviation is given in parentheses.

Parameters	Recreational	Charter	Commercial
Average number of crew	3.13 (1.43)	6.10 (2.24)	5.81 (1.04)
Average daily fishing hours	5.12 (1.59)	5.71 (1.45)	7.23 (1.50)

4.3.2. Total fisher participation

The total number of boat-fishers participating in the KZN offshore boat-based linefishery was estimated at between 21 220 and 28 857 fishers, which comprised 5 866-13 503 recreational boat-fishers, 15 000 charter boat-fishers and 354 commercial boat-fishers (Table 4.2). The number of boats participating was estimated at between 2 008 and 4 445, comprising 1 874-4 311 recreational, 96 charter and 38 commercial boats (Table 4.2). Using the number of non-local KZN anglers interviewed (i.e. 10.6% based on questionnaire survey, *see* Chapter 5), it is estimated that between 622 and 1 431recreational boat anglers (199-458 boats) visit KZN from other provinces.

Table 4.2- Estimates of total participation in the KZN recreational offshore boat-based linefishery in 2009 based on the four different methods (*see* materials and methods above).

Method	Total no. of Boats	Total no. of anglers	Reference
1	4311	13503	MCM unpublished data
2	2448	7662	NDSAA* & SALTBA**
3	2665	8341	BLSMS data and this study
4	1874	5866	This study (after Pradervand *et al.* 2003)

R. Hand, 2010, Chairman of NDSAA, pers. comm.
**B. Else, 2010, Finnlands Skiboat Club Secretary, pers. comm.

4.3.3. Total annual angling effort

Based on the BLSMS register (Khumalo *et al.* 2010), there were approximately 38 128 boat launches undertaken for the purpose of fishing along the KZN coast during 2009. This was made up of 30 435 recreational, 5 898 charter and 1 795 commercial boat launches. However, a large proportion of commercial effort (±54%) is not recorded on the BLSMS as many commercial boat-fishers neglect to fill in the BLSMS register and/or launch from launch sites that do not have a register (e.g. Richards Bay Harbour). For this reason, the number of outings reported by commercial fishers on the mandatory NMLS catch returns (known as the “Blue Books”) was used as a more reliable indication of commercial launch effort. Based on these commercial returns (MCM unpublished data; Y. Snyders, 2010, MCM, pers. comm.), a total of 3 331 commercial boat launches were recorded during 2009. Taking this more realistic value into account, total annual angling effort in the KZN offshore boat-based linefishery during 2009 was estimated to be 39 664 launches for all three sectors included. Note that this estimate excludes non-motorised fishing vessels such as paddle-skis (known locally as fishing-skis), which generally do not have to launch through registered launch sites (Pradervand *et al.* 2007a).

4.3.4. Spatial and temporal variation in fishing effort

Temporal boat fishing effort is shown in Figure 4.2. Recreational and charter boat-fishers have similar seasonal variation in fishing effort, with both having peaks in effort during popular school holiday periods (i.e. December, January, April and July). There was also a drop in angler effort for both sectors from September to November (i.e. spring) corresponding with the windy period. Commercial boat fishing effort is fairly high throughout the year, with a slight increase over the peak winter (i.e. May-July) and summer months (October-January).

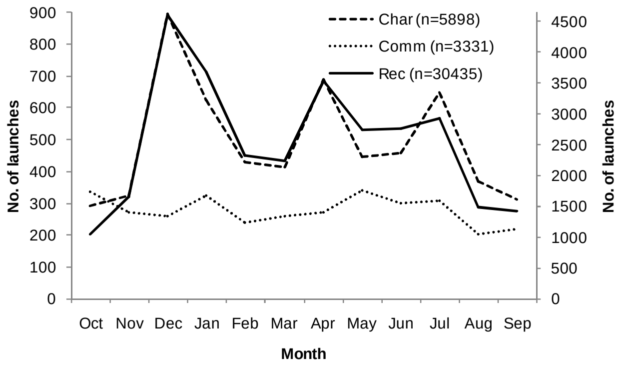


Figure 4.2- Temporal distribution of boat fishing effort between recreational (secondary axis), charter (primary axis) and commercial (primary axis) boat-fishers along the KZN coast during 2009 from the BLSMS and mandatory commercial NMLS returns (Rec- recreational; Char- charter; Comm- commercial).

Spatially, boat fishing effort differed along the coast and between the sectors (Fig. 4.3). Recreational boat-fishers generally launched from all zones except BN. Notably, the UV (2 211), DB (8233), RB (5 546) and CV (2 764) zones had the highest recreational boat use. Charter boat-fishers generally launched along the south coast of KZN, with UV (1 918) and SB (1 101) zones having the highest usage. SL (829) and TG (473) zones on the north coast also had relatively high charter boat usage. However, it should be noted that currently charter boat-fishers operating out of Durban Harbour do not complete the BLSMS register and have therefore been omitted from this assessment. Commercial fishing effort was highest in the RB (708) and TG (561) zones on the north coast and UT (455), UV (559) and TF (415) zones on the south coast. No commercial effort was recorded north of Richards Bay. However, this is because commercial fishing is prohibited in the MPAs within the iSimangaliso Wetland Park situated north of St Lucia.

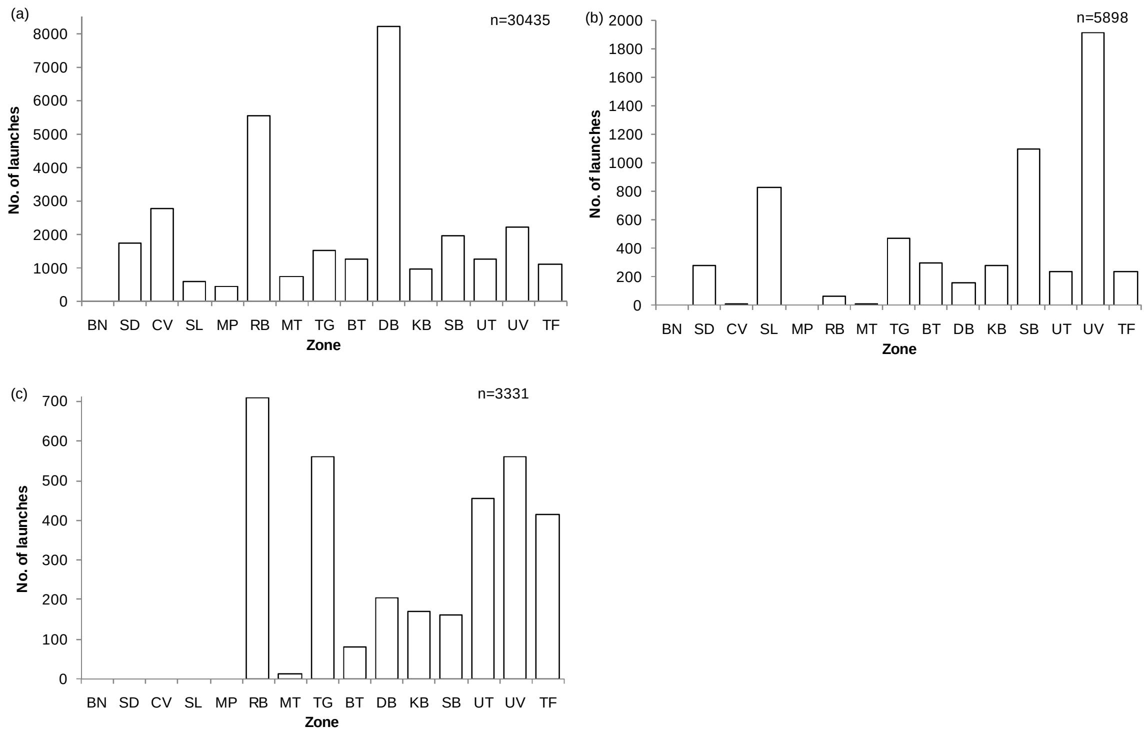


Figure 4.3- Spatial distribution of boat fishing effort along the KZN coast between (a) recreational and (b) charter boat-fishers from the BLSMS and (c) commercial boat-fishers based on mandatory commercial NMLS catch returns during 2008/9 (BN=Banga-Nek; SD=Sodwana; CV=Cape Vidal; SL=St Lucia; MP=Mapelane; RB=Richards Bay; MT=Mtunzini; TG=Tugela; BT=Ballito; DB=Durban; KB=Kingsburgh; SB=Scottburgh; UT=Umtentweni; UV=Uvongo; TF=Trafalgar).

4.3.5. Catch per unit effort (CPUE)

During the current survey a total of 1 318 boat outings were inspected. These vessels had caught and kept a total of 171 814 fish, constituting a total of 141 346 kg during 39 584 man-hours of fishing. Overall CPUE numerically (Kruskal-Wallis One-way ANOVA, $H = 929.59$, $df = 2$, $p = <0.001$) and by weight (Kruskal-Wallis One-way ANOVA, $H = 856.18$, $df = 2$, $p = <0.001$) was significantly different between the sectors of the KZN offshore boat-based linefishery (Table 4.3). The commercial boat sector had the highest CPUE both numerically ($p < 0.05$; 307.4 $fish.outing^{-1}$) and by weight ($p < 0.05$; 235.6 $kg.outing^{-1}$) compared to the other sectors (Dunn's test). Contrastingly, the recreational boat sector had the lowest CPUE both numerically ($p < 0.05$, 8.6 $fish.outing^{-1}$) and by weight ($p < 0.05$, 15.0 $kg.outing^{-1}$). The charter boat sector ($p < 0.05$, 26.6 $fish.outing^{-1}$ or 41.6 $kg.outing^{-1}$), although far lower than commercials, had a CPUE slightly higher than the recreational boat sector. A similar trend was found between the number of fish caught per angler per hour (Kruskal-Wallis One-way ANOVA, $H = 816.53$, $df = 2$, $p = <0.001$) and the weight of fish per angler per hour (Kruskal-Wallis One-way ANOVA, $H = 628.02$, $df = 2$, $p = <0.001$) between the different sectors (Table 4.3). In general, commercial boat-fishers catch a lot more than charter and recreational boat-fishers, however, these fish are mostly smaller in size. Similarly, charter boat-fishers catch more fish per outing than recreational boat-fishers, but this is because they often target smaller reef fish species and have on average greater crew sizes.

Table 4.3- Summary of CPUE results from 1 318 boat inspections conducted along the KZN coast between the period October 2008 and September 2009. Standard deviation is given in parentheses.

Parameters	Recreational	Charter	Commercial
Average number of fish.outing^{-1}	8.58 (15.11)	26.61 (19.71)	307.41 (274.17)
Average weight of fish.outing^{-1} (kg)	15.00 (17.75)	41.60 (41.26)	235.56 (193.46)
Average number of fish.fisher^{-1}.hour^{-1}	0.58 (1.43)	0.82 (0.55)	6.71 (4.94)
Average weight of fish.fisher^{-1}.hour^{-1}(kg)	1.04 (1.25)	1.35 (1.33)	5.18 (3.42)

Based on sampled catches, monthly variation in CPUE by number (fish.outing^{-1}) for each sector between October 2008 and September 2009 along the KZN coast is shown in Figure 4.4. Numerically, CPUE was not significantly different between months or austral seasons for any of the boat-based sectors (Fig. 4.4). This may be explained by the high variation (i.e. standard deviation) in catches. Nonetheless, CPUE for all three sectors seems to be slightly higher during late spring (October-November) and from March through to July (autumn to winter). Specifically, recreational (9.5 fish.outing^{-1}) and commercial (342.1 fish.outing^{-1}) boat-fishers had a relatively higher CPUE during autumn. August and September generally had the poorest CPUE for all sectors during the year

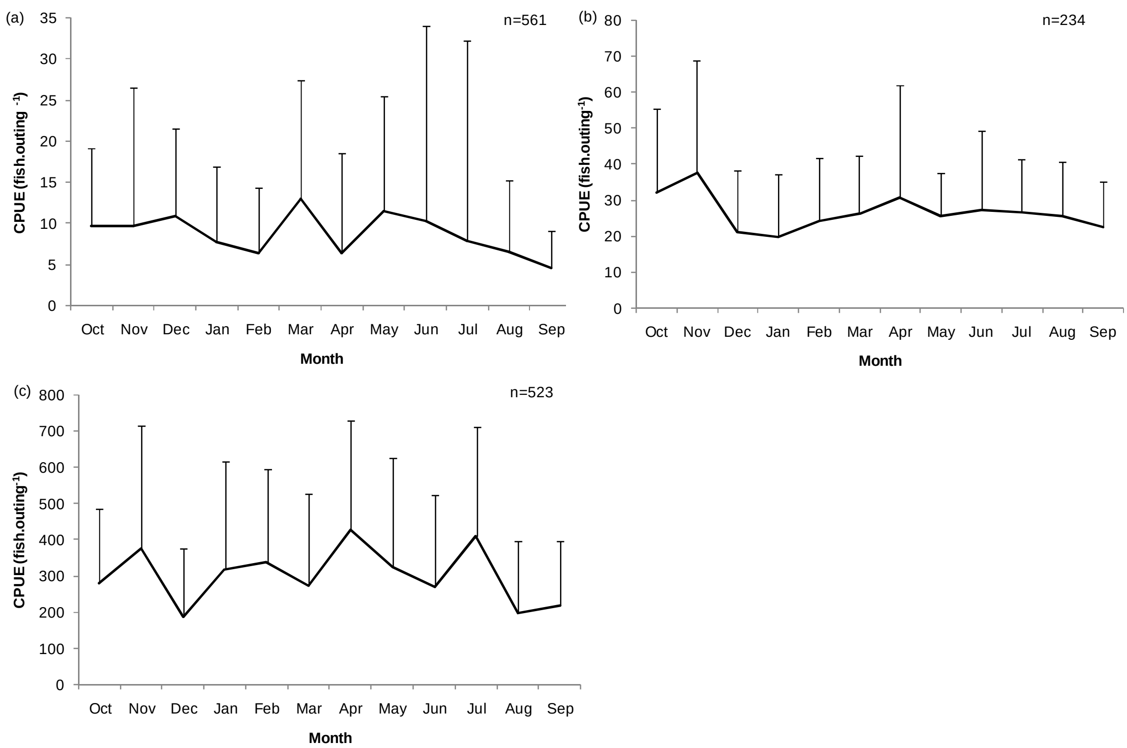


Figure 4.4- Monthly variation of mean (+ standard deviation) CPUE (fish.boat-outing^{-1}) for (a) recreational, (b) charter and (c) commercial boat-fishers recorded along the KZN coast from 390 access-point surveys conducted between October 2008 and September 2009.

Monthly variation in CPUE by weight (kg.outing^{-1}) for each sector between October 2008 and September 2009 along the KZN coast is shown in Figure 4.5. The only significant difference in CPUE by weight between the austral seasons was for the recreational boat fishery (Kruskal-Wallis One-way ANOVA, H = 41.5, df = 3, p= <0.00; Fig. 4.5b), where CPUE during winter (11.0 fish.outing^{-1}) was lower than during the summer (18.0 fish.outing^{-1}) months (Dunn's test). Again, the high variation in catches from month to month may explain why there was no significance difference between the austral seasons and the various sectors. Nonetheless, charter boat-fishers showed a distinct peak in CPUE by weight in summer (54.7 kg.outing^{-1}), and to a lesser degree in autumn (42. kg.outing^{-1}) and spring (45.6. kg.outing^{-1}). Fish caught during January and February by charter boat-fishers were of a larger size since CPUE numerically was lowest at this time of year (Fig. 4.6). CPUE by weight for commercials was highest from April (309.0 kg.outing^{-1}) through to July (277.7 kg.outing^{-1}).

In general, commercial CPUE by weight was identical to CPUE by number, showing four distinctive peaks throughout the year. This shows that commercial boat-fishers rely heavily on relatively small reef fish species when they are most abundant, whereas recreational and charter boat-fishers tend to target larger fish (i.e. pelagic gamefish). Nevertheless, there was a fairly high degree of overlap between the different sectors at certain times of the year suggesting that when a certain species is abundant, all sectors will target it (e.g. *Scomberomorus commerson* and *Coryphaena hippurus*).

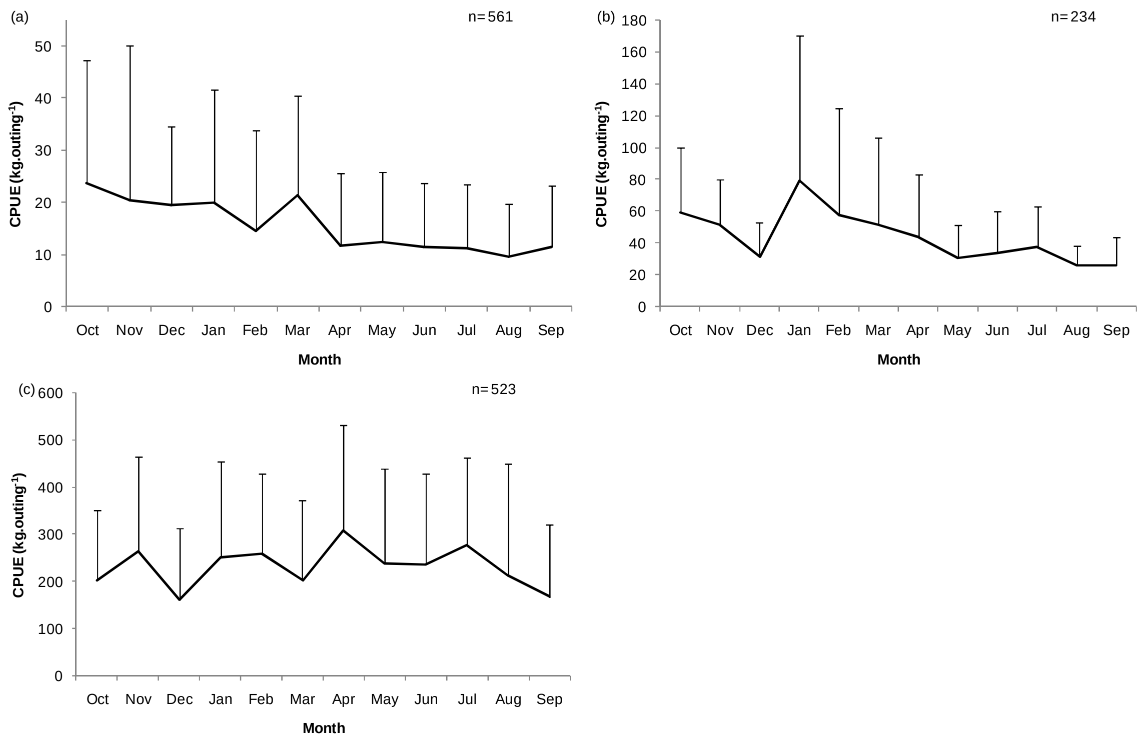


Figure 4.5- Monthly variation of mean (+ standard deviation) CPUE (kg.boat-outing^{-1}) for (a) recreational, (b) charter and (c) commercial boat-fishers recorded along the KZN coast from 390 access-point surveys conducted between October 2008 and September 2009.

It is difficult to clearly reflect spatial variation in CPUE along the KZN coast since charter and commercial boat-fishers do not operate from all launch sites (Fig. 4.6). For this reason, zones on the north coast (i.e. from Bhanga-Nek to Ballito) and zones on the south coast (i.e. from Durban to Trafalgar) of KZN were combined for statistical analyses. Commercial boat-fishers on the north coast (438.6 fish.outing^{-1}) had a significantly (Mann-Whitney U test, U = 6288.5, df = 521, p = <0.001) higher CPUE numerically than those on the south coast (107.2 fish.outing^{-1}) of KZN (Fig. 4.6a). Contrastingly, recreational boat-fishers on the south coast (9.9 fish.outing^{-1}) had a numerical CPUE significantly (Mann-Whitney U test, U = 31541, df = 559, p = 0.018; Fig. 4.6a) higher than those on the north coast (6.2 fish.outing^{-1}). Statistically, there was no difference in numerical CPUE between the north and south coasts of KZN for charter boat-fishers. However, the high variation in CPUE estimates may account for this.

By weight, commercial boat-fishers on the north coast (324.6 kg.outing^{-1}) had a significantly (Mann-Whitney U test, U = 7885, df = 521, p = < 0.001) higher CPUE than those on the south coast (99.7 kg.outing^{-1}) of KZN (Fig. 4.6b). In contrast, charter boat-fishers on the south coast (42.7 kg.outing^{-1}) had a significantly (Mann-Whitney U test, U = 693.5, df = 232, p = 0.014; Fig. 4.6b) higher CPUE by weight than those on the north coast (18.34 kg.outing^{-1}). Similarly, recreational boat-fishers on the south coast (17.1 kg.outing^{-1}) also had a CPUE by weight significantly (Mann-Whitney U test, U = 28866, df = 559, p = < 0.001; Fig. 4.6b) higher than those on the north coast (11.2 kg.outing^{-1}).

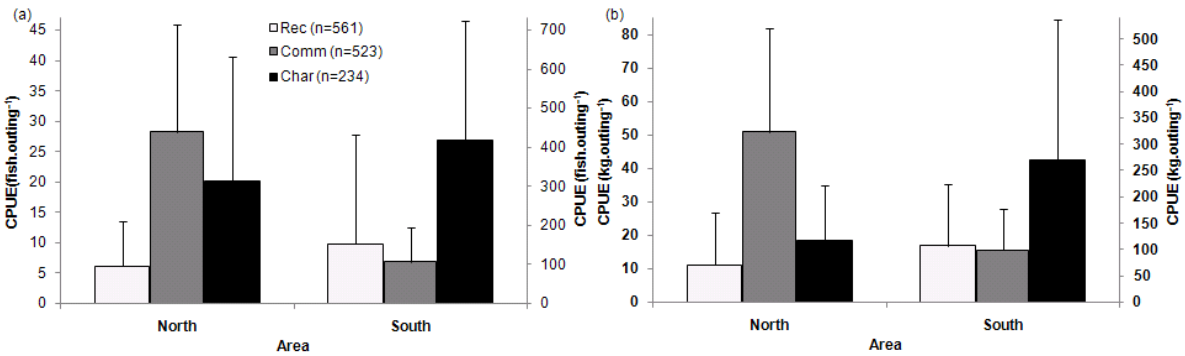


Figure 4.6- Mean (+ standard deviation) spatial variation of CPUE (a) numerically and (b) by weight for recreational (primary axis), charter (primary axis) and commercial (secondary axis) boat-fishers along the KZN coast from 390 access-point surveys conducted between October 2008 and September 2009.

4.3.6. Total catch and catch composition

Based on estimates of total annual angling effort, the total annual catch for the KZN offshore boat-based linefishery was estimated at 1 487 metric tonnes (mt) per annum (1 442 027 fish per annum). More specifically, 457 mt per annum (261 132 fish per annum) for recreational, 245 mt per annum (156 946 fish per annum) for charter and 785 mt per annum (1 023 949 fish per annum) for commercial boat-fishers.

In total, 84 teleost species, belonging to 26 families and two cartilaginous species representing one family were recorded in catches of boat-fishers (all sectors) during the study period (*see* Appendix V, VI, and VII). The top five species that comprised the bulk of the commercial catch numerically included *Chrysoblephus puniceus* (66.0%), *Cheimerius nufar* (22.4%), *Lethrinus nebulosus* (4.9%), *Pachymetopon aeneum* (1.9%) and *Chrysoblephus anglicus* (0.9%) (*see* Appendix V). Similarly, in terms of weight, the commercial catch was dominated by *C. puniceus* (53.0%), C. *nufar* (25.2%), *Epinephelus andersoni* (3.1%), *L. nebulosus* (3.3%) and *P. aeneum* (2.6%) (*see* Appendix V). Demersal reeffish species, particularly sparids and some soft-substrate species (e.g. Sciaenidae), play an important role in overall catches of commercial boat-fishers. For example, sparids alone contributed 91.9% and 85.3% of the catch by number and weight respectively. Pelagic gamefish were poorly represented in the commercial catches.

Recreational catch composition by number was dominated by *C. puniceus* (33.9%), *L. nebulosus* (9.0%), *Thunnus albacares* (7.4%), *Scomber japonicus* (5.3%) and *C. anglicus* (4.4%) (*see* Appendix VI). By weight, recreational catch composition was dominated by *T. albacares* (21.7%), *C. puniceus* (14.1%), *Coryphaena hippurus* (9.8%), *Cymatoceps nasutus* (5.1%) and *Euthynnus affinis* (4.9) (*see* Appendix VI). Importantly, pelagic gamefish comprise a large percentage of the catch both by number and weight. However, demersal reeffish species also make up an important component. Interestingly, *C. nasutus* made up an important component of catch composition by weight for recreational boat-fishers, whilst it was of less importance in the other sectors. Compared to charter and commercial boat-fishers, recreational boat-fishers target and catch a wider variety of fish.

The top five species numerically in charter boat-fishers' catches comprised *C. puniceus* (34.4%), *L. nebulosus* (16.7%), *T. albacares* (13.1%), *C. anglicus* (8.1%) and *P. aeneum* (4.6%) (*see* Appendix VII). Similarly, by weight catch composition for charter boat-fishers was dominated by *T. albacares* (43.0%), *C. puniceus* (11.1%), *C. anglicus* (8.0%), *L. nebulosus* (7.0%) and *P. aeneum* (4.2%) (*see* Appendix VII). As with commercial boat-fishers, demersal reeffish species are an important component of catches both numerically and by weight; however, pelagic gamefish species, such as *T. albacares*, also form an important part of charter boat catches. Furthermore, *C. hippurusis* is an important species taken by charter boats in the Durban area, especially during the summer months around Fish Attracting Devices (FADs).

Overall, there was significant overlap in catches made between all three sectors. However, commercial boat-fishers seem to focus far less on pelagic gamefish and concentrate on smaller, more abundant reef fish species (i.e. mostly sparids). Conversely, pelagic gamefish (including small pelagic bait fish species) are important in recreational boat-fishers catches, whilst reef fish species are less important. Interestingly, charter boat-fishers have a catch composition that closely reflects both the other two sectors. Importantly, a high proportion of endemic reef fish were caught and kept in all three sectors.

Directed angling effort, described by angler preference (i.e. which species anglers said they were targeting), showed that the majority (73%) of recreational boat-fishers preferred to target pelagic game fish (Fig. 4.7a), while commercial boat-fishers (89%) preferred to target demersal fish species (Fig. 4.7e). Charter boat-fishers had a larger range of target species, with pelagic gamefish (51%) and demersal species (46%) both comprising a large proportion of targeted effort (Fig. 4.7c). Actual catch (i.e. species composition by number) for recreational, charter and commercial boat-fishers according to target species groups is shown in Figure 4.7b, Figure 4.7d and Figure 4.7f respectively. For both charter and commercial boat-fishers, targeted catch was very similar to their actual catch. Reef fish, however, are more important in catches than described by angler preference for charter boat-fishers. Despite considerably more time spent targeting gamefish, reeffish remained more important in recreational anglers catches.

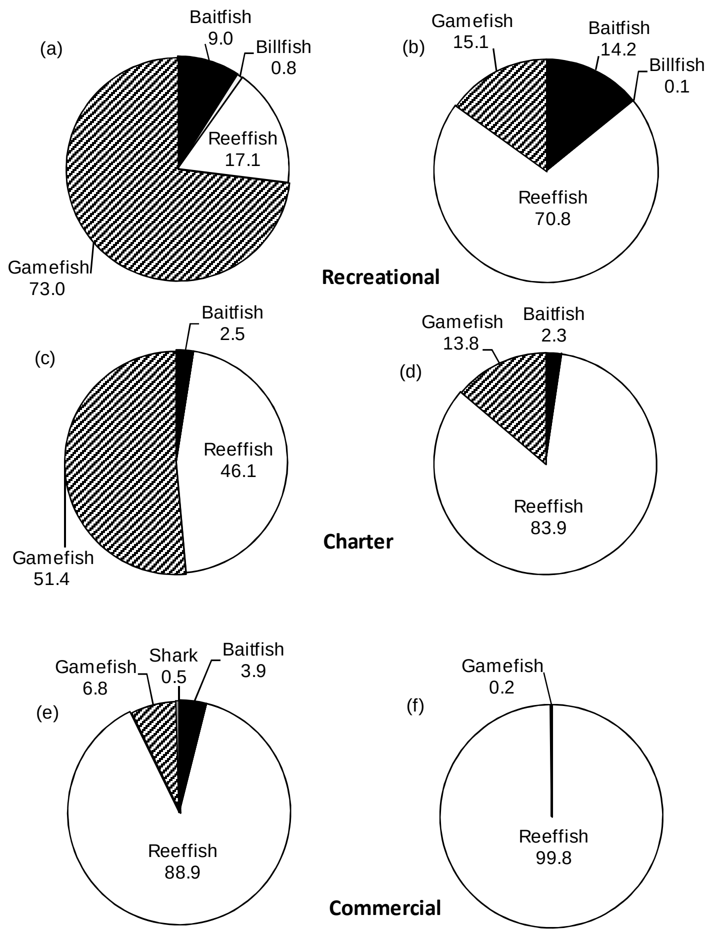


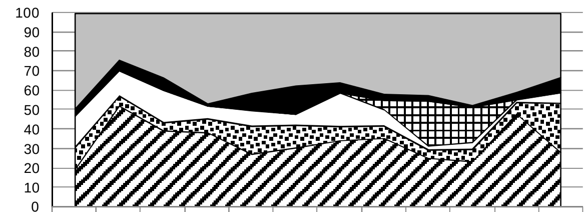
Figure 4.7- Percentage targeted effort by recreational, charter and commercial boat-fishers in terms of (left) angler preference and (right) actual catch (i.e. species composition by number) with regard to target species groups found along the KZN coast from 390 access-point surveys conducted between October 2008 and September 2009. Note that "reeffish" includes soft-substrate species.

The seasonal abundance of the top five species caught in each sector along the KZN coast is shown in Figure 4.8. The catch composition of recreational boat-fishers was quite variable throughout the year (Fig. 4.8a). This is particularly evident from the large proportion of 'OTHER' fish species caught each month. Although *C. puniceus* is the most abundant fish species all year round, *T. albacares* showed a significant increase in catches during spring and summer. Similarly, *C. anglicus* had a distinct increase in numbers from February to March and also in September. Interestingly, *S. japonicus* was only recorded in recreational boat-fishers catches in February and from May through to July. However, it only made up an important component in the latter period. *L. nebulosus* was caught in good numbers throughout the year, with notable increases in abundance during February-April and September-October.

Charter boat-fishers had a similar temporal variation in catch composition to recreational boat-fishers (Fig. 4.8b). *T. albacares* showed a significant increase in catches during spring and summer, whilst *L. nebulosus* was caught in good numbers throughout the year, with clear increases in abundance during February-April and September-October. Compared to the commercial boat fishery, charter boat-fishers seem to rely more heavily on *C. anglicus* and *P. aeneum* throughout the year. This, however, may be because *C. puniceus* does not form such an important component in the charter boat fishery as it does in the commercial boat fishery. Abundances of *C. anglicus* and *P. aeneum* had marked temporal increases similar to those experienced in the commercial boat fishery (*see* below), with *P. aeneum* being caught in good numbers in the later part of the year and *C anglicus* having a strong appearance in early summer. As in the recreational boat based fishery, 'OTHER' fish species also form an important part of the catch of charter boat-fishers at different times of the year.

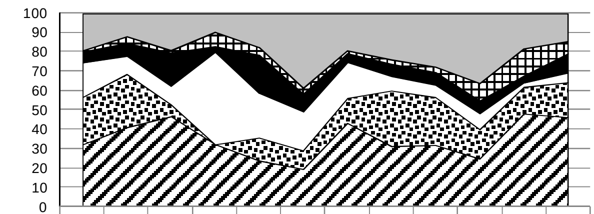
For commercial boat-fishers the catch is dominated by the top five species throughout the year, with only the months of August and September (spring), and to a lesser extent December, having a larger number of 'OTHER' fish species (i.e. sciaenids and serranids) being caught (Fig. 4.8c). *P. aeneum* seemed to be most prominent in catches during the latter half of the year, while catches of *C. anglicus* increased during summer (November and December) and early winter (April-June). It is obvious from these results that commercial boat-fishers are extremely reliant on two of the top five species (i.e. *C. puniceus* and *C. nufar*) throughout the year.

(a)



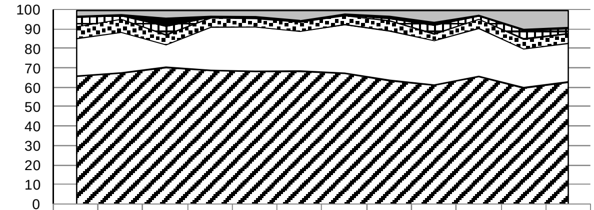
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
OTHER	49	24	33	47	41	38	36	42	42	48	41	33
ENGL	3	5	6	1	9	14	5	3	3	1	4	8
MCKR	0	0	0	0	0	0	0	5	23	18	0	0
YFTN	16	13	17	7	8	6	17	8	2	4	2	6
BMPR	11	5	4	7	14	12	7	6	4	6	6	25
SLNG	20	52	39	39	27	31	34	36	25	24	48	28

(b)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
OTHER	19	12	19	9	17	38	19	24	28	36	18	14
BLHT	1	3	1	7	4	3	1	2	3	9	14	6
ENGL	6	7	17	3	20	9	5	7	7	7	4	10
YFTN	18	10	9	47	23	20	19	8	6	8	2	5
BMPR	24	27	6	0	12	10	13	29	25	15	14	18
SLNG	32	41	47	32	24	20	43	31	32	25	48	46

(c)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
OTHER	3	2	4	3	3	5	2	3	6	2	10	9
ENGL	1	1	4	1	1	1	1	1	2	1	1	1
BLHT	5	2	4	0	0	0	0	1	5	2	4	2
BMPR	6	7	5	5	4	5	5	5	3	5	5	5
SNTR	20	21	12	22	23	21	25	26	23	25	20	20
SLNG	66	68	71	69	68	69	67	64	61	66	60	63

Figure 4.8- Monthly species composition of the major species caught by (a) recreational, (b) charter and (c) commercial boat-fishers along the KZN coast recorded during 390 access-point surveys conducted between September 2008 and October 2009 (BLHT= *Pachymetopon aeneum*; BMPR= *Lethrinus nebulosus*; ENGL= *Chrysoblephus anglicus*; MCKR= *Scomber japonicus*; SLNG= *Chrysoblephus puniceus*; SNTR= *Cheimerius nufar*; YFTN= *Thunnus albacares*; and OTHER= includes all other species caught and kept).

The spatial variation in catch composition of the top five species for each sector is shown in Figure 4.9 (note that zones on the north coast (i.e. from BN to BT) and zones on the south coast (i.e. from DB to TF) of KZN were combined for statistical analyses). Although there was some overlap between the north and south coast of KZN for each sector, some species were caught only or in greater abundances on the south coast compared to the north. For example, in the recreational boat fishery very few C. *anglicus* (0.74%), *T. albacares* (0.17%), and *L. nebulosus* (0.82%) and no *S. japonicus* were recorded on the north coast of KZN (Fig. 4.9a). Furthermore, in the north, although catches were dominated by *C. puniceus*, 'OTHER' fish species made up a larger proportion of the catch. A similar trend was also observed in the charter boat linefishery, where in the north 'OTHER' fish species made up approximately 60% of the catch, while on the south coast they made up only 20% (Fig. 4.9b). In both the recreational and charter boat fisheries, no *T. albacares* were recorded on the north coast of KZN. For the commercial boat fishery, *C. puniceus* forms an important component of catches on the north and south coast of KZN. The remainder of the catch by commercial boat-fishers is, however, different between the two areas, with *P. aeneum* and *C. anglicus* only being recorded in large numbers on the south coast, and *C. nufar* and *L. nebulosus* only recorded in good numbers on the north coast (Fig. 4.9c). ‘OTHER’ fish species also dominated catches of commercial boat-fishers more on the south coast of KZN than on the north coast. From the overall results, it is evident that *C. puniceus* is important in all three sectors, while *P. aeneum* and *C. anglicus* are more abundant in catches by all three sectors on the south coast.

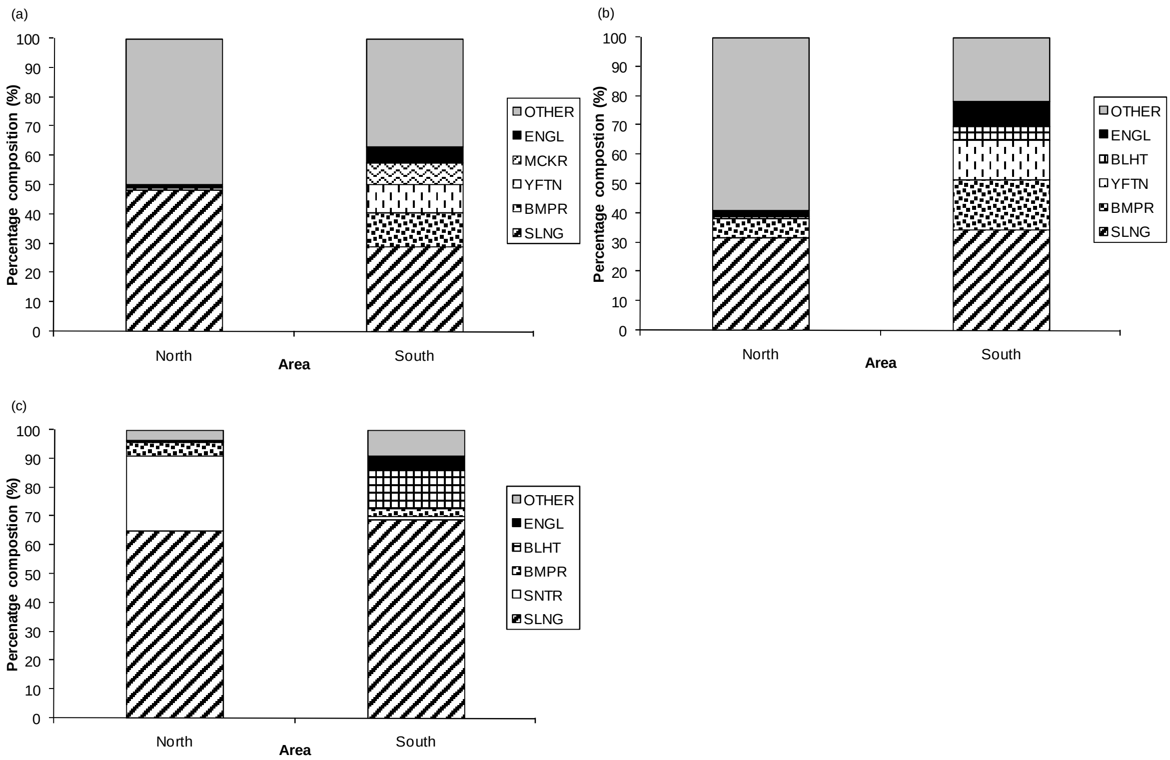


Figure 4.9- Spatial composition of the major species caught by (a) recreational, (b) charter and (c) commercial boat-fishers along the KZN coast recorded during 390 access-point surveys conducted between September 2008 and October 2009 (BLHT= *Pachymetopon aeneum*; BMPR= *Lethrinus nebulosus*; ENGL= *Chrysoblephus anglicus*; MCKR= *Scomber japonicus*; SLNG= *Chrysoblephus puniceus*; SNTR= *Cheimerius nufar*; YFTN= *Thunnus albacares*; and OTHER= includes all other species caught and kept).

The length frequency distributions of the five most important fish species caught and kept by boat-fishers (all three sectors combined) are shown in Figure 4.10. All of the top five species, barring *P. aeneum*, seem to have a frequency distribution skewed to the right. However, this can be explained by the minimum legal size limits that have been put in place on some of the fish species and/or due to hook-size selectivity (*see* Buxton & Allen 1989 and Alos *et al.* 2008). In general, all species showed a wide range of size classes that were caught and kept by boat-fishers. Worryingly, a substantial number of *C. anglicus* (11.9%) caught and kept by anglers were under their minimum legal size limit. Less than 0.1% of boat-fishers kept undersize *C.*

puniceus and *C. nufar*. Other important species that were commonly caught and kept under their minimum legal size limits were *Polysteganus praeorbitalis* (16.9%) and *Epinephelus marginatus* (17.8%). However, in general most boat-fishers adhered to the minimum legal size limits of fish they were targeting.

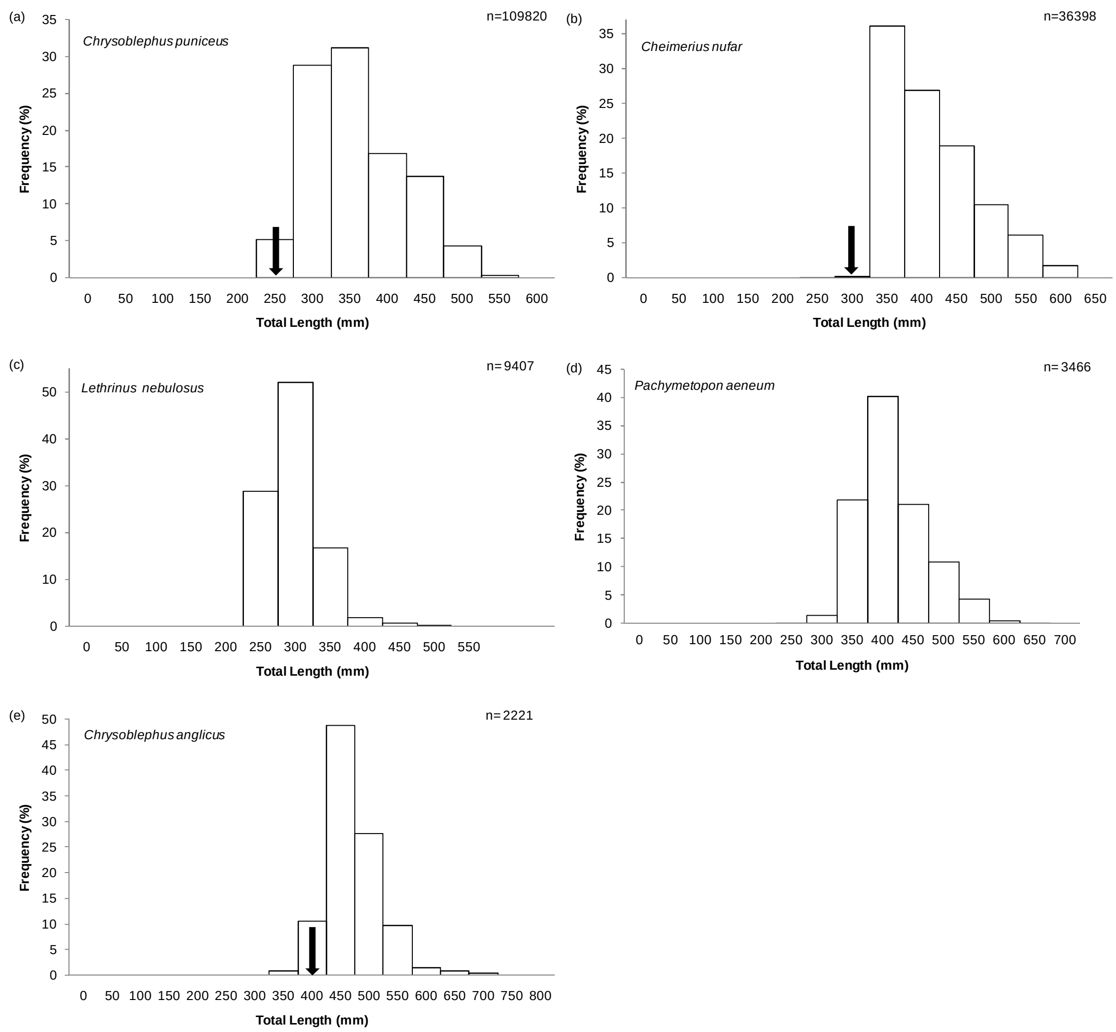


Figure 4.10- Length frequency distributions and minimum sizes (arrow), where applicable, of the five most important angling species, (a) *Chrysoblephus puniceus*, (b) *Cheimerius nufar*, (c) *L. nebulosus*, (d) *Pachymetopon aeneum*, and (e) *Chrysoblephus anglicus*, caught and kept by boat-fishers recorded during 390 access-point surveys conducted along the KZN coast between October 2008 and September 2009 (note that all catches made by the individual sectors were pooled together). *Scomber japonicus* was excluded as it is regarded as a baitfish species.

Analysis of the crew size and total number of fish caught on each fishing trip revealed that only 2.3% and 4.7% of recreational and charter boat-fishers kept more than the overall cumulative daily bag limit of 10 fish per person per day respectively. However, this does not take into account species-specific daily bag limits. Taking the species-specific daily bag limits of the top five most important fish species kept by recreational and charter boat-fishers into account (these species are not bag limited for commercials), most anglers caught under their bag limits, while only a small proportion of anglers interviewed had actually caught their bag-limits for the species they were targeting (Table 4.4). Few anglers also kept more than the bag limits of the fish they targeted (Table 4.4). In both sectors, *C. anglicus* had its bag limit reached or violated the most; however, this is because the daily bag limit for this species is only one per person per day. A similar trend, but to a lesser extent, was also observed for *C. puniceus*. All of the top five species for commercial boat-fishers are unlimited in terms of bag limits; however, several no sale 'recreational' fish species (*see* Government Gazette No. 27435, April 2005) were also recorded in commercial catches over the sample period. These included 82 *Pachymetopon grande*, 1 *Caranx spp*. and 1 *Diplodus hottentotus*.

Of all the fish recorded during access-point surveys, only *Pomatomus saltatrix* has a closed season (1 October-30 November in any year). However, no *P. saltatrix* were recorded in boat catches during its closed season. Although *Petrus rupestris*, a once commonly caught sparid found along the KZN and Eastern Cape coast (Penney and Wilke 1993), also has a closed season (1 September-30 November in any year), no *P. rupestris* were recorded in catches by boat-fishers along the KZN coast during the current survey.

Table 4.4- Percentage of recreational and charter boat-fishers (per trip) that violated or complied with the daily bag limits of the five most important fish species caught and kept along the KZN coast from 223 access-point surveys (BL = bag limit for each species; number in parenthesis is the bag limit (per person per day) for that species). *Scomber japonicus* was excluded as it is regarded as a baitfish species.

Species	Recreational			Charter		
	> BL	= BL	< BL	> BL	= BL	< BL
Chrysoblephus anglicus (1)	10.5	18.6	70.9	10.8	14.6	74.6
Chrysoblephus puniceus (5)	4.3	9.1	86.6	2.3	2.3	95.3
Lethrinus nebulosus (10)	0	1.1	98.9	0	0	100
Pachymetopon aeneum (5)	0	0	100	0	0	100
Thunnus albacares (10)	0	0	100.0	0	0	100

4.4. DISCUSSION

4.4.1. Survey techniques

The access-point sampling technique used in this study has remained the most favourable technique among linefish researchers in South Africa for sampling boat-based linefishers (Smale and Buxton 1985; Mann *et al.* 1997a; Sauer *et al.* 1997; Brouwer and Buxton 2002; Fennessy *et al.* 2003; Pradervand *et al.* 2003; Everett and Fennessy 2007; Pradervand and van der Elst 2008). Similarly, internationally it remains the method of choice when the fishery of interest can be sampled via relatively few, well defined public access sites/points (Robson 1960;

Robson and Jones 1989; Hayne 1991; Jones and Robson 1991; Wagner *et al.* 1991; Hilborn 1992; Pollock *et al.* 1994; Pollock *et al.* 1997; Steffe *et al.* 2008; Hartill 2010; Hartill *et al.* 2010).

In general, as with the shore linefishery, the methods used in this study to sample the KZN offshore boat-based linefishery were better designed and more comprehensive than the first survey conducted in 1994-96 (Mann *et al.* 1997a) since it took into account many logistical and sampling biases suffered in the previous linefish survey design. For example, in the previous KZN offshore boat-based survey only 18 of the 47 skiboat launch sites that were active in 1994-96 were inspected (Mann *et al.* 1997a). Whereas in the current study an attempt was made to cover most of the coastline in a random stratified manner, visiting 32 of the 45 registered launch sites with varying frequency according to the launching rates obtained from the BLSMS annual reports (Khumalo *et al.* 2009; 2010). Furthermore, because of the poorer sample size compared to the shore linefishery (*see* Chapter 2), additional data from MCM's Linefish Observer Program was obtained, which increased the total number of access-point surveys done to a notable 390 with an associated 1 318 (561 recreational, 234 charter and 523 commercial) boat inspections. This is in contrast to the 59 access-points surveys and 206 (174 recreational and 32 commercial) boat inspections done in KZN during the 1994-96 survey (Mann *et al.* 1997a). Note that prior to 1996 it was estimated that there were less than 10 formal charter boat operators operating off KZN (Pradervand and van der Elst 2008). For this reason, it is likely that this sector was under-sampled during the last national survey carried out in 1994-96 (Mann *et al.* 1997a).

As in the shore linefishery, there are inevitably still spatial and temporal biases associated with the sampling design used in this study. However, there are few other ways of obtaining such "snapshot" information on a multi-user fishery spread over a large area without creating exorbitant budgets that few agencies can afford. It was for this reason that the stratified random sampling technique used in this study was chosen. This technique was specifically designed to minimise any possible sampling biases associated with launching effort and is preferable since access-point surveys become ineffective when equal effort is spent sampling launch sites of high and low fishing intensity (Stanovick and Nielsen 1991). For example, the BN zone has very low/sporadic boat fishing effort (Khumalo *et al.* 2009) and was consequently not sampled in the current study. However, the SD zone, which does have high recreational fishing effort, was also not sampled due to logistical constraints (distance) and the fact that this launch site is well monitored (BLSMS & NMLS inspections) and falls within the iSimangaliso Wetland Park (a marine protected area).

Compared to the shore fishery, alternative survey techniques, such as postal or telephone surveys, may work quite effectively (i.e. allow for a greater sample size and better spatial and temporal coverage of boat-fishers) in the boat-based fishery since the majority of boat based fishers in KZN fall into the upper income group (i.e. have a telephone and/or mail address) (McGrath *et al.* 1997). However, in South Africa the access-point method still remains a preferred technique because surveys that tend to intercept anglers (i.e. on-site techniques) are more accurate than those that rely on simple angler-reporting of harvests with associated angler recall bias (Mann-Lang 1996; Penney 1997; Sauer *et al.* 1997). Furthermore, on site sampling allows for accurate identification of fish caught and measuring of length frequencies. Several advantages and disadvantages of certain survey methods are discussed at length by Pollock *et al.*(1994). It is important that the choice of sampling techniques/methods should suite the objectives of the survey and characteristics of the fishery being sampled.

4.4.2. Total fisher participation

The estimated total number of recreational and commercial boat anglers (excluding charters) participating in the KZN offshore-boat based linefishery (i.e. 6 220-13 857 fishers and 1 912-4 349 boats) was very similar to that recorded in the 1994-96 survey (i.e. 3 103 boats and 10 059 anglers) (Mann *et al.* 1997a). It would thus seem that there has been relatively little change in participation in the boat-based linefishery over the past 12 years. However, if one takes a closer look at each sector of the fishery, some interesting results appear.

There were 173 commercial vessels in the KZN boat-based linefishery in 1994-96 (Mann *et al.* 1997a) and in 2009-10 there were 51 (of which only 38 had activated their rights). Therefore, the commercial sector has effectively been decreased by 70% since 1994-96. This is in line with the government decision to reduce the allocation of commercial rights and thus commercial linefishing effort between 2002 (medium-term rights) and 2006 (long-term rights; *see* Chapter 1). By contrast, the number of charter vessels operating in the boat-based linefishery has increased from less than 10 in 1995 (Pradervand and van der Elst 2008) to approximately 100 boats in the current study. This is an annualised rate of increase of 6.9% per annum. It is likely that the reduced number of commercial fishing rights (i.e. abolishment of old A- and B-licenses) resulted in unsuccessful commercial applicants opting to move into the charter boat sector. This applied particularly to the B-licence holders who did not solely rely on the linefishery as a source of income. Furthermore, many B-licence holders, although classified as semi-commercials at the time, were in fact running chartering businesses and also sold their catch. Over the years charter fishing has also become an increasingly popular activity among visitors to KZN and even for local anglers who do not have the opportunity to fish offshore (Pradervand and van der Elst 2008). This fact, as well as the diminishing returns from commercial boat linefishing (Mann *et al.* 2001) may have fuelled the number of vessels moving into this sector. Interestingly, although the number of vessels operating in the offshore boat-based linefishery has remained fairly constant over the past ten years, there has been an increase in the number of boat-fishers participating, particularly from the charter sector. The main reason for this increase is that most charter boat anglers are in fact clients that fish on a once off basis.

Clearly, charter fishing has important implications for resource management, tourism and socio-economic development in KZN. Although a thorough assessment of the charter fishery was completed in 2003-04 (Pradervand and van der Elst 2008), this sector has been allowed to grow without any resource management intervention. This is worrying since in many parts of the world the charter fishery is understood to take the majority of the recreational linefish landings due to its greater professionalism (i.e. inherently commercial nature) and therefore more efficient fishing practices (Figueira and Coleman 2010). A similar trend was observed in the current study (*see* catch composition below) and while the reduction in commercial fishing effort was imperative, the uncontrolled increase in charter fishing effort will result in fish stocks being driven beyond the bio-economic equilibrium (Clark 1985) and thus effectively limit any stock rebuilding taking place. It is obvious that recreational fishing effort is less sensitive to diminishing returns than that of commercial and subsistence fisheries. It is thus recommended that management of the entire KZN charter boat linefishery should urgently be reviewed (i.e. taking the results from this study and those from Pradervand & van der Elst (2008) into consideration). Management efforts must be focused on bringing this growing sector under control, both for economic reasons and to ensure the continued sustainable use of KZN's linefish resources. The currently well regulated and managed traditional commercial linefishery can be used as a guideline for this purpose (*see* Chapter 7).

The recreational boat sector has undergone several fluctuations in angler numbers since 1994-96. Historical permit sales data from KZN (i.e. the code 10 permit required by skippers of recreational and charter boats; MCM unpublished data) suggests that the highest number of recreational boats participating in the fishery was in 1999 (Table 4.5). This, however, was largely due to a misunderstanding by boat anglers on the requirements of a code 10 boat skippers angling permit. When it was first introduced, most boat anglers assumed you needed to be in possession of a code 10 permit but only later did clarification take place that it was only required by the skipper of a vessel (A. Cockcroft, 2010, MCM, pers. comm.). It is therefore likely that numbers of recreational angling vessels have in fact remained reasonably constant over the past 12 years. This trend was predicted by McGrath *et al.* (1997), who stated that the demand for fishing trips will grow at a slower rate than the population growth rate and growth of income. Few ‘new’ boat anglers are therefore expected to come into the fishery. It is also likely that there are several economic limitations, such as the cost of the boat (rig), tackle and annual maintenance of the vessel, that prevent many people from entering the boat-based linefishery (Brouwer 1997; McGrath *et al.* 1997); these barriers are less prevalent in the shore linefishery. Furthermore, since boat angling is a sport in which most participants begin young and continue throughout their lives (McGrath *et al.* 1997), one can expect little increase in boat angler numbers over a short period. This last point is also emphasised by the older age structure of skippers and associated years of experience (*see* Chapter 5). It must be noted that the introduction of jetskis and paddle-skis in the last 10 years has given many anglers access to offshore resources that were previously economically unavailable to them. This issue is discussed in more detail in Chapters 5 and 7.

Table 4.5- Number of code 10 skipper permits sold annually by the Post Office and EKZNW in KZN from 1999 to 2009.

Year	No licenses sold
1999	12070
2000	4716
2001	4181
2002	3868
2003	3227
2004	3028
2005	3463
2006	3524
2007	3381
2008	3538
2009	not available

4.4.3. Total annual angling effort

Total annual boat angling effort recorded in the current study (39 664 launches.annum^{-1}) was considerably lower than that estimated by Mann *et al.* (1997a) during 1994-96 (50 491 launches.annum^{-1}). However, the drastic cut in commercial linefishing effort can probably explain the overall lower effort recorded in this study. For instance, there were an estimated 15 491 launches by commercial boat-fishers in 1994-96 (Mann *et al.* 1997a) compared to the 3 331 recorded in the current study. The fact that commercial boat-fishers are no longer allowed to sell their rights and move between the three geographical regions has also contributed to decreasing fishing effort for this sector. Furthermore, when commercial effort was capped, several commercial boat-fishers switched to recreational or charter boat fishing and as a result they now do not launch as often as they would have if they were still fishing commercially and relied on the fishery as a direct source of income. In addition to the reduction in commercial effort, since the cessation of hostilities in Mozambique in 1992, many recreational boat-fishers have turned their attention to that region, which has contributed to a reduction in the overall effort recorded by recreational boat-fishers in KZN (Penney *et al.* 1999). The fact that South Africans also no longer need a visa to enter Mozambique and the anecdotal reports of good catches made in this region, has further amplified the spread of fishing effort to Mozambique.

Another possible reason why total fishing effort was lower in the current study could be because the estimates of fishing effort determined by Mann *et al.* (1997a) were based on average launch rates. These may have been biased by avidity and therefore constituted an overestimate of true annual angling effort (Thompson 1991). Furthermore, general weather conditions might have been less favourable for skiboat launching during 2009 than they were in 1994-96, which again effects the number of launches per annum. The fact that in the current study ‘climate change’ was a common response to reasons given for a deterioration in linefish catches over the years confirms this point (*see* Chapter 5). A similar trend has been recorded by Hecht (1993), who showed that the exposed nature of several launch sites (i.e. more susceptible to inclement weather conditions) limits the number of fishing days in the Port Alfred commercial linefishery. Other similar observations have also been made by Smale & Buxton (1985) and Fennessy *et al.* (2003). Although the weather/fishing conditions were recorded during the access-point surveys conducted by the author, the majority of the data used (i.e. from MCM’s Linefish Observer Program) did not have weather related statistics. The impact that weather/fishing conditions have on the boat-based linefishery was therefore not analysed. Considering the findings in the above-mentioned publications, it might be useful to include this variable in MCM’s Linefish Observer Program in the future.

The BLSMS is a valuable database that has provided fishery managers and other stakeholders with a unique record of usage patterns of launch sites and a better understanding of the use of offshore marine resources accessed through boat launching. However, as with other monitoring initiatives, there are inherent biases associated with this database system. Some of these include unknown coverage (i.e. some harbour-based launch sites still do not participate in the BLSMS and not all boat launches are recorded on the register) and prestige bias (successful anglers are more likely to complete the catch return section of the register than unsuccessful anglers thereby exaggerating catch rate estimates) (Khumalo *et al.* 2010). Nevertheless, the estimates of total annual angling effort for the offshore boat-based linefishery provided in the current study are believed to be a fairly accurate representation of actual boat fisher effort in KZN. This is because as a condition of the Environmental Management Plan for each licensed (registered) small craft launch site (excluding those in Durban and Richards Bay Harbours), a mandatory launch and catch register system (i.e. BLSMS register) must be in place. Thus, every sea launch made by any motorised boat should be recorded on this system. Although commercial fishing effort was underestimated by the BLSMS launch register, the number of launches per annum can be obtained from MCM as part of the mandatory completion of monthly catch returns or by multiplying the average launch rates calculated from this study (*see* Chapter 5) with the total number of commercial boats operating in a given year. Alternatively, commercial fishers should be compelled to complete the BLSMS register for all launches as recreational and charter fishers are. In conclusion, the BLSMS register can be used to estimate recreational and charter boat effort quite accurately, but caution should be taken when estimating commercial effort from the register. Furthermore, different methods (such as those used in the current study) should be used to obtain catch related statistics from the fishery since there are many biases involved with angler reported harvest rates (Pollock *et al.* 1994; Mann-Lang 1996; Penney 1997; Sauer *et al.* 1997).

4.4.4. Spatial and temporal variation in fishing effort

This study found considerable overlap in temporal effort between the recreational and charter boat fisheries. Effort for these two sectors was extremely variable, with noticeable peaks in December, April and May. In general, fishing effort for these two sectors was strongly governed by popular holiday periods, favourable weather conditions and to a lesser degree by the seasonality of target fish species. Similar trends have been observed in Eastern Cape (Smale and Buxton 1985; Hecht and Tilney 1989; Brouwer 1997) and in KZN during the last national linefish assessment (Mann *et al.* 1997a). The commercial boat fishery on the other hand is governed more by the seasonality of target species, favourable weather conditions and economic factors. Effort for the commercial boat fishery is characteristically higher from May through to July (early winter) and October to January (early summer). The latter period corresponds with the good catch rates of several linefish species, which often coincides with peak spawning activity (e.g. *Atractoscion aequidens* (Garratt 1988); *Cheimerius nufar* (Garratt 1985); *Chrysoblephus anglicus* (Garratt *et al.* 1994); *Chrysoblephus puniceus* (Garratt 1985); *Pachymetopon aeneum* (Garratt 1988)) and the annual ‘sardine run’ (van der Lingen *et al.* 2010). Interestingly, the months leading up to the annual spawning period of many species along the KZN coast also had relatively high commercial fishing effort. This may be due to the fact that several linefish species appear to feed more actively prior to spawning, possibly to build up body reserves (B. Mann, 2010, ORI, pers. comm.). In general, effort in the commercial linefishery is far less variable than the charter and recreational linefisheries. It is also considerably higher throughout the year. This behaviour is obvious since commercial fishers launch on every possible day as they rely on the fishery as their main source of income.

Regionally, according to the BLSMS it appears that the majority of charter fishing effort takes place on the lower south (Shelly Beach and Rocky Bay) and upper north (Tugela, St Lucia and Sodwana) coast of KZN. This is a fairly accurate representation and is partly because these areas are popular holiday destinations. Similar results were reported in 2003/04 for the charter boat sector in KZN by Pradervand & van der Elst (2008). However, it should be noted that Durban Harbour serves a large charter boat fishery that was under-sampled in the current study. In contrast, commercial fishing effort is highest in areas where there are productive reef systems, such as off Richards Bay, Tugela and the lower south coast of KZN (Mann-Lang *et al.* 1997; Penney *et al.* 1999).

The recreational boat fishing effort in KZN was more evenly spread across the coast with peaks in the SD, CV, RB and DB zones. The high recreational boat fishing effort at Sodwana and Cape Vidal can be explained by the fact that these areas are popular holiday destinations (situated in the iSimangaliso Wetland Park) that attract a broad spectrum of recreational fishers from all over KZN and inland during the holiday periods. The peaks in recreational fishing effort at Richards Bay and Durban are a result of the large number of recreational boat anglers that reside in these urban and peri-urban areas that utilise the fishery regularly. An important aspect of the Richards Bay and Durban Harbour (including Vetch's Pier, i.e. Durban Skiboat Club) is the fact that they are sheltered launch sites where boats can launch under almost all weather conditions, thereby increasing the number of possible fishing days and thus effort (Mann-Lang *et al.* 1997).

4.4.5. Catch per unit effort (CPUE)

The overall CPUE differed significantly between the different sectors of the offshore boat-based linefishery in KZN. This was expected and is related to the substantial variation in directed fishing effort as well as the extent to which income is derived from linefishing within each of the sectors. For example, recreational boat-fishers (8.6 fish.outing^{-1}/15.0 kg.outing^{-1}) have an average CPUE considerably lower than that of commercial boat-fishers (i.e. 307.4 fish.outing^{-1}/235.6 kg.outing^{-1}) since their catch restrictions differ considerably (*see* Chapter 1) and they do not directly rely on the fishery as a source of income. Furthermore, directed fishing effort or targeting differs considerably between these two sectors (*see* below). On the other hand, charter boat-fishers, who are essentially recreationally motivated, have a relatively high average CPUE (26.6 $fish.outing^{-1}$/41.6 $kg.outing^{-1}$), threefold higher than the recreational boat fishery. However, CPUE per angler (0.82 $fish.angler^{-1}.hour^{-1}$/1.35 $kg.angler^{-1}.hour^{-1}$) indicates that these patterns of average CPUE for charter boat outings are largely driven by the higher number of anglers on the vessel rather than an increased catch rate per angler. It must be noted however, that charter operators do rely indirectly on fishery performance since they are profit driven (i.e. number of customers per trip and trip regularity) and past catches (i.e. catch rates on previous trips) determine customer returns (Figueira and Coleman 2010).

Since CPUE differs significantly between the sectors of the KZN offshore linefishery, retrospective trends in CPUE for each sector are discussed separately.

Recreational boat linefishery

The overall mean CPUE by number and weight in the KZN recreational boat linefishery has changed very little since 1994-96 (Mann *et al.* 1997a) (Table 4.6). These catch rates were similar to those found in the Transkei region of the Eastern Cape (Fennessy *et al.* 2003), but were lower than those recorded in the southern part of the Eastern Cape (Brouwer and Buxton 2002; Donovan 2010) and higher than those in the Southern Cape and West Coast (Sauer *et al.* 1997).

Table 4.6- A comparison of mean CPUE of several important linefish species (arranged alphabetically) caught and kept by boat-fishers from two independent linefish surveys conducted in KZN (Note: species were selected by their relative importance in the current study)

Species	2008-09 (This study)						1994-96 (Mann *et al.* 1997a)					
	Fish.outing^{-1}			Kg.outing^{-1}			Fish.outing^{-1}			Kg.outing^{-1}		
	Rec	Char	Comm	Rec	Char	Comm	Rec	Char	Comm	Rec	Char	Comm
Argyrosomus thorpei	0.02	0.00	0.24	0.01	0.00	0.25	0.20	-	0.34	0.17	-	0.37
Atractoscion aequidens	0.01	0.01	0.19	0.04	0.09	0.99	0.02	-	0.13	0.14	-	0.99
Cheimerius nufar	0.09	0.11	11.79	0.09	0.07	10.13	0.13	-	0.88	0.10	-	0.59
Chrysoblephus anglicus	0.12	0.34	0.49	0.20	0.53	0.85	0.06	-	0.65	0.06	-	0.66
Chrysoblephus puniceus	0.91	1.47	34.68	0.66	0.74	21.37	0.26	-	9.49	0.17	-	5.12
Coryphaena hippurus	0.07	0.01	0.06	0.46	0.07	0.34	0.01	-	0.00	0.04	-	0.03
Dinoperca petersi	0.04	0.01	0.17	0.07	0.01	0.29	0.03	-	0.15	0.03	-	0.12
Epinephelus andersoni	0.08	0.05	0.34	0.20	0.11	1.26	0.18	-	0.55	0.35	-	1.07
Epinephelus rivulatus	0.05	0.09	0.30	0.03	0.06	0.10	0.01	-	0.38	0.01	-	0.18
Lethrinus nebulosus	0.24	0.72	2.60	0.17	0.47	1.33	0.04	-	2.15	0.01	-	0.77
Pachymetopon aeneum	0.08	0.20	0.99	0.09	0.28	1.03	0.00	-	0.50	0.00	-	0.43
Polysteganus coeruleopunctatus	0.03	0.10	0.10	0.03	0.06	0.21	-	-	0.64	-		0.51
Polysteganus praeorbitalis	0.06	0.13	0.15	0.07	0.15	0.25	0.04	-	0.24	0.04	-	0.34
Scomberomorus commerson	0.03	0.00	0.00	0.16	0.02	0.00	0.17	-	0.05	1.44	-	0.53
Thunnus albacares	0.20	0.56	0.01	1.02	2.88	0.08	0.10	-	0.03	0.82	-	0.39
Overall CPUE*	8.58	26.61	307.41	15.00	41.60	235.56	6.85	-	104.43	13.37		88.1

*Overall mean CPUE from each study. Measure of variability not applicable.

There are a number of possible reasons why CPUE for recreational boat-fishers has changed very little since the 1994-96 survey (Table 4.6). Firstly, there have been considerable improvements in the technology used in the boat-based fishery since 1994-96 (i.e. effort-creep). For example, many recreational skiboat-fishers now use more efficient global positioning systems and three dimensional fish finders, which locate reefs with ease. Moreover, several advancements in fishing gear, such as thinner, stronger braided lines, vertical jigs and scented baits (drop shots), have also taken place. These technological advancements that have taken place since 1994-96 can therefore partly explain the sustained CPUE trends, which would otherwise likely have decreased bearing in mind the overall depressed stock status of several linefish species in KZN (e.g. *C. puniceus* (Punt *et al.* 1993), *Polysteganus praeorbitalis* (Garratt *et al.* 1994; Mann *et al.* 2005), *C. nasutus* (Buxton and Clarke 1989) and *P. rupestris* (Smale and Punt 1991)). This reason has also been highlighted as one of the main contributors to increasing effective effort in the traditional commercial linefishery in the Cape Province (Griffiths 2000). Secondly, the sampling effort and hence the estimation of CPUE in 1994-96 was temporally and spatially biased. For example, sampling during the year was not continuous (i.e. several months were under sampled). Furthermore, only 18 out of the 47 launch sites that were operating in KZN during 1994-96 were inspected. Thus, overall CPUE may have been considerably underestimated during the 1994-96 survey (Mann *et al.* 1997a) and therefore could have actually decreased in the last decade. Lastly, several shifts in directed effort may explain why catch rates have not decreased over the years. For example, catch rates of *Argyrosomus* *thorpei*, *Epinephelus andersoni* and *Scomberomorus commerson* have decreased since 1994-96, while catch rates of several other fish have increased, e.g. *C. puniceus C. nufar*, *L. nebulosus* and *Thunnus albacares* (Table 4.6). The sequential switching of target species is a well-known phenomenon which has sustained catch rates in the KZN boat-based linefishery for many years (Penney *et al.* 1999).

In general, the fact that CPUE in the recreational boat linefishery has changed very little over the past 12 years even though there have been several changes in linefish regulations for this sector, suggests that either management interventions are working or previous estimates of CPUE were unreliable. Although one of the stated aims of management intervention was to facilitate the harvesting of fast growing, migratory fish species, such as pelagic gamefish, it seems that when these fish are less abundant, recreational boat-fishers quickly swith to targeting the more vulnerable and easier to catch resident reef fish. This has serious implications for the management of the fishery, especially since there is strong competition between the various sectors of the boat fishery. It must be noted that although snapshot estimates of CPUE can provide some indication of the status of the fishery, long-term CPUE trends and/or more reliable stock status assessments need to be conducted before any firm decisions can be made.

The fact that CPUE for *S. commerson* determined in this study was less than 20% of what it was in 1994-96 is of great concern (Table 4.6). Historically, *S. commerson* has been the most important linefish species caught and targeted by recreational boat-fishers in KZN (Govender 1992; Govender and Radebe 1999b). However, recent CPUE trends suggest a collapse has occurred in the *S. commerson* fishery. Although it is well known that there is high variability in the stock size of this species due to changing cohort strength and recruitment success in previous years (Govender and Radebe 1999b; Lamberth *et al.* 2009), it is recommended that an urgent stock assessment be conducted on this important linefish species. This is especially important since this species is prone to recruitment overfishing and although fishing in KZN may be sustainable, many juveniles are caught in the artisanal beach-seine fishery and as a by-catch of the prawn-trawl fishery in Mozambique (Govender and Radebe 1999b). It should also be noted that there is also a possible link between *S. commerson* and the abundances of *Thryssa vitrirostris* in Mozambique waters (S. Lamberth, 2010, DAFF, pers. comm.). The above reasons also highlight the urgent need for joint management of the *S. commerson* stock between Mozambique, Tanzania and South Africa (Govender and Radebe 1999b)

Charter boat linefishery

The charter boat linefishery in KZN has historically suffered from a lack of information and knowledge of its extent. This is evident since no charter boat-fishers were interviewed in the 1994-96 survey (Mann *et al.* 1997a), while only a crude six-week survey of the Durban Harbour headboat fishery (Grljevic 1995) had been done prior to 2004. Note that some charter boats were in actual fact sampled in the 1994-96 survey, but most were registered as commercials (B-license holders) and could thus sell their catches. Their catch indices were subsequently included as part of the commercial sector in that study. Although the latter survey provided some valuable insight into the operations of the headboat linefishery off Durban, it was conducted over a relatively short period with a small sample size. Nonetheless, using Grljevic (1995) as a reference point, it would seem CPUE has changed considerably since 1995 (Table 4.7). A more recent evaluation of the charter boat sector in 2003-04, however, revealed similar results to the current study (Table 4.7). It is therefore likely that comparison of the headboat fishing operation off Durban with skiboat based charter fishing operating off the rest of the KZN coast is unrealistic. Furthermore, CPUE estimates made by Grljevic (1995) included those fish that had been released, whereas estimates made by Pradervand & van der Elst (2008) and in the current study were based on retained fish only. Since charter boat CPUE estimates exceed those of the recreational boat sector, any further uncontrolled increase in charter fishing effort will result in fish stocks being driven beyond the bio-economic equilibrium (*see* general discussion in Chapter 7).

Table 4.7- Summary of mean CPUE for charter boat-fishers from three independent linefish surveys conducted in KZN. Measure of variability not applicable.

Parameter	1995 (Grljevic 1995)	2003-04 (Pradervand and van der Elst 2008)	2008-09 (This study)
$Fish.angler^{-1}.hour^{-1}$	1.36	0.91	0.82
$Kg.angler^{-1}.hour^{-1}$	0.38	1.43	1.35

Commercial boat linefishery

The overall mean CPUE by number and weight in the KZN commercial boat linefishery has increased by almost threefold since 1994-96 (Mann *et al.* 1997a) (Table 4.6). This increase is in direct contrast to other coastal provinces where the overall CPUE for commercial linefishers has been found to have decreased considerably over the years (Attwood and Farquhar 1999; Griffiths 2000; Brouwer and Buxton 2002). However, a similar increase in overall CPUE was recorded by Donovan (2010) in Port Alfred (Eastern Cape) for the period 1998-2007. Interestingly, commercial effort was reduced during this period, most significantly in KZN by 70% during 2003-06. It would seem then that the reduction of commercial fishing effort during this period has been largely successful in increasing the overall catch (i.e. suggesting a recovery of the fishery) of commercial linefishers in KZN. However, these results may be misleading and such a broad assumption needs to be carefully analysed. It is well-known that in most fisheries 20% of the fishermen catch 80% of the fish (Hilborn 1985; Smith 1990; Baccante 1995; Branch *et al.* 2006). In the long-term rights allocation process in 2006 it was only those applicants that could prove substantial reliance on the fishery that won rights. It is thus likely that although the commercial fishery in KZN was effectively reduced by 70% in terms of number of vessels, those that remained in the fishery were the better fishermen. This in effect has resulted in an increase in CPUE for the commercial fishery as a whole.

In addition to the above explanation, three other reasons may explain the considerable differences in CPUE between 1994-96 and the current study. Firstly, a shift towards smaller more abundant sparids (i.e. *C. nufar*, *C. puniceus*, *L. nebulosus*, etc) could explain the overall higher CPUE numerically associated with lower CPUE by weight. This is evident since catch rates of *L. nebulosus* and *P. aeneum* have increased since 1994-96 (Table 4.6). Furthermore, since catch rates of several larger sciaenid species, such as *A. aequidens* and *A. thorpei*, have decreased since 1994-96 (Mann *et al.* 1997a) (Table 4.6), commercial fishers now have no option but to target smaller more abundant reef fish all year round, while catches of larger sciaenid and endemic reef fish are only occasional occurrences. A similar trend was observed in the shore linefishery of KZN in this study (*see* Chapter 2). Importantly, a similar shift in directed effort for commercial linefishers in KZN was recorded between the 1950s and 1985 (Penney *et al.* 1999). Secondly, as with the charter boat linefishery, the sampling effort in 1994-96 was very biased by the inclusion of B-license vessels catch and effort data. In a sense, these licenses 'diluted' the overall catch and effort results of the commercial sector. Thus, overall CPUE values may have been considerably underestimated during the 1994-96 survey (Mann *et al.* 1997a). Lastly, possible strong recruitment of several important linefish species during 2008-09, such as *C. nufar*, *C. puniceus*, *L. nebulosus* and *P. aeneum*, could have allowed commercial linefishers an opportunity to target these fish extensively throughout the year. This is confirmed by the fact that there were no clear seasonal CPUE trends in the commercial sector in KZN in the current study. A similar trend was observed in the Port Alfred linefishery, where between the years 2002-2007 *A. aequidens* dominated commercial linefish catches (Donovan 2010), whereas prior to these years the stock was considered to have collapsed (Griffiths 1999; 2000; Hutton *et al.* 2001). In addition to these three reasons, several additional factors, such as improvements in skipper experience, vessel seaworthiness, decrease in hook size, widening of exploited area (i.e. depth and distance), have also increased many catch rates to unsustainably high levels over the years (Hecht 1993; Penney *et al.* 1999; Griffiths 2000).

It must be noted that reductions in fishing effort do not result in instantaneously improved catches. It takes several years, or even decades, before any recovery in a fishery can be detected. Furthermore, the complicated life-histories (i.e. slow growth, late maturity and sex change) of many important linefish species further complicates this recovery period. However, it may be possible that the current improvements in catch trends in all three sectors are reflecting some recovery in the fishery, which is a result of ongoing management intervention since 1985. However, thorough research to establish if there really has been a recovery in the fishery is advised, possibly through detailed stock assessments on the top priority species.

4.4.6. Total catch and catch composition

Although total effort and participation in the recreational boat fishery was considerably higher than the commercial boat fishery, total estimated catch by weight for the commercial boat fishery (785 mt) was almost twofold higher than that estimated for the recreational boat fishery (457 mt). This was expected considering the characteristics of these two sectors. For example, commercial boat-fishers have a much longer average trip duration than recreational boat-fishers, and they generally have double the number of crew. It is also commonly known that commercial boat-fishers are generally more effective fishermen than recreational boat-fishers (Smale and Buxton 1985; Figueira and Coleman 2010). Furthermore, the fact that recreational catch restrictions are far stricter than commercial catch restrictions also helps to explain the comparatively large catches made by commercial boat-fishers even though their overall effort is much lower. Recreational boat-fishers also spend more time fishing for pelagic game fish, which is less productive per unit effort than bottom fishing (Penney *et al.* 1999; Jairam 2005). Compared to the 1994-96 survey (402-470 mt versus 457 mt), total catch for the recreational boat sector has changed relatively little. Contrastingly, total catch for the commercial sector has decreased quite substantially (1 364 mt versus 785 mt). The reduction of commercial effort between 2002 and 2006 has therefore been partially successful in reducing the total landings made by this sector.

The charter boat sector had a very high total catch (245 mt) even though there were only ±100 boats participating in the charter fishery in 2008-09. This is in contrast to the total catch of 456 mt made by more than 2000 recreational vessels for the same period (current study), and is similar to the 300 mt estimated for the charter boat fishery in 2003-04 in KZN (Pradervand and van der Elst 2008). The high total catch of this flourishing sector again highlights the urgent need for improved management. Importantly, from these results it is evident that the charter boat fishery represents a potential threat to the future conservation and management of the linefish resources of KZN.

Most of the fishing effort by charter and commercial boat-fishers in KZN was directed at reef fish. The similar distribution of directed charter fishing effort towards pelagic game and reef fish is partly accounted for by the demands of the paying customers and since charter operators are profit driven. In other words, a charter operator will often target pelagic gamefish as a first option and only target bottom fish (i.e. reeffish) as an alternative when/if catches of pelagic gamefish are poor. Furthermore, on many charter fishing trips (and commercial outings for that matter) pelagic gamefish are targeted with a ‘trap stick’ using a drift or live bait while simultaneously targeting reef fish with bottom tackle.

Recreational boat-fishers in KZN primarily target pelagic gamefish, with bottom fish only making up a small proportion of directed effort. Similar to charters, bottom fish are generally only targeted as an alternative when catch rates of pelagic gamefish are low. This was particularly evident in the current study since catch rates of *S. commerson* were low, while several bottom fish had a high CPUE compared to the 1994-94 survey (Mann *et al.* 1997a) (Table 4.6). Overall, similar trends in directed fishing effort for each of the different sectors of the offshore linefishery have been recorded by Brouwer (1997), Mann *et al.* (1997a) and Fennessy *et al.* (2003).

A high number of linefish species (84) were recorded in the KZN offshore boat fishery. This has several management implications as a number of species can be targeted at different times of the year by different fishers within each sector. The multi-species nature of most linefisheries along the South African coastline makes them extremely difficult to manage (Smale and Buxton 1985; Hecht and Tilney 1989; Brouwer and Buxton 2002). Furthermore, the complicated life histories of many of these species as well as several problems associated with catch and release (i.e. barotrauma-rapid expansion of the swim bladder with decreasing depth), further complicates management of the resource.

Catch composition in 1994-96 for the commercial boat sector was dominated numerically by *C. puniceus* (53.5%), *L. nebulosus* (12.1%), *C. nufar* (5%), *Polysteganus coeruleopunctatus* (3.6%) and *C. anglicus* (3.6%) (Mann *et al.* 1997a). This was very similar to the current study.

C. puniceus is still the most important linefish species caught by commercial boat linefishers in KZN, as it has been since 1985 (Penney *et al.* 1999). However, the percentage composition of this species in catches is much higher than in previous studies, which could correspond to an increased reliance on this species since catches of other important linefish species are lower. Interestingly, *P. coeruleopunctatus* seemed to be less important in catches during the current study and appears to have been replaced by *P. aeneum*. Although this could represent overexploitation of this species, it is more likely that during boat inspections *P. coeruleopunctatus* was misidentified by observers with the similar looking *C. nufar* (van der Elst 1993a) and therefore was proportionally underestimated in the overall catch. Furthermore, several boat launch sites, such as Rocky Bay/Park Rynie, where this species is mainly targeted by boat-fishers on deeper reefs (50-100 m) were under sampled. By weight, *C. puniceus* (34.2%), *E. andersoni* (7.2%), *A. aequidens* (6.6%), *L. nebulosus* (5.2%) and *C. nufar* (3.9%) dominated catches in 1994-96 (Mann *et al.* 1997a), which was almost identical to the current study. Importantly, *A. aequidens* seemed to be less important in catches during the current study and appears to have been replaced by *P. aeneum*. This trend could be a sign of overexploitation as when catches of one species are low anglers quickly switch to another more abundant species to maintain their catch rates. The lower catch rates of *A. aequidens* corresponds with recent research conducted on this species (Griffiths and Hecht 1995; Griffiths 1999; 2000; Hutton *et al.* 2001). However, it must be mentioned that this species (including *A. japonicus*) could have been under-reported in the current study due to limited sampling of vessels fishing at night when these species are known to aggregate to feed and spawn.

Overall, there seems to have been relatively little change in catch composition in the commercial boat sector, with most differences being attributed to interannular variation in linefish abundances caused by natural processes (e.g. fluctuations in temperatures and the influence of the ‘sardine run’) and/or due to biases in data capture and entry. This is unlike several dramatic changes in species composition caused by overfishing that have been previously recorded in KZN (*see* Penney *et al.* 1999). It must again be noted that *S. commerson* made up an insignificant contribution by weight and number in the commercial boat sector in the current study. This trend was similar to that observed in the recreational boat fishery and could suggest a collapse has occurred in this species. As recommended above, an urgent stock assessment needs to be conducted on this important linefish species.

Species composition in the recreational boat sector has changed considerably since 1994-96. In 1994-96, *Decapterus spp.* (14.1), *C. puniceus* (11.7%), *A. thorpei* (8.8%), *E. andersoni* (7.9%)

and *S. commerson* (7.7%) dominated catches numerically, while by weight, *S. commerson* (32.7%), *T. albacares* (18.6%), *E. andersoni* (7.9%), *E. affinis* (6.1%) and *A. thorpei* (3.9%) dominated catches. In the present study *Decapterus spp.*, *A. thorpei* and *S. commerson* were considerably less abundant in catches, while *E. andersoni* still formed the sixth most important species caught. Although *Decapterus spp.* are traditionally under-reported in catches because they are regarded as a bait species, the lower abundances of *A. thorpei* and *S. commerson* are cause for concern. Historical trends reveal that *A. thorpei* was an important species in both the recreational and commercial boat sectors in the mid-1980s to 1990s. However, recent catch trends reveal that it has dwindled in importance (Sauer *et al.* 1997; Penney *et al.* 1999) and stocks are thought to have collapsed due to a combination of overfishing (Fennessy 1994; Fennessy *et al.* 1994; Fennessy and Radebe 1998) and a current drought period (Lamberth *et al.* 2009). It is recommended that a stock assessment be redone on this species, especially considering that the growth parameters and the size at 50% maturity were poorly estimated in the last stock assessment (van der Elst *et al.* 1990; Fennessy and Radebe 1998). Recommendations for *S. commerson* are already discussed (*see* above).

Although no charter boats fishers were interviewed *per se* during the 1994-96 survey, comparisons with a study conducted during the same period, namely Grljevic (1995), revealed substantial differences in catch composition since 1995. However, this study was based on only five headboats operating out of Durban Harbour and the catches made on these vessels were not comparable to the skiboat-based charter operations surveyed in the current study. Comparisons with the study conducted by Pradervand & van der Elst (2008) show that in the last six years there has been very little change in catch composition in the charter boat fishery. Only *C. nufar* has decreased in importance and has been replaced with *P. aeneum* (reasons for this are discussed below).

Overall, there was a high proportion of endemic sparids (e.g. *C. puniceus*, *C. anglicus* and *P. aeneum*) recorded in catches in all three sectors. These findings have been reported by several other publications in KZN (Penney *et al.* 1989; Mann-Lang *et al.* 1997; Mann *et al.* 1997a; Penney *et al.* 1999; Jairam 2005; Pradervand and van der Elst 2008). Overfishing of these endemic species will ultimately cause substantial socio-economic hardships to a large sector of society, particularly in the commercial, and to a lesser degree, in the charter boat sector. Furthermore, the loss of these endemic species may have several consequences for the ecology and biodiversity of the region. Priority should be given to monitoring these species, and precautionary management policies should be developed including the establishment of more marine protected areas (see Chapter 7). Past management procedures can be used as a guideline for this purpose (e.g. *P. undulosus*).

A slight gradient in species composition was noted from the north to the south on the KZN coast. In the north species composition was dominated by subtropical ichthyofauna (i.e. *C. nufar*, *L. nebulosus* and *C. puniceus*), whilst in the south it was dominated by a mixture between warm-temperate (i.e. *P. aeneum* and *C. anglicus*) and subtropical ichthyofauna. Although this transition is more obvious further south of KZN (Turpie *et al.* 2000; Fennessy *et al.* 2003), there are still some obvious differences in catch composition between the north and south, particularly at certain times of the year (i.e. seasonal changes in species composition). Similar differences in catch composition between the north and south coast of KZN were also recorded by Penney *et al.* (1999). Interestingly, recreational and charter boat-fishers caught more *T. albacares* on the south coast than on the north coast of KZN. This may be due to the fact that *T. albacares* rarely enters the Natal Bight preferring to remain in the clear waters of the Agulhas Current, which is found close inshore south of Durban (B. Mann, 2010, ORI, pers. comm.). Good catches of *T. albacares* are also made north of St Lucia where the water is again clear and the continual shelf is narrow. However, this was not apparent in the current study due to the under-sampling of Sodwana Bay.

Interestingly, although the distributional range of *C. nufar* extends as far south as Cape Agulhas (Garratt 1984), it was caught in far less abundance on the lower south coast of KZN by all three sectors in the current study. In fact, for the commercial linefish sector only 262 fish were recorded on the south coast, compared to 35 783 fish on the north coast. This is a worrying observation and could be an indication of localised overfishing. The fact that the reefs on the north coast have only really been utilised since the 1970s with the opening of the port of Richards Bay, whilst the reefs on the KZN south coast have been utilised since the early 1900s (Penney *et al.* 1999), adds support to this supposition and could also explain the overall lower catch rates and differences in catch composition between these two regions. Unfortunately, with the expansion of fishing effort in the past 30 years several reef systems that may have previously served as natural refuges for several fish species are now extensively exploited. Instances of newly located reefs in KZN being quickly overexploited have been previously documented (Mara 1985). This is further emphasised by the high recapture rate of tagged reeffish in the Pondoland MPA (Maggs in press).

Seasonal changes in species composition observed for the offshore boat fishery were similar to those recorded in the region in past literature (Garratt 1988; Mann *et al.* 1997a; Penney *et al.* 1999; Fennessy *et al.* 2003; Jairam 2005). This was despite several differences in directed effort between the different sectors, as discussed above. This study confirmed observations of previous studies, whereby several of the warm-temperate species observed in catches undertake spawning-migrations to KZN from southern waters during winter, while several subtropical species migrate from northern waters in summer. For example, in the charter and recreational boat fisheries, *T. albacares* made up a large proportion of the catch composition from October through to May. Similar seasonal trends, whereby *T. albacares* is mainly caught in summer, have been recorded by Smale and Buxton (1985), Talbot & Penrith (1968) and De Jager *et al.* (1963). Similarly, *A. aequidens* and *P. aeneum* made up a greater proportion of catches in all three sectors during winter and spring, coinciding with the annual spawning season of these species (Garratt 1988).

It should be noted that seasonal changes in species composition may not only reflect changes in species-specific abundances, but could also be an artefact of sampling, or as a result of a change in targeting. It is a known fact that boat-fishers will concentrate effort on certain reef areas that they know from previous experience produce good catches of certain fish species at different times of the year. Furthermore, seasonal differences, such as strength of prevailing currents, only allow anglers to target certain reef areas at certain times of the year. These two points may account for some of the variations in catch composition that cannot be explained purely by natural processes. Ultimately, it is very difficult to tease apart influences of the environment, fishing pressure, natural processes and other anthropogenic factors on fish abundances. This is further exacerbated by natural fluctuations in abundances (i.e. years of good recruitment), which often weaken support for management decisions and/or actions. A crucial problem in South African fisheries management is that of ‘crisis management’, whereby only once a stock has been identified as being overexploited, are management decisions or actions taken (van der Elst and Garratt 1984). Fishery managers often also have a rather myopic view of resource management, with the overall result being that they are unable to be proactive in solving management problems (Clark 1985). These problems have left many species overexploited, a prime example of this being *P. undulosus* (Ahrens 1964) and *Petrus rupestris* (Penney and Wilke 1993).

In general, most boat-fishers adhered to the catch restrictions that have been implemented for certain fish species within each sector. The only area of concern was the high number of boat-fishers that violated the catch restrictions for *C. anglicus*. Both its minimum legal size limit (i.e. 40 cm) and the daily bag limit of one fish per person per day (pppd) for recreational and charter boat-fishers were frequently broken in both sectors. Stricter monitoring and control by EKZNW is needed to curtail this problem. This is further emphasised by the fact that catch rates of this species have increased in the charter and recreational boat fisheries despite the introduction of stricter catch restrictions in April 2005 (*see* Chapter 1). Although *P. grande* is a no-sale recreational species (i.e. are not allowed to be sold by commercial boat-fishers), 82 were recorded in commercial catches. However, this species is easily confused with *Polyamblyodon germanum and P. aeneum.* Further analysis of this discrepancy is needed, particularly since *P. grande* is vulnerable to overfishing (Buxton and Clarke 1992; Booth 1999) (*see* Chapter 6).

4.4.7. Conclusion

Overall, from the analyses of participation within the three sectors, it appears that there have been few new entrants into the boat-based linefishery since 1994-96. Rather there has been an associated shift in participation between the sectors associated with changes in licensing structure and the successful development of a tourism based charter-fishing industry. Total effort on the other hand (especially in the commercial fishery) appears to have decreased substantially since 1994-96. From this it can be concluded that management measures have been partially effective in reducing fishing pressure on the linefish resources. This is important since the KZN offshore linefishery has historically been heavily overexploited (Mann-Lang *et al.* 1997; Penney *et al.* 1999). However, since the charter boat sector has no formal management regime in place and has both recreational and commercial objectives, it poses an enormous threat to the biological sustainability and future economic development of the offshore boat-based linefishery. Furthermore, since charter boat fishing is subsidised by paying customers, the bio-economic equilibrium is exceeded and greater pressure is placed on fish stocks. To avert overexploitation of an already vulnerable linefishery, the charter boat sector needs to be recognised in terms of the MLRA and carefully regulated. For further recommendations, refer to Chapter 7 and Pradervand & van der Elst (2008).

Analysis of overall CPUE, catch composition and total catch in the KZN offshore boat-based linefishery has shown it to be currently in a relatively stable condition. Furthermore, management measures within each sector, barring the charter sector, seem to have been effective in limiting total landings. However, in comparison to the catches recorded throughout the most part of the 20^{th} century, current catch trends suggest that linefish resources have been fished to very low levels which are ‘superficially’ sustainable at current fishing effort levels.

Furthermore, although catch trends of many species are encouraging, some species (e.g. *A. aequidens*, *A. thorpei* and *S. commerson*) may be severely overexploited. The increased percentage composition of *C. puniceus*, *C. nufar* and *L. nebulosus* in current catches of commercial boat linefishers could be reflecting a gradual transition in landings to smaller, more abundant species, which is analogous to serial overfishing. For this reason, it is advised that several stock assessments should be carried out on the species highlighted in this study as a matter of urgency (e.g. *S. commerson*, *C. puniceus* and *A. thorpei*). In this way stock rebuilding of those species that are overexploited can be carried out before any collapse occurs.

The differences in effort, catch composition, CPUE and total landing between the different sectors within the KZN boat-based fishery have obviously been shaped by changes in the management and economic environments. However, natural processes and fisher behaviours not related to changes in fish abundances must also be taken into consideration when making management decisions. Although management of the different sectors needs to be carefully adjudicated, all the sectors operating within the fishery cannot be managed individually. Ultimately, any changes that occur within one sector of the offshore linefishery will have substantial effects on sustainable management of the marine resources as a whole, which will directly effect the other sectors involved.

CHAPTER 5

SOCIO-ECONOMICS OF THE KWAZULU-NATAL OFFSHORE BOAT-BASED LINEFISHERY

5.1. INTRODUCTION

As described in Chapter 3, fishery management systems in South Africa are now understood to include an understanding of how sociological, economic and ecological forces, in combination with management decisions, affect the distribution of fishing opportunities over time and space (Brouwer 1997; McGrath *et al.* 1997; Sauer *et al.* 1997; Griffiths *et al.* 1999). This is important since previous management decisions that were based on species-specific biological data failed to incorporate the behaviour of fishers and their perceptions of the stock status and were heavily criticised by both the managers and the fishers themselves. Furthermore, issues relating to equity and access to certain fisheries play an important role in shaping the direction of fisheries management policy in South Africa (McGrath *et al.* 1997).

Studies by Mann *et al.* (1997a) and McGrath *et al.* (1997) highlighted the magnitude and importance of the offshore boat-based linefishery in KwaZulu-Natal (KZN). They provided invaluable data and management recommendations based not only on biological data, but on socio-economic data as well, which few other studies in South Africa had done before. However, since 1994-96 many changes have occurred in the linefishery (*see* Chapter 1), the most obvious being a reduction in commercial linefishing effort. Although, several studies have evaluated several aspects of the KZN offshore-boat based linefishery since 1994-96, the majority have failed to evaluate the boat-based linefishery as a whole. For example, the study by Jairam (2005), although it incorporated aspects of both commercial and recreational boat-fishers, was confined to the Richards Bay harbour. Similarly, studies done by Pradervand & van der Elst (2008) and Mann *et al.* (2001) only focused on specific sectors of the boat-based linefishery in KZN, namely the charter and commercial boat sectors respectively. Contributions by Penney *et al.* (1999) were also based mainly on the National Marine Linefish System (NMLS), which has several well-known biases associated with it (Mann-Lang 1996; Penney 1997; Sauer *et al.* 1997). Furthermore, the recreational boat sector has suffered from a lack of information and understanding of its extent despite it traditionally having the highest number of boat-fishers participating in it (Mann-Lang *et al.* 1997; Mann *et al.* 1997a; Penney *et al.* 1999; Leibold and van Zyl 2008). Ultimately, the successful management of any fishery cannot be solely based on biological data on the resource being harvested, but needs to understand fishing practices and the dynamic responses of all anglers and fish to variations in fishing pressure and conditions. The primary aim of this chapter was therefore to: (1) determine boat fisher demographics and associated socio-economics; (2) determine current boat fisher awareness, attitudes and compliance towards linefish regulations applying to offshore resources; and (3) make comparisons with other similar independent assessments previously conducted in South Africa and abroad.

5.2. MATERIALS AND METHODS

With the aid of a short questionnaire, socio-economic information was collected from a sub-sample of skippers encountered during access-point surveys (*see* Appendix VIII). In instances where skippers were unavailable for an interview, the crew was requested to nominate one representative to answer the questionnaire. However, such instances were uncommon. As in the access-point surveys, all fish caught were identified (to lowest taxonomic level), measured and weight was calculated using standard length/weight regressions (Froese & Pauly 2010; Mann 2000; Oceanographic Research Institute, unpublished data). For catches that were kept but could not be measured (i.e. uncooperative fishers), fish lengths (and thus weights) were estimated using the average recorded for that species. Where large catches were made, such as on commercial vessels, all fish were counted but only a sub-sample of fish was measured and the total catch was estimated. Skippers that were encountered again during inspections and that had already been previously interviewed had only catch and effort information recorded as part of the access-point survey. Note, all catch and effort data collected during the questionnaire survey was incorporated into the access-point surveys (*see* Chapter 4).

During the study period, few interviews with commercial boat-fishers were obtained as they spent long periods out at sea fishing, often returning after dark. For this reason a telephonic survey, based on the original questionnaire survey and Pollock *et al.* (1994), was designed. Commercial skippers contact details were obtained from MCM and 20 commercial operators were interviewed over the phone during April 2010. An attempt was made to interview at least one commercial operator from the same zones that were covered during the access-point surveys.

The questionnaire was divided into five sections (*see* Appendix VIII). Section A and E dealt with general information such as locality, ethnic group, angler age, bait type, and general angling questions. Section B dealt with catch and effort data, including trip length and the number of years spent fishing. Section C referred to anglers attitudes to management and certain questions dealing with new regulations and the permit system. The different species targeted and the knowledge of current linefish regulations was also dealt with here. Section D was the economic section and dealt with travelling distances, residency, expenditures and other economic questions. All questions were based on those used by Sauer *et al.* (1997) and McGrath *et al.* (1997) for comparative reasons, while additional questions were added to consider changes that have occurred in the boat-based fishery since the last national linefish assessment carried out in 1994-96 (*see* Chapter 1). For the purpose of this study, economic data were analysed at a relatively simple level.

5.3. RESULTS

5.3.1. Socio-economics

A total of 151 skippers (115 recreationals, 20 commercials, and 16 charters) was randomly interviewed from various zones along the KZN coast, although the number interviewed from each zone and per month differed for several logistical reasons. Importantly, the 20 commercial skippers interviewed represented 53% of the total number of activated commercial rights holders as of February 2010. Whilst the 16 charter and 115 recreational skippers interviewed represented only approximately 16% and <8% of the total number of boat-fishers participating in each sector respectively. Based on pooled results from all these sectors combined (i.e. recreational, commercial and charter), most skippers self-owned their vessels, with only a few charter and commercial skippers owning more than one boat. Eighty-two percent of the skippers interviewed were using rigid-hulled (mono or multi-hull) skiboats, while inflatables (10.6%), jetskis (4%) and paddle-skis (3.3%) were less common. Boat skippers varied between three ethnic groups (Fig. 5.1a); ninety-three percent from the White community, while Indian and black African skippers made up six and one percent respectively. Similarly, the crew composition was predominantly from the White (76.4%) community, while black Africans (15.0%), Indians (8.5%) and Coloureds (0.1%) made up the remainder (Fig. 5.1b). There were no female skippers interviewed, although females did make up 2.2% of the crew recorded on vessels. The mean age of skippers was 44.8 ±11.3, with a range between 20 and 71 years old (Fig. 5.2a). Crew age structure was normally distributed with most anglers falling in the 31-45 age class group (Fig. 5.2b). Commercial crew age data was not included in the analyses because during the telephonic survey most commercial skippers were unsure of the actual age of their crew. This was in contrast to face-to-face interviews where crew age was obtained directly from the crew members themselves.

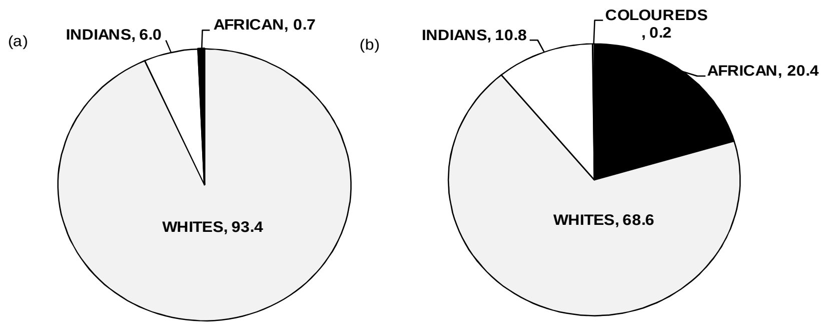


Figure 5.1- Ethnic composition of (a) skippers (n=151) and (b) crew members (n=813) encountered along the KZN coast during a questionnaire survey conducted between February 2009 and April 2010.

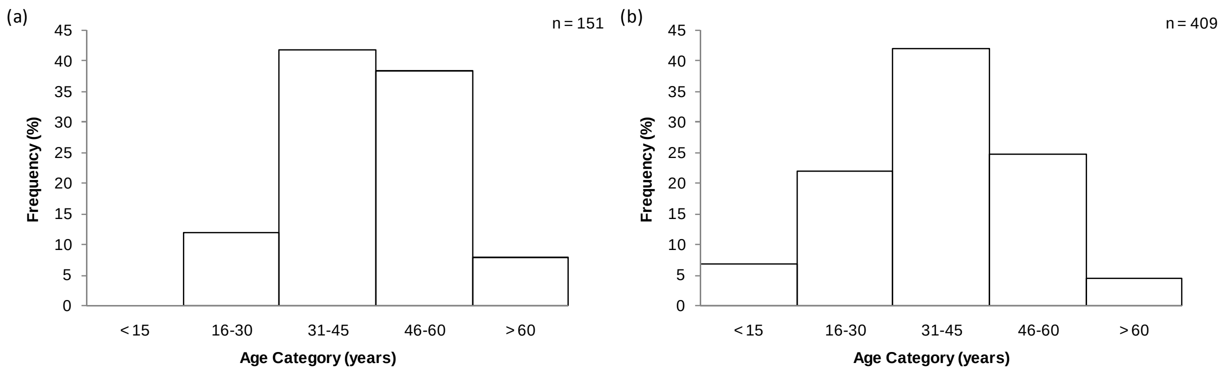


Figure 5.2- Frequency distribution of the age structure of (a) skippers and (b) crew members encountered along the KZN coast during a questionnaire survey conducted between February 2009 and April 2010.

All charter and commercial skippers interviewed resided in KZN. The majority of recreational skippers also resided in KZN (89.4%); however, nine percent were from Gauteng and Mpumalanga (Fig. 5.3). Two recreational skippers interviewed were foreigners and only one of them resided outside of South Africa. Thirty percent of the recreational skippers interviewed were on holiday and/or staying overnight at a venue away from home, while all charter skippers interviewed stated they did not travel on holiday or stay away from home as a charter boat operator (note that if they went on holiday with their vessel they did so on a recreational basis). Similarly, most commercial skippers interviewed stated that they did not stay overnight away from their home base (launch site) because of the costs involved in travelling and the fact that commercial linefish rights are now regionalised (i.e. right holders in KZN are limited to operating in the region between Port St Johns and St Lucia). However, it must be noted that some commercial boat-fishers do travel on a daily basis to different launch sites to target migratory fish stocks, such as *Atractoscion aequidens*. In addition, many commercial operators on the KZN south coast annually obtain beach seine net permits to harvest sardines (*Sardinops sagax*) (see van der Lingen *et al.* 2010) and move up and down the coast following shoals of these fish during the winter months (June-August). This temporarily displaces some of the effort away from the linefishery.

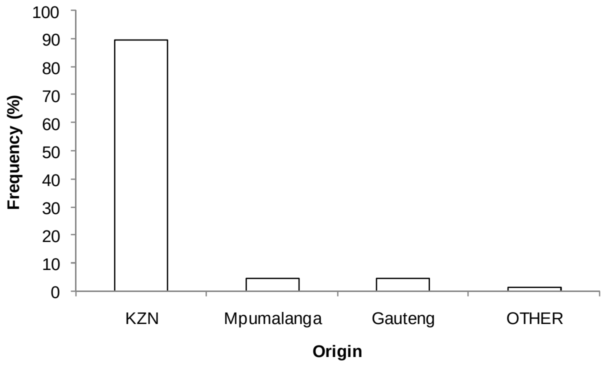


Figure 5.3- Domicile of 115 recreational skippers interviewd along the KZN coast during a questionnaire survey conducted between February 2009 and April 2010.

The frequency distribution of boat-fishers starting and finishing times are shown in Fig. 5.4. Most boat-fishers preferred to start fishing in the early morning between 05h00 and 9h00, with a sharp decrease throughout the day. There were some boat-fishers that started fishing in the afternoon, but very few were recorded starting later than 16h00. Most angler outings ended between 10h00 and 14h00. Figure 5.4 highlights the fact that most boat-fishers prefer to start fishing in the early morning before the wind or weather changes since they are heavily reliant on sea conditions. Note that for the purpose of calculating CPUE, the length of a boat outing was based on actual angler fishing times and did not include launch time and time spent travelling to and from a fishing destination. Furthermore, commercial fisher outings were not included in this analysis since commercial skippers were interviewed telephonically and not directly after a fishing event/outing, thereby avoiding memory-recall bias (*see* Pollock *et al.* 1994). Boat anglers fishing at night were not interviewed for logistical and safety reasons. However, night fishing does represent an important part of the fishery, especially at certain times of the year (e.g. July-October when *A. aequidens* and *Argyrosomus japonicus* are targeted). All commercial boat operators interviewed were night rated[*], while only 13.1% and 25% of recreational and charter skippers interviewed, respectively, could legally fish at night. Charter skippers fished the least frequently at night (6.3% of their outings), while recreational and commercial skippers admitted to fishing at night with a regularly of 6.9% and 15.9 % of their outings respectively.

[*] This is an additional qualification required by skippers to allow them to go fishing off a boat at night. Note that vessels also need to be night rated.

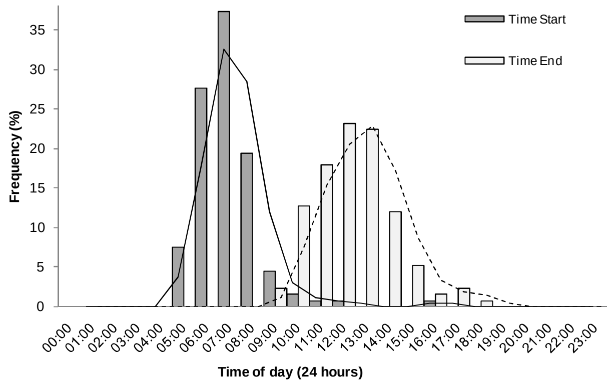


Figure 5.4- Combined frequency distribution of recreational (n=115) and charter (n=16) boat anglers fishing trip starting and finishing times over a 24-hour period from a questionnaire survey conducted between February 2009 and April 2010 along the KZN coast. (Commercial boat outing times were not included since they were interviewed telephonically).

There was a significant difference in fishing regularity (i.e. number of angler outings/launches per year) between the different sectors (Kruskal-Wallis One-way ANOVA, H = 50.02, df = 2, p = < 0.001). The Dunn's test showed that recreational boat-fishers (37.8 ±36.9 launches.year^{-1}) fished the least out of all three sectors, while, as expected, commercial (125.8 ±32.2 launches.year^{-1}) and charter (77.4 ±48.2 launches.year^{-1}) boat-fishers launched more regularly. As in the shore linefishery, these estimates were subject to avidity bias whereby anglers that fish often were more frequently intercepted during the access-point surveys. By accounting for avidity according to the equation developed by Thompson (1991) (*see* Chapter 3), new values of 11.4 launches.year^{-1} for recreational, 42.4 launches.year^{-1} for charter and 117.3 launches.year^{-1} for commercial boat-fishers were calculated. Although the majority of skippers had been boat fishing for more than 10 years, 29.2% had only taken up boat fishing in the last decade. Angler/skipper experience did not differ significantly (Kruskal-Wallis One-way ANOVA, H = 2.98, df = 2, p = 0.23) between the sectors; however, the high variation in angler experience may account for this. On average, skippers claimed to have fished for approximately 19.6 ±14.0 years; this ranged from less than 12 months to as long as 58 years. The majority of recreational (92.2%) and charter (100%) skippers interviewed were registered to skiboat clubs, while only 55.0% of commercial boat operators interviewed were affiliated to a club. The Durban Skiboat Club, Park Rynie Skiboat Club (Rocky Bay), Shelly Beach Skiboat Club and Richards Bay Skiboat Club were the most popular clubs that respondents were affiliated to; however, this was influenced by sampling bias.

Regarding the distance travelled (one-way) to a particular launch site on the day of an angler outing, there was no significant difference between the different sectors of the KZN boat-based linefishery (Kruskal-Wallis One-way ANOVA, H = 0.09, df = 2, p = 0.95; Table 5.1). On average, boat-fishers travelled 15.9 ±33.3 km to a launch site; however, this distance ranged from less than 0.1 km up to 300 km one-way. Although the majority of recreational boat-fishers on holiday or staying overnight stayed in close proximity to their preferred launch site, if one includes where they had come from for their holiday/overnight trip (i.e. from their place of residence), distance travelled for these boat-fishers would be considerably higher.

Operating costs, in terms of average bait expenditure per angler outing, was significantly different (Kruskal-Wallis One-way ANOVA, H = 56.23, df = 2, $p < 0.001$) between the different sectors of the KZN boat-based linefishery (Table 5.1). The Dunn's test showed that on average all three sectors expended different amounts of money on bait per boat outing ($p < 0.05$), with commercial boat-fishers spending the most (R446 ±R212; Table 5.1). Yearly expenditure on bait for each of the sectors, by taking the total annual angling effort for each sector (*see* Chapter 4) and multiplying it by average expenditure on bait per boat outing (Table 5.1), was calculated to be R2 058 015 for the recreational, R827 548 for the charter and R1 485 626 for the commercial boat sectors. Other operating costs, such as fuel and labour cost, were not included in the current survey because of time constraints associated with the questionnaire (*see* Pollock *et al.* (1994) for biases associated with lengthy questionnaires).

The average investment in the KZN boat-based linefishery was established in terms of the resale value of equipment directly used by boat-fishers (i.e. value of the boat and associated equipment, including motors, trailers, GPS, echo-sounder, fishing tackle and fishing equipment). Although the results were highly variable, there was a significant difference between the value of the boat and associated equipment between the different sectors (Kruskal-Wallis One-way ANOVA, H = 26.03, df = 2, $p = <0.001$). The value of the boat and associated equipment was significantly ($p < 0.05$) lower in the recreational boat sector (Table 5.1). Also, recreationals interviewed were using a range of vessel types including jetskis and paddle-skis, which are considerably cheaper than a skiboat. The charter and commercial boat sectors rely on the fishery as a source of income and therefore the average value of their boats and associated equipment was far higher than recreational boat-fishers were. Both these sectors seem to invest similar amounts of capital into the fishery ($p > 0.05$). There was no significant difference (Kruskal-Wallis One-way ANOVA, H = 3.16, df = 2, p = 0.20) between the different sectors in terms of the value of the fishing tackle and equipment they owned, with the average investment in this regard being R29 755 ±R33 048 (Table 5.1). The high variation in fishing tackle and equipment expenditure may explain this discrepancy (Table 5.1).

Table 5.1- Average travelling distance, expenditure on bait per boat outing and overall investment by each sector of the KZN offshore boat-based linefishery from 151 questionnaires conducted between February 2009 and April 2010. Standard deviation is given in parentheses.

Parameter	Rec (n=115)	Char (n=16)	Comm (n=20)	Average
Distance travelled (km)*	16.2 (34.2)	18.1 (37.6)	13.0 (23.6)	15.8 (33.3)
Bait Cost	67.6 (105.5)	140.3 (89.4)	446.1 (212.0)	125.5 (176.9)
Tackle cost**	30896 (34969)	35875 (28603)	18300 (20490)	29755 (33048)
Rig cost***	184800 (134262)	405375 (356252)	360450 (182843)	231437 (194466)

* The distance travelled (one-way) to a particular launch site on the day of a boat outing/fishing event.

* Value of rods, reels, general fishing gear (lures, hooks, line, etc.) owned by the skipper.

***Value of the boat and associated equipment, i.e. motor(s), trailer, GPS, radio, echo-sounder, etc. (excluding vehicle, tackle, and bait).

Compared to the shore linefishery, there were far fewer *unemployed and economically inactive* and *retired* (7.9%) anglers/skippers interviewed in the KZN recreational boat-based linefishery (Table 5.2). The majority of the economically active recreational skippers interviewed fell into the '*self employed*' (31.3%) occupational category. As with the shore linefishery, there was a proportionate overrepresentation of *professional/semi and technical* (16.5%) and *managerial/executive and administrative* (15.7%) workers in the recreational linefish sector. Forty percent of the commercial skippers interviewed stated that commercial boat linefishing was their sole form of income. The remaining eight respondents had alternate employment that fell into the *services* (e.g. charter boat linefishing), *artisan, apprentice or related* and *managerial/executive and administrative* occupational categories. Similar to the commercial boat sector, 43.8% of charter skippers interviewed stated that charter boat linefishing was their sole source of income. The remaining skippers interviewed all had alternate permanent employment, with the majority being '*self employed*' (18.75%). From the characteristics of employment discussed, it is obvious that boat-fishers belong to the higher income distribution in South Africa.

Table 5.2- The percentage of recreational skippers interviewed that fell into different occupational categories in KZN based on a questionnaire survey conducted between February 2009 and April 2010 (occupational categories modified from McGrath *et al.* 1997).

Occupational category (n=115)	%
Self-employed	31.3
Professional/semi and technical	16.5
Managerial/executive and administrative	15.7
Artisan, apprentice and related	9.6
Clerical and sales	8.7
Retired	7.0
Skilled agricultural and fishery workers	6.1
Services	2.6
Foremen, supervisor and mining	1.7
Unemployed and not economically active	0.9
Operators and semi-skilled	0

This study allowed for several characteristics of commercial and charter boat linefishers to be investigated. Most commercial skippers had been commercial fishing for approximately 22.9 ±9.9 years, and only one had started in the last decade. All commercial operators interviewed paid their crew per weight (kg) of fish caught. In addition, a minimum weight needed to be caught before crew earned any pay. On average, crew earned R4.93 ±R1.53 per kg of fish caught; however, this ranged from as little as R0.50 up to R8.00 per kilogram. Mean weight of fish caught per crew member per boat outing was 35.85 ±14.55 kg. Taking into account the total number of trips (i.e. launches) in the last 12 months by each commercial operator, mean crew earnings were estimated to be R23 436 ±R15 453 year^{-1} or R1 953 ±R1 288 month^{-1}; though this ranged from R1 800 to R86 400 year^{-1} or R150 to R4 950 month^{-1}. All of the commercial boat operators interviewed claimed to have attempted to register their crew on the 'crew list' since its implementation (*see* Chapter 1). However, all of the operators complained that the process of crew registration was problematic, and most stated that they had been waiting for a long time for several crew to be registered by MCM. From these results, it seems that the implementation of the crew register by MCM has been problematical.

Charter skippers had been boat fishing on average for 18.5 ±15.0 years; however, this did not represent how long they had been a charter boat operator, since many had only started in the last decade (*see* Chapter 4). Only one of the charter skippers interviewed was not licensed through the Department of Transport (DOT) to take out paying customers. All but one charter skipper interviewed charged per head on the boat. On average, this amounted to R473 ±R111 per customer. Taking into account the average crew size and average number of launches per year for this sector, charter boat operators have a turnover of approximately R122 450 ±R28 673 year^{-1} (note that this excludes the sale of fish caught which is illegal by this sector). However, this does not take into account any operating or additional costs involved in running a chartering business. Refer to Pradervand & van der Elst (2008) for a more detailed evaluation of the charter boat fishery in KZN. Twelve skippers interviewed (made up of commercials and recreationals) also claimed to charter illegally from time to time when the market was available. This was obviously during the popular holiday periods.

5.3.2. Bait utilization

Overall, 87% of the boat-fishers interviewed were using some sort of bait organism to capture fish rather than artificial lures. A total of 14 bait types were recorded for recreational boat-fishers (Table 5.3); the three most common being pilchard/sardine (*Sardinops sagax* 29.5%), mackerel (*Scomber japonicus* 14.5%) and squid (*Loligo spp.* 12.4%). Similarly, seven and five bait types were recorded for charter and commercial boat-fishers respectively (Table 5.3). Both charter and commercial boat-fishers predominantly used pilchard/sardine and squid as bait, with other bait organisms (i.e. mackerel, red-eye sardine *Etrumeus teres*, scad *Decapterus spp.*, maasbanker *Trachurus delagoa*) only making up 20.0% and 9.2% of their bait usage respectively (Table 5.3). Most of the latter bait species were caught during the boat outing using "Yo-zuri's" (trace made up of several fly like lures) rather than being purchased.

Table 5.3- Percentage contribution of the bait types used by the different sectors of the KZN offshore boat-based linefishery from a questionnaire survey conducted between February 2009 and April 2010. Bait types are arranged alphabetically by common name.

Common Name	Scientific Name	% Rec	% Char	% Comm
Artificial lure	-	16.7	2.9	-
Cutlass fish	*Trichiurus lepturus*	0.4	-	-
Eastern little tuna*	*Euthynnus affinis*	3.9	-	-
Elf/shad*	*Pomatomus saltatrix*	1.7	-	-
Japanese mackerel	*Cololabis spp.* & *Scomberesox spp.*	1.7	-	-
Live bait*	Unspecified type	5.1	5.7	-
Maasbanker*	*Trachurus delgoa*	8.1	2.9	2.3
Mackerel*	*Scomber japonicus*	14.5	2.9	4.6
Pilchard/sardine	*Sardinops sagax*	29.5	42.9	45.5
Pink prawn	*Haliporoides triarthrus*	0.4	-	-
Red-eye sardine*	*Etrumeus teres*	4.7	5.7	2.3
Sarda-sarda/bonito*	*Sarda orientalis*	0.4	-	-
Scad*	*Decapterus spp.*	0.4	-	-
Squid	*Loligo spp.*	12.4	37.1	45.5

* Indicates bait species generally self-caught rather than bought

5.3.3. Angler attitudes towards current management measures

The majority of recreational (81%) and charter (75%) skippers interviewed agreed with the current linefish regulations (Table 5.4). Commercial skippers, however, were not of the same opinion and had less regard for the minimum legal size limits (45%) and daily bag limits (55%) (Table 5.4). Recreational (76%) and charter (62%) skippers strongly disagreed with the current ban on driving on the beach, while just under half (40%) of the commercial skippers interviewed were not in favour of it. Although the majority of recreational (96%) and charter (100%) skippers interviewed agreed with the current minimum legal size limits that are in place on certain fish species, a large proportion admitted to knowingly disobeying them (Table 5.4). Contrastingly, the majority of the skippers interviewed from these two sectors stated that they had not kept over their daily bag limits, which suggests better compliance with this type of linefish regulation by these two sectors. Since the majority of the commercial skippers interviewed did not support the minimum legal size limits and daily bag limits, 95% and 45% of them knowingly disobeyed these two types of regulations respectively. In all three sectors a large proportion of skippers (recreational 45%; charter 44%; commercial 90%) admitted to keeping undersize fish for bait while targeting larger piscivorous reeffish species (e.g.

Epinephelus spp.). Although some commercial skippers stated that they sometimes brought undersize fish that had died from barotrauma back to shore, they indicated that these undersize fish were given to the crew and were not sold. Consequently, they did not record these fish on the mandatory NMLS catch returns. Relatively few skippers in all three sectors admitted to having kept fish in a closed season, fished illegally in a marine reserve/marine protected area (MPA) and/or driven on the beach illegally (Table 5.4).

When questioned about their knowledge of the regulations on the three most important species of fish that they were targeting, recreational interviewees (66%) had the poorest knowledge of the current linefish regulations, while charter (86%) and commercial (92%) operators were better informed (Table 5.4). Specifically, minimum legal size limits seemed to be the least well known of the regulations in all three sectors. The closed seasons on certain fish species (e.g. *Pomatomus saltatrix* and *Petrus rupestris*) were relatively well known in all three sectors (Table 5.4).

Table 5.4- Percentage of skippers from three boat-based linefish sectors (n=151) that agreed with, admitted to disobeying and knew the current linefish regulations for their target species during a questionnaire survey conducted in KZN between February 2009 and April 2010.

Regulation	Frequency (%)								
	Recreational (n =115)			Charter (n = 16)			Commercial (n = 20)		
	Agree	Disobey	Knowledge	Agree	Disobey	Knowledge	Agree	Disobey	Knowledge
Minimum Size	96	67	50	100	56	73	55	95	83
Bag Limit	91	18	61	69	19	90	45	45	93
Closed season	95	19	86	88	13	96	90	15	100
Marine reserves	97	6	-	81	6	-	70	10	-
Beach ban	24	19	-	38	13	-	60	5	-

Ninety-six percent of the skippers interviewed had been checked at least once by an EKZNW officer or fishery inspector since they had started offshore linefishing. The regularity at which skippers had been checked differed significantly between the different sectors (Kruskal-Wallis One-way ANOVA, $H = 13.64$, $df = 2$, $p = 0.001$). According to Dunn's test, charter skippers were checked significantly ($p < 0.05$) more often (13.01 ±31.5 times.year^{-1}), while commercial (6.11 ±23.7 times.year^{-1}) and recreational (4.52 ±18.2 times.year^{-1}) skippers were checked less regularly. Note these estimates were corrected for avidity (*see* Chapter 3).These rates of inspection may be exaggerated as many skippers assumed that seeing an EKZNW officer at a launch site was equivalent to being inspected. Forty-five percent of the boat skippers interviewed expressed unhappiness with the manner in which the offshore boat-based linefishery was managed by EKZNW. Most of them (52%) criticised management and said

EKZNW did not police the fishery correctly, while 38% also said there were insufficient personnel to control or implement effective management along the coast. Other criticisms from skippers included lack of well-trained staff (6%), corruption (3%) within MCM and EKZNW and racism (1.5%) from EKZNW officers towards certain angler groups.

Most (57%) of the recreational and charter skippers interviewed stated that EKZNW had informed them of the linefish regulations either by direct (verbal) or indirect communication. The remainder claimed to have either learnt about the regulations over the years (i.e. by word of mouth) or through various media (e.g. signboards, internet, newspapers, television and magazines). All commercial operators claimed to have obtained information about the regulations through MCM during annual reactivation of their commercial rights.

All commercial skippers interviewed possessed a long-term commercial right (2006-2013) issued to them by MCM. Similarly, all recreational and charter skippers interviewed had purchased a general marine recreational angling permit. Additionally, 80% of them had purchased a recreational skipper permit (code 10); with the remainder claiming not to have known about this additional permit requirement. For recreationals and charter skippers interviewed, the Post Office remained the most common place to purchase an angling permit (73%), while some skippers had bought their permits at EKZNW outlets/offices (26%). In addition to the general recreational angling permits, 108 skippers interviewed had also purchased other marine recreational permits including an east-coast rock lobster permit (code 07; 27 permits purchased) “mollusc” or general-bait permit (code 09; 17 permits purchased), castnet permit (code 03; 11 permits purchased) and others (27 permits purchased). An individual skipper therefore had anything from a single general angling permit to up to seven additional marine recreational permits.

The majority (88%) of recreational skippers interviewed claimed to fish for recreational purposes (i.e. relaxation and companionship), while 9% also claimed to fish for competitive reasons. Seventy-nine percent of charter skippers interviewed gave the fish caught on a boat outing to the clients as part of the “package”, while 21% either sold the fish illegally or kept it for their own use. As with the shore linefishery, a surprising number of recreational skippers (10%) fished purely for fun and released their catch. Most recreational skippers, however, claimed that they fished for pleasure and that they kept the fish they had caught as an additional source of protein, while some (25%) simply gave it away to friends and family. Only three recreationals admitted that they did sell fish illegally from time to time. Seventy-four percent of the boat anglers interviewed (all sectors) practiced other types of fishing; the most common were rock and surf (34%), freshwater (33%) and estuarine (21%) fishing.

Thirty-six percent of the skippers interviewed (all sectors) that had been fishing for 10 or more years stated that they fished less frequently nowadays. ‘Weather’ (34%) and ‘work/family’ (32%) were the main reasons given for this reduced frequency of fishing. Other responses, such as the ‘cost of fishing’ (17%) and ‘poorer catches’ (11%), also featured prominently in angler responses.

The majority of the skippers interviewed (recreational 80%; charter 75%; commercial 60%) believed that fishing along the KZN coast had deteriorated over the years (Fig. 5.5). Recreational (43%) and charter (46%) skippers both felt that general overfishing was the main reason for this, while 54% of commercial skippers interviewed were concerned more about the impact that climate change was having on fish abundance (Fig. 5.5). Trawling was another common reason given for the decline by all three sectors (Fig. 5.5).

As in the shore linefishery, the questionnaire survey provided a unique opportunity to check the recapture and reporting rates of fish tagged in the ORI Tagging Project. Briefly, only 39 (26%) skippers interviewed reported that they had caught a tagged fish during their lifetimes. Of those skippers, 10 (26%) had just released the fish without recording the tag number or had simply not bothered to report it. One quarter of the tagged fish recaptured by skippers interviewed along the KZN coast were therefore not reported to the Tagging Officer at ORI. Furthermore, of the remaining 29 skippers (74%) that had “reported” catching a tagged fish, 20 (69%) stated that they had received feedback from ORI about the fish. So again, some of this “reported” recapture information may also have gone unrecorded. Overall, boat-fishers are more compliant in terms of returning tag recapture information to ORI than shore-anglers (*see* Chapter 3). The fact that many tag recaptures are fish under their minimum legal size limits could be contributing to the under-reporting of tagging information (J. Maggs, 2010, ORI, pers. comm.). Furthermore, some boat-fishers deliberately do not report tag recaptures as they do not support several linefish regulations (*see* above) and they believe that reporting of this information may lead to stricter catch restrictions. Failure to report tag recaptures have also been recorded in several other cooperative tagging programs (Crossland 1976; Trumble *et al.* 1990; Shimada and Kimura 1994; Gillanders *et al.* 2001).

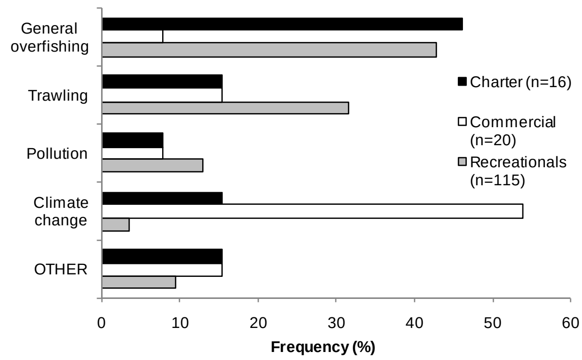


Figure 5.5- Primary reasons given by skippers for the decline in linefish catches in the KZN offshore boat-based linefishery from a questionnaires survey conducted between February 2009 and April 2010.

5.4. DISCUSSION

5.4.1. Socio-economics

On account of the limited sampling period (i.e. one year) and the dual function of this study (i.e. assessment of shore and boat-based linefisheries), the number of skippers interviewed was relatively low (i.e. 151). Furthermore, during the study period few interviews with commercial skippers were conducted since they spent long periods out at sea fishing, often returning after dark. There was also an element of unwillingness by boat-fishers, particularly charter and recreational boat-fishers, to participate in the onsite questionnaire survey. A similar problem was found by Pradervand & van der Elst (2008). However, this was largely because boats often returned from sea around the same time and there was subsequently a lot of congestion at the launch site, skippers were therefore generally in a hurry to hitch up their boats and get home. An alternate questionnaire survey technique, such as that conducted in the commercial sector (i.e. telephonic survey) might be better designed for the offshore boat-based linefishery (*see* Pollock *et al.* (1994) for alternate survey techniques). Overall, as a result of these logistical constraints all skipper interviews were done on a *ad hoc* basis during access-point surveys, while commercial skippers were interviewed over the phone when the weather/fishing conditions were not favourable. Data collected was pooled and not presented on a per-site or per-month basis.

Only rigid-hulled (mono or multi-hull) skiboats were used by commercial and charter boat-fishers to access the offshore linefish resources in KZN. In contrast, 17% of the recreational skippers interviewed were using other types of vessels, including inflatables, jetskis and paddle-skis. These vessels have important implications for resource management and socio-economic development of the boat-based linefishery in KZN. Not only are they relatively easier to manhandle and launch through the surf, but the financial outlay for entrants into the fishery using these vessels is comparatively low. Furthermore, in the case of paddle-ski fishers, launching of craft into the ocean is not restricted to licensed launch sites (except in the iSimangaliso Wetland Park). As a result of the advantages that these vessels have over skiboats, effective fishing effort may increase particularly within one nautical mile of the coast. It is thus recommended that the use of these vessels should be carefully monitored by EKZNW during their routine shore patrols (*see* Pradervand *et al.* 2007a).

Most of the skippers interviewed in the current study were white males between the ages of 31 and 60 years of age and had been fishing for an average of 19.6 years. Boat fisher experience is therefore generally high, which confirms the findings of McGrath *et al.* (1997) that boat fishing is a sport in which participants begin young and continue throughout their lives. It can be expected then that relatively few new anglers will enter the fishery each year, which substantiates the results described in Chapter 4. Several economic barriers, such as the cost of the vessel and annual maintenance, also hinder new entrants into the offshore linefishery.

Historically, White skippers have dominated the boat-based linefishery in KZN, with the previously disadvantaged race groups being considerably under-represented (McGrath *et al.* 1997; Sauer *et al.* 1997). Economic forces and political inequalities suffered in the past have played a major role in this regard. Although the recreational component of the offshore boat-based linefishery is open access in nature, other forces have a major influence on fisher participation. However, ethnic composition of the crew on vessels was noticeably different, with the crew on commercial vessels being dominated by black African people. A similar result was also described for commercial skiboat operators in 1994-96 (McGrath *et al.* 1997). In general, the current study showed a distorted ethnic composition that is not representative of the population of KZN as a whole (Statistics South Africa Census 2001). This is likely explained by the fact that fishing is more popular among higher income groups (Clarke and Buxton 1989; Brouwer 1997; McGrath *et al.* 1997) and KZN traditionally has a high unemployment rate in black African and Coloured population groups (Statistics South Africa Census 2001). Furthermore, compared to the shore linefishery, the offshore boat-based linefishery (with exception of commercial crew) is almost entirely characterised by fishers who represent the higher quintiles of income distribution in South Africa (McGrath *et al.* 1997). As discussed in the shore linefishery, Zulu people in KZN were not culturally dependent on fish and fishing and are therefore underrepresented in the fishery as a whole (Merrett and Butcher 1991). Although the commercial rights allocation process attempted to facilitate transformation in the traditional boat-based linefishery by promoting greater access to previously disadvantaged persons, there appears to have been relatively little change in ethnic composition since the study conducted by Mann *et al.* (2001).

The age structure and sex-ratio of skippers in the current study was slightly different to that of the crew. Skippers were generally from the older age class groups, with none being under the age of 20, while crew had a wider age structure and sex ratio. Few females were recorded during the entire questionnaire survey. This is unlikely to be because of sampling bias, but probably represents the true nature of the fishery (i.e. boat fishing is traditionally a male dominated activity). Similar trends have been recorded in other linefish studies focussing on offshore boat-based fisheries (Mann *et al.* 1997a; McGrath *et al.* 1997; Mann *et al.* 2001; Brouwer and Buxton 2002; Fennessy *et al.* 2003; Jairam 2005; Pradervand and van der Elst 2008). Interestingly, it the number of females participating in the shore linefishery has increased from 1.1% to 17% (*see* Chapter 3). Commercial crew age data was not included in the analyses because during the telephonic survey most commercial skippers were unsure of the actual age of their crew. This problem is exacerbated by the fact that commercial skippers often utilise several different crew members depending on their availability. Several commercial skippers stated that they often struggled to find sufficient crew since many experienced crew had moved on or had died in recent years from AIDS and related diseases. A similar problem was recorded by Mann *et al.* (2001). Furthermore, since being a crew member on board a commercial vessel is a tough job (i.e. unpredictable work hours, strenuous working conditions, minimal pay and few employee benefits), there is a high turnover rate of different crew members. The rights allocation process, through the crew list/register, was designed to register crew members so that standards could be set to improve livelihoods and to alleviate the problem of crew shortages. The results presented here have shown that this process to date has been largely unsuccessful. Progress regarding crew registration is still unclear and several commercial skippers are still waiting for crew members to be successfully registered. MCM needs to address this problem urgently.

In 1994-96 the average earnings for a commercial crew member in South Africa was estimated at R7500 per year or R63 per trip (McGrath *et al.* 1997). Considering inflation rates (CPI) over the past 12 years, this amounts to R15 648 in current day Rands. Thus, commercial crew earnings in KZN (R23436) recorded in the current study are approximately 34% higher than that recorded in the 1994-96 survey. However, it is not known whether there have been similar increases in crew earnings in the commercial linefishery elsewhere in South Africa.

From the results in this chapter, it is obvious that offshore boat-based linefishing is an important economic activity that extends beyond the value of the landed catch. Not only does it provide an income for many people directly and indirectly involved in the linefishery, but in the case of recreational boat-fishers (including those fishers that fish off charter boats), it also provides substantial sociological benefits, such as relaxation, enjoyment of the outdoors and companionship. Although the individual investment in the KZN offshore boat-based linefishery is far greater by charter and commercial boat-fishers (Table 5.1) and both these sectors on average launch far more frequently than recreational boat-fishers, the greater number of boats participating in the recreational boat sector (*see* Chapter 4) accounts for a greater economic contribution. This was particularly evident in the current study where bait expenditure per outing was considerably higher by commercial boat-fishers, yet annual expenditure on bait by recreational boat-fishers far exceeded that of the other boat sectors.

The annual turnover made by charter boat operators (R122 450 year^{-1}) calculated in this study did not take into account any of the running costs or capital costs involved in boat fishing. Nonetheless, the turnover of R122 450 year^{-1} suggests that most operators are in the lower income quintiles of the country. As shown by Pradervand & van der Elst (2008), profit margins are low in the charter boat sector, with 25% of charter boat operators interviewed in their study admitting to actually running at a loss. From the results of this study and those of Pradervand & van der Elst (2008) it would seem that chartering in KZN is an opportunistic business, with most charter boat operators only operating during popular holiday periods (*see* chapter 4). The fact that twelve commercial and recreational skippers interviewed in this study claimed to take charters illegally[*] from time to time when the market was available, confirms this point. A similar trend was found in KZN during the 1994-96 survey (Mann *et al.* 1997a) and by Mann *et al.* (2001). Overall, charter fishing seems to be subsidised in most cases by alternate employment and does not appear to be a viable option as a sole source of income, unless it is done on a relatively large scale where there is strong public demand (i.e. using several boats operating at popular holiday destinations, such as St Lucia and Shelly Beach). However, as discussed in Chapter 4, the current uncontrolled increase in charter fishing effort will ultimately result in fish stocks being driven beyond the bio-economic equilibrium (Clark 1985) and thus effectively limit any stock rebuilding taking place. Furthermore, unless there is rationalisation (i.e. capping) of the number of charter boats operating at launch sites along the KZN coast, the economic viability of individual operators is likely to be compromised. Therefore, it is

[*] Commercial right-holders are not allowed to take out paying customers as a condition of their permit, whereas as recreationals (i.e. their vessel) would have to be registered through the Department of Transport to take out paying customers.

recommended that the charter boat sector be officially recognised in terms of the Marine Living Resources Act (No. 18 of 1998) and managed as a separate sector. It must be noted that there is a considerable lack of information and understanding of the extent of the charter boat sector outside of KZN. This, however, must not compromise management decisions for this growing sector.

5.4.2. Bait utilization

The number of boat-fishers interviewed that used some sort of bait organism to target linefish species was exceptionally high (87%). Although artificial lures were also recorded on several occasions during interviews, these were all in the recreational boat sector (Table 5.3). These results were expected and a similar trend was observed in KZN during the last national linefish assessment conducted in 1994-96 (Mann *et al.* 1997a) and on a smaller scale in a skiboat linefish survey conducted in the Richards Bay Harbour (Jairam 2005). Similar bait usage was also observed in the Eastern Cape skiboat linefishery (Brouwer 1997); however, few other publications describe bait usage by boat-fishers outside of KZN.

Generally, charter and commercial boat-fishers used bait organisms that were commercially available from bait retailers and wholesalers (i.e. pilchard/sardine and squid). Other small pelagic bait fishes, such as mackerel (*Scomber japonicus*) and red-eye sardine (*Etrumeus teres*), were also recorded on several occasions; however, these were only used on rare occasions when they were self-caught while fishing at sea. A similar trend was reported by Pradervand & Fennessy (2009) from informal observations of the charter boat sector in KZN and by Brouwer (1997) in the Eastern Cape for the commercial linefishery. It must be noted that several smaller reeffish are often used as filleted bait while at sea to target larger piscivorous reeffish, such as *Epinephelus spp*. These smaller fish are mainly used for bait because they are often under their minimum legal size limit (particularly *C. puniceus*) and would have died from barotrauma if released and/or because they are unmarketable.

In contrast to the other sectors of the KZN boat-based linefishery, recreational boat-fishers had a wider variety of bait types, which also reflects the greater number of species recorded in the catch composition (*see* Chapter 4). In particular, small pelagic baitfish species form an important component (32%) of bait usage in the recreational boat sector. This trend is partly due to the fact that recreational boat-fishers spend more time fishing for pelagic gamefish (*see* Chapter 4), which are targeted mainly with live baits (e.g. mackerel, red-eye sardine, scad, maasbanker). This is in contrast to bottom fishing, where squid and sardine are generally used.

In addition to this behaviour, recreational boat-fishers often directly target small pelagic bait fish species and sell them illegally to fishing tackle shops since they are highly desired by shore-anglers as bait (Pradervand and Fennessy 2009). The fact that mackerel was the fourth most important fish (numerically) targeted by recreational boat-fishers in the current study confirms this point (*see* Chapter 4). Furthermore, one of the main reasons why fishing tackle shops source these small pelagic baitfish species illegally from recreational boat-fishers is because commercial boat-fishers generally do not target these bait fish species as the financial returns are relatively poor compared to their normal target species (i.e. bottom fish) (Pradervand and Fennessy 2009). Other sources of these baitfish species, namely from purse-seine netters, are also of an inferior quality compared to line-caught fish and are therefore frequently unsuitable for bait purposes (Pradervand and Fennessy 2009). It must be noted that the demand for high quality bait by both shore-anglers and boat-fishers is a relatively new development, which may have future relevance for food security in the fishing industry.

Fortunately, the overall high usage of pilchard/sardine and squid in the offshore linefishery is not regarded as presenting a management or conservation problem (Pradervand and Fennessy 2009). This is firstly because the fisheries for these two species are considered to be well-managed (De Oliveira *et al.* 1998; Sauer *et al.* 2003; Glazer and Butterworth 2006), and secondly because they contribute only a small proportion (< 10%) of their respective total annual catches to the bait industry (Augustyn *et al.* 1992; Sauer *et al.* 2003; Pradervand and Fennessy 2009). Furthermore, the KZN offshore boat-based linefishery only uses approximately 6% of the total quantity (kg) of pilchard/sardine and squid sold annually in KZN (Pradervand and Fennessy 2009). Of concern, however, is the increased usage and illegal selling of locally harvested small pelagic baitfish species. In this regard, as discussed in Chapter 3, the opportunity possibly exists to develop some small-scale, localised bait fisheries for these species (Cockcroft *et al.* 2002; Mackenzie 2005; Pradervand and Fennessy 2009). This could be relatively simple bearing in mind that several illegal sources of these bait species already exist and there is also a strong market demand (Pradervand and Fennessy 2009). Furthermore, if the quality of purse-seine netted baitfish can be improved, e.g. smaller catches that are put straight into the slurry, an alternative small-scale commercial fishery can be developed. The well-managed traditional commercial linefishery can be used as a guideline for this purpose. However, thorough investigation is needed to clarify if this is biologically sustainable, especially since many bait species may comprise shared stocks with Mozambique. For further reading consult Pradervand & Fennessy (2009) and Mackenzie (2005).

Overall, the annual expenditure on bait in the KZN offshore boat-based linefishery (i.e. ~R5 million) is considerably less than the ~R40 million spent on bait in the shore linefishery (*see* Chapter 3). However, together, both these linefisheries contribute significantly to the local coastal economies of KZN. Unfortunately, few studies have estimated the value of the bait industry at a national level. Interestingly, the total catch estimated for the offshore boat-based (i.e. 1 487 mt) and shore linefisheries (i.e. 249-277 mt) in the current study is far less than the total amount of sardine and squid estimated to be used by the same fisheries in KZN (i.e. ~3400 mt; Pradervand & van der Elst 2008). It is therefore possible that Pradervand & Fennessy (2009) over-estimated the amount of bait used in KZN.

5.4.3. Angler attitudes towards current management measures

The majority of the recreational and charter skippers interviewed supported the current linefish regulations (with the exception of the beach vehicle ban) used for the management of the KZN offshore boat-based linefishery (Table 5.4). Similar findings were reported for the recreational boat sector by Mann *et al.* (1997a), Sauer *et al.* (1997), Fennessy *et al.* (2003) and Everett & Fennessy (2007). The lack of support for the beach vehicle ban was also observed in the shore linefishery during the current study. Fortunately, few anglers from these two sectors admitted to driving on the beach illegally, which suggests that management of this regulation by EKZNW is good. This is particularly important since the beach vehicle ban has effectively acted as a no-take MPA in many areas along the KZN coast (where there are no access-points) and has therefore been an effective management measure.

Despite the strong support for the fishery regulations in the recreational and charter boat sectors, a number of skippers interviewed in these two sectors had relatively poor knowledge of the legislation, while many admitted to disobeying them (it should be noted that general compliance and knowledge of the regulations is far higher in the offshore boat-based linefishery than in the shore linefishery; *see* Chapter 3). In particular, the minimum legal size limits were the least well known of the regulations and were the most frequently violated. A similar trend was found during the last national survey in 1994-96 (Mann *et al.* 1997a). The actual number of skippers that admitted to disobeying the regulations may in fact be higher than that recorded since many anglers fear prosecution and deny disobeying the regulations during face to face interviews. Unlike the shore linefishery, which is also primarily recreational in nature, violations of the fishery regulations by recreational and charter boat-fishers are less likely to be as a result of poor knowledge (*see* Chapter 3), but rather as a result of deliberate disregard for the fishery regulations. This can be ascribed to the lack of enforcement of fisheries regulations by EKZNW as well as traditional management problems, such as incorrect identification and measuring of fish, which undermine effective management of the fishery (*see* below). However, it is likely that barotrauma also contributes to boat-fishers keeping undersize fish and over their daily bag limits (Mann *et al.* 1997a). This is because, in the case of bottom fish, most boat-fishers regard it as pointless releasing a fish that they know will probably die from barotrauma.

'Capture depth' has been shown to be one of the most significant factors affecting the survival of released line-caught fish (Wilson and Burns 1996; Parker *et al.* 2006; Hannah *et al.* 2008; Sumpton *et al.* 2010). This fact, however, does not explain why daily bag limits were not violated in a similar manner to minimum legal size limits. However, smaller fish that have died from barotrauma are often used as filleted bait while at sea to target larger piscivorous reeffish, which accounts for this discrepancy. Additionally, anglers are known to frequently high-grade catches (Copes 1986; Gillis *et al.* 1995; Welch *et al.* 2008; Kristofersson and Rickertsen 2009). High-grading is a process whereby once a daily bag limit of a specific species has been reached, any larger fish caught of the same species are kept and smaller fish that had been retained earlier in the fishing outing/event are discarded. The fact that daily bag limits of several species commonly targeted by recreational and charter boat-fishers are rarely attained, particularly for pelagic gamefish species that have a daily bag limit of 10 fish per person per day (*see* Chapter 1; Fennessy *et al.* 2003), further explains the lower overall violations of the daily bag limits. Similar trends of non-compliance by recreational fishers have been recorded elsewhere in South Africa (Bennett 1992; Attwood and Bennett 1995; Brouwer *et al.* 1997; Sauer *et al.* 1997; Mann *et al.* 2002b; Fennessy *et al.* 2003; Mann *et al.* 2003; Pradervand *et al.* 2003; Mackenzie 2005; Beckley *et al.* 2008).

In contrast to the recreational and charter boat sectors, approximately half the commercial skippers interviewed did not support the minimum legal size and daily bag limits that are in place on certain fish species. This is in contrast to several other studies conducted in South Africa (Mann *et al.* 1997a; Sauer *et al.* 1997; Fennessy *et al.* 2003), where commercial skippers generally agreed with all the fishery regulations that were in place. An exception to this was in the Southern Cape, where only 29% of commercial skippers supported minimum legal size limits and 31% supported closed seasons (Sauer *et al.* 1997). It is possible that the stricter catch restrictions on several important commercial linefish species that have come about since 1994-96 (*see* Chapter 1, Table 1.2), e.g. *Atractoscion aequidens*, *Chrysoblephus anglicus*, *Argyrosomus spp.*, *Polysteganus praeorbitalis*, etc., can account for this lack of support. This point is further amplified by the fact that commercial boat linefishers rely on the linefishery as a source of income and any newly introduced catch restrictions directly affect their main source of income. As a result of the lack of support for these two fishery regulations, a large proportion of skippers admitted to disobeying them. The minimum legal size limits were the least supported with nearly all (95%) of the commercial skippers interviewed admitting to breaking this fishery regulation. Interestingly, only half of the commercial skippers interviewed admitted to violating daily bag limits. This discrepancy is explained by the fact that most of the important linefish species targeted by commercial boat-fishers do not have a daily bag limit (i.e. unlimited; *see* Chapter 1, Table 1.2), whereas minimum legal size limits apply to all sectors. Fortunately, the majority of commercial skippers did support closed seasons, marine reserves and the beach vehicle ban and did not admit to disobeying them as often as they did the minimum legal size and daily bag limits.

Overall, there seemed to be a cline-gradient from boat-fishers who fished occasionally for recreation (i.e. recreational boat-fishers) and did not know the fishery regulations very well, to those that had good knowledge of the fishery regulations and who fished on a fairly regular to permanent (i.e. charters or commercials) basis. A similar gradient between sectors was recorded by Mann *et al.* (1997a), Sauer *et al.* (1997) and Fennessy *et al.* (2003). The fact that the regulations are relatively well-known in all three sectors, but are still frequently violated is of concern. These results may partly be accounted for by the inspection frequency by EKZNW staff. Both commercial (6.11 $year^{-1}$) and recreational (4.52 $year^{-1}$) boat-fishers were inspected less frequently and subsequently violated the fishery regulations more often (Table 5.4). Charter boat-fishers on the other hand were inspected more frequently (13.01 $year^{-1}$) and subsequently violated the fishery regulations less often (Table 5.4). A similar correlation between angler compliance and inspection frequency was recorded by Sauer *et al.* (1997) and Fennessy *et al.* (2003). Interestingly, the catch inspection rate by EKZNW staff for commercial boat-fishers in 1994-96 was 2.5 times per annum, which is considerably less than the 6.11 times per annum recorded in the current study. Overall, despite the increased inspection rate recorded in this study, many boat-fishers continue to admit to disobeying many of the fishery regulations. It is apparent therefore that compliance-orientated boat inspections conducted by EKZNW are not that effective in managing the fishery. A clear example of this ineffectiveness is the fact that commercial boat-fishers launch far more than charter boat-fishers do but are inspected less frequently. The fact that a large proportion of skippers interviewed stressed that policing by EKZNW was ineffective further supports this observation (*see* below). However, it is also possible that the lack of compliance recorded in this study is related to mistrust, false perceptions, misinformation and a lack of appreciation of the principles of environmental conservation.

As in the shore linefishery, the introduction of the marine recreational angling permit in 1998 has been very successful in KZN. All the charter and recreational skippers interviewed exhibited compliance with the requirement for a general recreational fishing permit, which was considerably higher than the 78.2% of skippers who were willing to pay for an annual license fee in the 1994-96 linefish survey in KZN (Mann *et al.* 1997a). Good compliance with the requirement to be in possession of a marine angling license can partly be accounted for by the fact that boat anglers can be easily inspected when returning from sea. Although frequency of boat inspections conducted by EKZNW have undoubtedly increased over the years (Maggs *et al.* 2010), it is likely that the focus of these inspections has changed to compliance with permitting requirements rather then compliance with the species-specific fishery regulations. Although 80% of skippers exhibited compliance with the requirement for the additional code 10 skipper permit, some skippers were unaware that they were required to purchase this additional permit as skipper on a vessel. It is suggested that skippers buying general angling licenses need to be made aware that they also require the code 10 skipper permit to operate a vessel at sea. This can be done at the Post Offices where the permits are sold to the public.

It is obvious from these results that a better system of law enforcement/recreational user compliance needs to be implemented. As suggested in Chapter 3, EKZNW needs to invest in better training of responsible staff, teaching them to identify common angling species correctly and ensuring that they have a thorough knowledge of the associated fishing regulations and permit requirements. In this way, those anglers that disobey fishery regulations can be brought to justice (i.e. extensive fines and confiscation of fishing gear) and a clear example can be sent out to the rest of the fishing community. Money and assets generated can also be used to further enhance compliance along the coast as was originally intended with the development of the Marine Living Resources Fund (Marine Living Resources Act No. 18 of 1998). Although this last point is very important, it must be emphasised that until environmental courts can be opened in KZN, as they were the Western Cape during 2003/04, conviction rates are likely to remain low. This is mainly because magistrate courts are currently overburdened with more serious crimes such as murder and rape, and environmental crimes are subsequently considered less important (Moolla 2008). Furthermore, as magistrates are often unfamiliar with the environmental legislation, transgressors tend to be dealt with too leniently and are either thrown out of court on minor technicalities or receive relatively small fines that do not act as a deterrent for the rest of the fishing community (Mann 2006). Additional options that can help strengthen compliance with the MLRA in KZN include appropriate training of the judiciary, the appointment of honorary inspectors, promoting greater awareness at skiboat clubs and/or encouraging self-regulation through peer-pressure (Mann 2008). The recent publication (2010) of the magistrate's bench-book for environmental crime is a positive response in this regard.

Compared to the charter and recreational boat sectors, the commercial boat sector is relatively well managed. However, only 38 of the 51 commercial rights allocated for KZN were activated as of February 2010. The reasons for the low number of activated rights is difficult to assess but may be as a result of lower catch returns and associated increases in operating costs. In terms of the Traditional Linefish Policy, commercial operators are now allowed to obtain up to 50% of their gross annual income from sources other than commercial fishing. This fact has allowed many commercial boat-fishers to continue operating when they would otherwise have been forced to stop fishing with decreasing catches (i.e. bio-economic equilibrium; Clark 1985). Although this has serious implications for the sustainability of linefish resources since subsidised fishing can lead to overfishing, the strict evaluative/exclusionary criteria of the rights allocation process compensates for this problem. For instance, the commercial rights allocation process excludes individuals who have applied to enter the fishery in order to gain financial benefit without direct involvement in the main activities associated with exploiting linefish resources. Furthermore, rights holders are regularly assessed (i.e. after one year and thereafter every three years) with regard to their performance in the linefishery. This ensures that the objectives of the fishery are being met and that management methodologies and procedures remain current and suitable for the fishery. It is advisable that MCM continues with its rigorous management of this sector, but reviews several aspects such as transformation and registration of crew.

It must be noted that one of the biggest threats to the linefish resources of KZN is the large number of recreational and charter boat-fishers that operate along the coast using similar gear, targeting the same species as commercial fishermen and whom sell their catch (Mann *et al.* 2001). Surprisingly, only three recreational and no charter skippers admitted to selling their catch in the current study, which is far less than the 54% who admitted to selling their catch in 1994-96 (Mann *et al.* 1997a). However, the actual number of recreational and charter boat-fishers that do sell their catch is likely to be far higher considering that many boat-fishers would not admit to selling their catch in face-to-face interviews. Furthermore, some commercial right holders also operate a charter boat and therefore sell fish caught during the charted fishing trips under their commercial right. This has serious implications for management of the resource given that commercial boat fishing can then be subsidised at certain times of the year, ultimately putting greater fishing pressure on an already depressed fishery. A similar problem was identified by Mann *et al.* (2001). Overall, prohibition of sale of fish by recreational and charter boat-fishers is extremely difficult to enforce and many fishers believe that the sale of fish should be legalised, especially considering rising costs involved in going fishing. Fortunately, several initiatives to curtail this problem have been introduced. One of these is the South African Sustainable Seafood Initiative (SASSI), which aims at empowering the consumer and making them aware of which species not to buy, either because they are classed as recreational 'no-sale' species or because they are biologically vulnerable to overexploitation. One of the major aims of this initiative is to promote voluntary compliance of the law through education and awareness. Initiatives such as these are vital management tools that can facilitate compliance in the fishery, firstly through education and secondly through empowering the public/consumers and making them, in a sense, the largest 'watch dogs' of illegal activities. Other options the are available to curtail this problem include: banning of night fishing for recreational boat-fishers because this is when many of them target aggregations of *A. aequidens* and *Argyrosomus spp.* for financial gain (*see* Mann *et al.* 2001 and Mann 2008); introduction of a fish marking technique (i.e. pectoral fin removal) for recreational/charter boat-fishers to deter unregulated black market sale of fish, such as that which has been implemented in Australia; and introduction of illegal activity hotline numbers. Although EKZNW has initiated a hotline number to report illegal activities, such as poaching, it became apparent during the study that this appears to have been largely unsuccessful due to a lack of effective response.

The questionnaire survey provided a unique opportunity to assess whether boat anglers fish less nowadays than before and for what reasons. Only a relatively small percentage (34%) of anglers stated that they did fish less nowadays than before, with climate change/weather being the most common reason given. This is obviously because the boat-based linefishery is far more reliant on weather/fishing conditions, especially since the majority of the launch sites on the KZN coast are open surf launches. Hecht (1993) showed that the exposed nature of several launch sites (i.e. more susceptible to inclement weather conditions) in the Port Alfred linefishery limits the number of fishing days. Furthermore, the results presented above on launching rates within each sector illustrate that recreationals fish nearly once every month, charter-boats go to sea every fishable weekend day and commercials go to sea most fishable days. Thus, the overall impression is that effort is at a maximum and will only increase with new intrants into the fishery.

As in the shore linefishery, many anglers also stated that ‘work/family commitments’ had prevented them from going fishing as much as they used to. This response is likely explained by the economic recession that has affected the South African economy since 2007 (Arieff *et al.* 2010). This point is particularly important in the offshore boat-based linefishery since costs associated with going fishing are generally greater than those in the shore linefishery (McGrath *et al.* 1997; Mann *et al.* 2001; Pradervand and van der Elst 2008). The fact that the higher costs involved in going fishing was the third most important response given by boat-fishers, confirms this point. Although there have been several changes to the management of the offshore boat-based linefishery over the past 12 years (*see* Chapter 1), this does not seem to have deterred boat-fishers from going fishing. As predicted by McGrath *et al.* (1997), it seems that anglers do not simply stop fishing when certain regulations or changes in licensing are introduced. This is especially important to managers since they need to be aware of how the social behaviour of anglers will be affected when various linefish regulations are implemented. A classic example of this was with the introduction of an angling permit in South Africa in 1998. The lessoned learned is that unless there are a limited number of permits available, such as currently in the commercial boat sector, boat angling effort is unlikely to be reduced (Brouwer *et al.* 1997; McGrath *et al.* 1997; Sauer *et al.* 1997).

The majority of recreational and charter skippers interviewed felt that fishing had deteriorated over the years. This was in contrast to commercial skippers, where only 60% agreed that catches had declined. Overall, there has been little change in reasons given for why fishing has deteriorated since 1994-96 (Mann *et al.* 1997a). Interestingly, half the commercial skippers interviewed believed that climate change was responsible for the observed decrease in fish abundance over the years. However, such a statement needs to be further investigated, particularly since climate change has been shown to have strong effects on aquatic ecosystems (Harder *et al.* 1995; Southward *et al.* 1995; Anderson and Piatt 1999; O'Reilly *et al.* 2003; Clark 2006; Portner and Knust 2007). Contrastingly, it can be argued that many fishers are unable to distinguish between environmental cycles and climate change and related changes in catch. There is strong evidence that linefish catches in KZN and other subtropical regions go though numerous short and long-term cycles (Govender 1992; Lamberth *et al.* 2009). This therefore may explain the lower catches, which many anglers perceive is as a result of climate change.

Interestingly, during interviews a large number of skippers, particularly from the charter and commercial boat sectors, complained about the large number of hooked linefish that are being consumed by sharks. The majority of these skippers stated that the problem had become worse over the years and was most prevalent during the winter and spring months. This is a serious issue and could be a clear sign of an imbalance in the ecosystem caused from overfishing. Possible reasons for the increased shark activity include habituation (e.g. shark feeding) by the diving industry, oceanographical changes, prey scarcity and optimal foraging (line tethered fish are easier to catch). There is no easy solution to this problem and simply culling the responsible shark species (e.g. *Carcharhinus limbatus*, *C. brevipinna*, *C. obscurus*, etc.) will cause further damage to the ecosystem and have a detrimental affect on the growing shark diving industry, such as that of Aliwal Shoal (Dicken and Hosking 2009). Similar human and 'top predator' conflicts have been highlighted in the hake fishery of the Benguela ecosystem (Yodzis 2001) and fish yields with whales off Japan (Gerber *et al.* 2009). It is recommended that MCM should address this contentious issue, especially since several shark-culling fishing competitions have been proposed by affected anglers.

5.4.4. Conclusion

In general, the socio-economic characteristics of the KZN offshore boat-based linefishery have changed very little since the last national linefish assessment in 1994-96. This correlates directly with the total participation, which, barring a shift between the commercial and charter boat sectors, has also changed very little over the past 12 years. One concern, which was also raised in Chapter 4, is that of the charter boat sector. This sector, if not managed correctly has serious implications for management of the resource and its closely competing sectors. An overwhelming majority of boat anglers believe that fishing has deteriorated over the years, which is a worrying concern, especially since several important linefish species (e.g. *S. commerson, A. thorpei, A. japonicus, A. aequidens*) have shown decreases in CPUE values and there have been changes in catch composition (*see* Chapter 4). It is clear that improved management action is urgently needed. Considering that there are only a limited number of sites where boat-fishers can launch from, effective management of the offshore boat-based linefishery should not be that difficult to achieve. Effective enforcement of the fishing regulations by well-trained EKZNW staff, coupled with improved awareness of the fishers themselves is key to getting it right. Recommendations are discussed in Chapter 6 and 7.

CHAPTER 6

COMPARISONS WITH THE NATIONAL MARINE LINEFISH SYSTEM (NMLS)

6.1. INTRODUCTION

Efforts to collect long-term catch and effort data from the South African linefishery began in the early 1970's with the development of separate commercial and recreational catch and effort data-collection systems in the Cape and KwaZulu-Natal (KZN) respectively (Mann-Lang 1996; Penney 1997; Sauer *et al.* 1997). Early commercial data sources included basic catch and effort information obtained from Cape fisheries harbours, purchase records from major linefish dealers and voluntary monthly catch returns from a few fishing areas that did not have fisheries harbours (Penney 1997; Sauer *et al.* 1997). In contrast, the recreational catch and effort data was obtained from voluntary catch logs or cards from clubs or individuals, and from angling competition returns from the various recreational facets (e.g. KwaZulu-Natal Coast Anglers Union (KZNCAU)). Both the initial commercial and recreational data collection initiatives had valuable data that needed to be combined, analysed and compared. This fuelled the development of the National Marine Linefish System (NMLS), which has become a highly successful data collection tool providing valuable long-term catch and effort data that has been used to monitor the linefishery. In 1984 Ezemvelo KwaZulu-Natal Wildlife (EKZNW) began compliance orientated shore patrols, which later (1986) included skiboat inspections as well (Mann-Lang 1996; Penney 1997; Sauer *et al.* 1997). The implementation of data collection procedures on these compliance-oriented patrols/inspections has become the basis of data collected for the recreational linefishery in KZN (Maggs *et al.* 2010). Similarly, catch and effort data for the commercial linefishery is currently collected through mandatory catch returns submitted by the commercial operators to MCM and captured onto the NMLS.

However, over the years the NMLS has been heavily criticised in terms of its accuracy and reliability for making management decisions (Adams 1980; Hughs 1989; Mann-Lang 1996; Sauer *et al.* 1997; Penney *et al.* 1999; Everett 2004; Singh 2004; Jairam 2005). It was partly for this reason that the first national marine linefish survey was conducted in 1994-96 (*see* Chapter 1). This survey generated information and recommendations that were valuable for improving management systems. One notable recommendation was that a national survey should be repeated periodically to validate the NMLS catch and effort data in light of several proposed improvements to the system. It has now been over 12 years since the last national linefish survey was completed and since any meaningful validation of the NMLS has been conducted.

Although several studies have analysed aspects of the NMLS in recent years (e.g. Everett 2004; Singh 2004; Jairam 2005), none have done so on a national or regional basis. Considering the overall lack of validation of the NMLS catch and effort data over the past few years, the aim of this chapter was: (1) to compare catch and effort data obtained in this study to recreational catch and effort data collected by EKZNW (shore patrols and skiboat inspections) and to compare commercial catch and effort data collected in this study with the mandatory commercial NMLS catch returns; and (2) to identify any biases/differences between the two data collection initiatives; and (3) make recommendations towards improving long-term monitoring of the KZN linefishery.

6.2. MATERIALS AND METHODS

It is recommended that readers refer to the following publications for a detailed description of the methods used by EKZNW to conduct shore patrols and skiboat inspections (Mann-Lang 1996; Penney 1997; Maggs 2010).

6.2.1. Shore linefishery

To compare and evaluate the accuracy of the data collected by EKZNW, results collected during roving creel surveys (RCS) conducted in this study (*see* Chapter 2) were compared to shore patrols conducted by EKZNW in the same zones. EKZNW shore patrol data were therefore extracted from the NMLS for the period January 2009-December 2009. It must be noted that data were extracted after the compilation of the 2009 NMLS annual report (Maggs *et al.* 2010) and hence there are several differences between the 2009 annual report and values reported in this chapter. The main reason for this discrepancy is because some shore patrols were entered into the NMLS database after the initial data extraction process for the 2009 annual report (*see* Maggs *et al.* 2010). Although the sampling period in the current study started in February 2009 and ended in January 2010, data from the NMLS was extracted for 2009 only since many shore patrol forms for January 2010 had not been received/entered yet.

To make reliable comparisons between the two data sources (i.e. shore patrols from the current study and by EKZNW), several sampling related parameters were chosen. These included: total number of patrols, total distance patrolled, mean distance patrolled (averaged per patrol), anglers.km^{-1} (averaged per patrol), total time on patrol, mean time on patrol (averaged per patrol), total number of anglers checked, number of fish recorded (including released fish), number of fish per angler inspected and number of species recorded. Further comparisons were made between the number of shore patrols done spatially and temporally, CPUE (fish.angler^{-1}.hour^{-1}) and catch composition.

After initial comparison of the results between the two different data sets (Table 6.1), it became apparent there were a number of sampling biases that could account for large discrepancies between the results. For example, the BN and SD zones were poorly sampled in the current RCS compared to EKZNW patrols (*see* Chapter 2) and therefore accounted for the major differences in CPUE and catch compositions between the two data sets. Thus, to account for any biases caused by inadequate sampling coverage in the current study, several zones were excluded from the analysis. These included the BN, SD, MP, RB and TG zones. During data analysis, it also became apparent that EKZNW sometimes patrolled the UV and UT zones as one zone. To resolve this problem these two zones were also excluded from the overall analysis between the two datasets.

6.2.2. Offshore boat-based linefishery

Recreational and charter boat linefisheries

To compare and evaluate the accuracy of the data collected by EKZNW, results collected during access-points surveys (APS) conducted in this study (*see* Chapter 4) were compared to skiboat inspections conducted by EKZNW. EKZNW skiboat inspection data was extracted from the NMLS for the period January-December 2009.

As in the shore linefishery, several parameters were chosen to make reliable comparisons between the two data sets. These included the total number of launch sites visited, the total number of APS (also known as launch site visits) completed at specific launch sites, total number of boats inspected, average number of boats inspected per APS, number of fish recorded, number of species recoded and CPUE. Launch site inspection frequency between the two data sets was also compared. Note that the overall results from recreational and charter boat inspections from the current study (*see* Chapter 4) were combined since EKZNW skiboat inspections do not distinguish between the recreational and charter boat sectors. Furthermore, CPUE estimates in terms of weight calculated from EKZNW skiboat inspections are likely to be an under representation of actual CPUE since several EKZNW staff failed to record the weight of fish caught on the boat inspection forms. Since there are approximately 45 skiboat launch sites and most of the highly utilised sites were well sampled in the current study (*see* Chapter 4), comparisons between results collected in this study with those of EKZNW skiboat inspections were done on a regional scale.

Commercial boat linefishery

Unlike the recreational linefishery, commercial catch and effort data is collected through mandatory catch returns submitted by the commercial operators to MCM. To evaluate the accuracy of these mandatory catch returns, catch and effort data from the current study (APS) were compared with catch returns submitted to the NMLS for selected vessels checked on a specific date. A similar approach as described in Sauer *et al.* (1997) was chosen, whereby data on the NMLS was checked seven days either side of the date of the APS to allow for incorrect data reporting by the commercial operator. Furthermore, data were subdivided into three categories:

(1) records for a specific vessel with a catch registered during the APS, but where the NMLS data were either zero or missing;
(2) records for a specific vessel with a catch registered during the APS and a catch recorded on the NMLS;
(3) records for a specific vessel with a catch reported on the NMLS, but no catch was recorded during the APS.

Once data was subdivided, only catch records with a catch registered during the APS and a catch recorded on the NMLS (*see* point 2 above) were further analysed. This procedure allowed for the direct comparison of specific boat outings recorded during this study to those recorded by the commercial operators. Using this remaining data, CPUE and catch composition was presented. Unfortunately, due to the time constraints in the current study, data was only analysed on a regional scale and not on a per area or species level. All instances where catch records were missing or zero in the NMLS (*see* point 1 above) and/or the APS (*see* point 3 above) were recorded as they effectively represent the degree of under and over-reporting respectively. However, correction values for the degree of possible under/over-reporting were not calculated.

6.3. RESULTS

6.3.1. Shore linefishery

Summaries of the shore patrol results from this study (RCS) and those conducted by EKZNW during 2009 are shown in Table 6.1. The mean distance patrolled during this study (4.8 ±3.0

km.patrol^{-1}), was higher than the average distance patrolled by EKZNW (3.0 ±5.5 km.patrol^{-1}) (Table 6.1). Consequently, the average number of anglers checked per kilometre was considerably higher on EKZNW shore patrols (9.2 ±19.0 anglers.km^{-1}) compared to those done in the current study (3.7 ±7.3 anglers.km^{-1}) (Table 6.1). In contrast to the mean distance patrolled, the average time spent on patrol was higher on EKZNW shore patrols (1.3 ±1.7 hours.patrol^{-1}) than in the current study (1.1 ±0.7 hours.patrol^{-1}) (Table 6.1). However, the average number of fish recorded per angler checked on patrol in the current study (0.6 fish.angler^{-1}) was similar to that recorded in EKZNW shore patrols (0.5 fish.angler^{-1}) (Table 6.1). Similarly, average CPUE in the current study (0.2 ±0.3 fish.angler^{-1}.hour^{-1}) was similar to that recorded in EKZNW shore patrols (0.2 ±0.5 fish.angler^{-1}.hour^{-1}) (Table 6.1). However, it must be noted that some EKZNW patrol officers often record fish that are ‘released’ onto the shore patrol forms and therefore the actual number of fish recorded per angler and CPUE calculated from EKZNW shore patrols may be an overestimate of actual harvest rates. This is in contrast to the current study where CPUE was calculated only on the number of fish kept per angler. This bias needs to be addressed, especially if long-term CPUE trends from the NMLS are going to be used as stock status indicators (*see* Griffiths *et al.* 1999).

Spatially, the number of patrols done by EKZNW seem to be focussed at certain access points, with some zones having wide spatial coverage (e.g. BN, SD, TG, BT) and other zones having more limited spatial coverage (e.g. UT, UV and TF) (Fig. 6.1). Spatial coverage in the current study was more uniform with fairly consistent patrolling effort in each zone (with exception of the BN and SD zones; *see* Chapter 2). A more detailed description of sampling effort in each zone is provided below.

Temporally, most of the EKZNW shore patrols were started in the morning (07h00-11h00) and ended at around midday (11h00-12h00) (Fig. 6.2). Although some patrols were started in the afternoon, the majority were finished at or before 16h00. There were a few night patrols conducted between 18h00 and 02h00, but no patrols were recorded between 02h00 and 05h00. In contrast, the current study had an equal number of patrols conducted in the morning and afternoon, with most sampling effort being conducted during the midday (10h00-14h00). No night patrols were conducted during the current study for safety reasons.

Table 6.1- A comparison between the results of shore patrols conducted in KZN during this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	406	12599
Total distance patrolled (km)	1967	37405
Mean distance patrolled (km)	4.8(3.0)	3.0(5.5)
Anglers.km^{-1*}	3.7(7.3)	9.2(19.0)
Time on patrol (hours)	474.6	16370
Mean time on patrol (hours)	1.1(0.7)	1.3(1.7)
Number of anglers checked	5048	104226
Number of fish recorded	4933	50668
Number of fish recorded per angler	0.6	0.5
Number of species recorded	84	105
CPUE (fish.angler^{-1}.hour^{-1})*	0.17(0.32)	0.16(0.45)

*Averaged per patrol

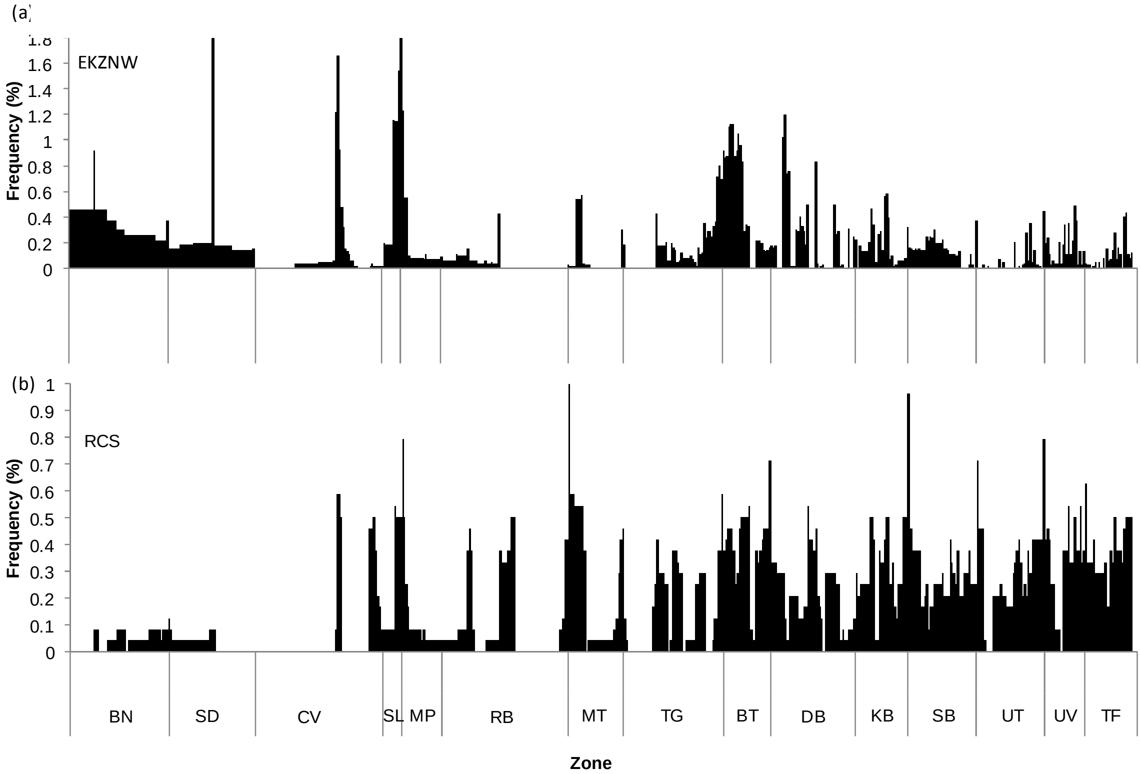


Figure 6.1- A spatial comparison between shore patrols conducted in KZN from this study (RCS) and those by EKZNW during 2009-10.

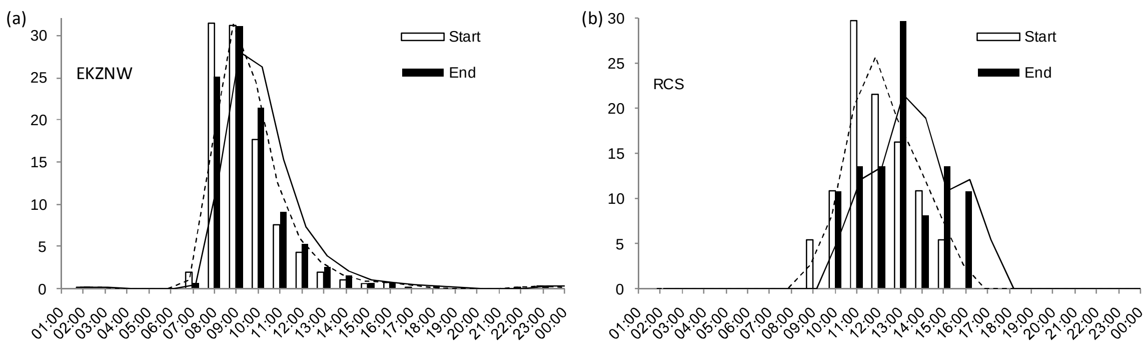


Figure 6.2- A temporal comparison between shore patrols conducted in KZN from this study (RCS) and those by EKZNW during 2009-10.

There were many differences in overall catch composition recorded between this study (RCS) and the EKZNW shore patrol data (Table 6.2). Most notably were the different percentage contributions of *Sarpa salpa* and *Pomatomus saltatrix* between the two data sets. In the current study, *S. salpa* was the most important shore linefish species, contributing 35% of the catch by number, while *P. saltatrix* made up only 15%. In contrast, in EKZNW shore patrol data, *P. saltatrix* made up 42% of the catch by number, while *S. salpa* made up only 19%. Another major difference between the two datasets was the fact that *Neoscorpis lithophilus* made up 4% of the catch in EKZNW shore patrol data, while in the current study this was far less. Similarly, *R. holubi* made up 5% of the catch in the current study, while it was far less important in EKZNW shore patrol data. Interestingly, the percentage contribution of "OTHER" species in the current study was far higher than that in EKZNW shore patrol data. Overall, the main difference in catch composition between the two datasets was the non-reporting of less well-known fish species by EKZNW.

Table 6.2- Overall catch composition in KZN from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		NMLS	
Overall		Overall	
84 species 4933 fish		105 species 50668 fish	
Sarpa salpa	35%	*Pomatomus saltatrix*	42%
Pomatomus saltatrix	15%	*Sarpa salpa*	19%
Diplodus capensis	15%	*Diplodus capensis*	15%
Pomadasys olivaceum	7%	*Pomadasys olivaceum*	4%
Rhabdosargus holubi	5%	*Neoscorpis lithophilus*	4%
OTHER	24%	OTHER	16%

Overall, although sampling effort by EKZNW was far higher than that achieved in the current study, there are some strong similarities in results obtained between the two datasets. However, a more detailed comparison of results is needed to understand similarities and differences on a zonal scale. For this reason, summaries of shore patrol results for eight of the 15 EKZNW zones are presented below:

Cape Vidal (CV) Zone

Results from this study and those of EKZNW shore patrols conducted in the CV zone during 2009-10 are shown in Table 6.3. The mean distance patrolled in CV during this study (2.6 ±1.2 $km.patrol^{-1}$), was slightly lower than the average distance patrolled by EKZNW (2.8 ±4.7 $km.patrol^{-1}$) (Table 6.3). However, the average number of anglers checked per kilometre was twofold higher during EKZNW shore patrols (8.0 ±7.5 $anglers.km^{-1}$) compared to those done in the current study (4.1 ±4.3 $anglers.km^{-1}$) (Table 6.3). The average time spent on patrol was also higher on EKZNW shore patrols (1.8 ±0.8 $hours.patrol^{-1}$) than in the current study (0.9 ±0.7 $hours.patrol^{-1}$) (Table 6.3). The average number of fish recorded per angler checked in the current study (0.1 $fish.angler^{-1}$) was considerably lower than that recorded on EKZNW shore patrols (0.4 $fish.angler^{-1}$) (Table 6.3). Similarly, average CPUE in the current study (0.06 ±0.16 $fish.angler^{-1}.hour^{-1}$) was lower than that recorded on EKZNW shore patrols (0.11 ±0.27 $fish.angler^{-1}.hour^{-1}$) (Table 6.3).

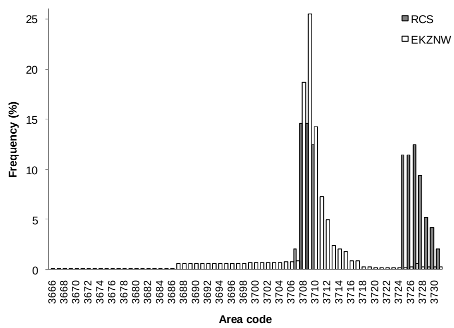
Spatially, shore patrols conduced in the CV zone by EKZNW were mainly focussed in the immediate vicinity of the beach access point (i.e. 3708-3712), with some patrols extending north to Leven Point (i.e. 3687) and south to Mission Rocks (i.e. 3727) (Fig. 6.3). It must be noted that although Mission Rocks is a popular beach access point for shore-anglers, there were few shore patrols conducted by EKZNW in this area. In contrast, the current study focussed sampling effort equally at the Cape Vidal beach access point and at Mission Rocks (Fig. 6.3). Although there was no sampling effort in the current study north of 3707 (Oscars) and between 3712 and 3724 (South Ledges), these areas are remote and difficult to access and were therefore not sampled. No shore patrols were conducted north of Leven Point (3687) as this is a sanctuary area in the St Lucia Marine Reserve where all fishing activities are prohibited.

Temporally, there was a clear bimodal sampling regime practised by EKZNW (Fig. 6.3). Most shore patrols either started in the early morning and ended before midday or started in the afternoon and ended at 16h00. In the current study, shore patrols were conducted more evenly throughout the day, with strong peaks at 10h00 and 12h00 (Fig. 6.3).

Table 6.3- A comparison between the results of shore patrols conducted in the Cape Vidal (CV) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	26	800
Total distance patrolled (km)	68	2217
Mean distance patrolled (km)	2.6(1.2)	2.8(4.7)
$Anglers.km^{-1*}$	4.1(4.3)	8.0(7.5)
Time on patrol (hours)	22.4	1443.2
Mean time on patrol (hours)	0.9(0.7)	1.8(0.8)
Number of anglers checked	228	8764
Number of fish recorded	138	3334
Number of fish recorded per angler	0.1	0.4
Number of species recorded	28	26
CPUE ($fish.angler^{-1}.hour^{-1})^*$	0.06(0.16)	0.11(0.27)

*Averaged per patrol



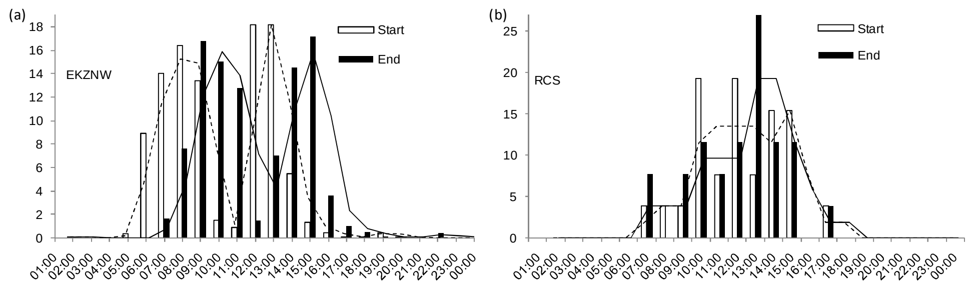


Figure 6.3- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in Cape Vidal from this study (RCS) and those by EKZNW during 2009-10.

Catch composition in the CV zone recorded in the current study was quite different to that recorded on EKZNW shore patrols (Table 6.4). In particular, *P. saltatrix* was not as important in catches in the current study as it was in EKZNW shore patrols. Furthermore, several species recorded as important by EKZNW were less important in catches in the current study. As described above, the main discrepancy between shore patrols conducted in this study and by EKZNW is the lack of reporting of less well-known fish species in the EKZNW shore patrol data.

From these comparisons, it is clear the EKZNW staff have developed an established routine of patrolling the main fishing area (i.e. the main beach access point) during the early morning and again in the early afternoon. This coincides with the most popular fishing area and times when angler numbers are highest. This also explains the high percentage of *P. saltatrix* in anglers catches as this species is frequently targeted and caught in large numbers in the bay at Cape Vidal, especially in the early morning.

Table 6.4- Catch composition in the Cape Vidal (CV) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		**NMLS**	
Cape Vidal 28 species 138 fish		Cape Vidal 26 species 3334 fish	
Trachinotus botla	19%	*Pomatomus saltatrix*	74%
Monodactylus falciformis	15%	*Trachinotus botla*	11%
Epinephelus marginatus	7%	*Diplodus capensis*	8%
Sarpa salpa	7%	*Monodactylus falciformis*	2%
Neoscorpis lithophilus	7%	*Trachinotus africanus*	1%
OTHER	45%	OTHER	4%

St Lucia (SL) Zone

A summary of comparisons between this study and EKZNW shore patrols in the SL zone during 2009-10 are shown in Table 6.5. The mean distance patrolled in the current study (4.0 ±1.4 $km.patrol^{-1}$) was slightly higher than the average distance patrolled by EKZNW (3.3 ±2.1 $km.patrol^{-1}$) (Table 6.5). The average number of anglers checked per kilometre on EKZNW shore patrols (4.7 ±4.6 $anglers.km^{-1}$) was similar to that recorded in the current study (5.2 ±5.6 $anglers.km^{-1}$) (Table 6.5). The average time spent on patrol was slightly higher on EKZNW shore patrols (1.7 ±0.9 $hours.patrol^{-1}$) than in the current study (1.3 ±0.7 $hours.patrol^{-1}$) (Table 6.5). The average number of fish recorded per angler checked in the current study (0.6 $fish.angler^{-1}$) was identical to that recorded on EKZNW shore patrols (0.6 $fish.angler^{-1}$) (Table 6.5). Similarly, average CPUE in the current study (0.18 ±0.35 $fish.angler^{-1}.hour^{-1}$) was similar to that recorded on EKZNW shore patrols (0.17 ±0.47 $fish.angler^{-1}.hour^{-1}$) (Table 6.5).

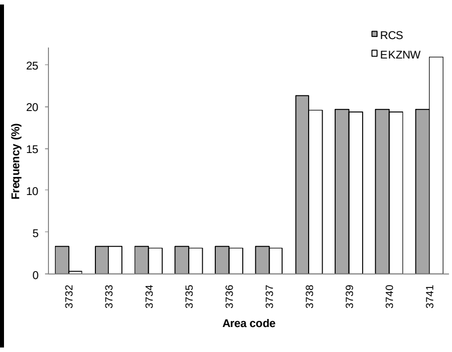
Spatially, EKZNW shore patrol effort in the SL zone was almost identical to that conducted in the current study (Fig. 6.4). The only discrepancy identified was the lack of patrols conducted in the First Rocks area by EKZNW (3732).

Temporally, as in the CV zone, there was a clear bimodal sampling regime practised by EKZNW in the SL zone. Most shore patrols were started between 08h00 and 09h00 in the morning and/or at 15h00 in the afternoon (Fig. 6.4). There was little sampling effort by EKZNW between 12h00 and 14h00. Shore patrols at SL conducted in the current study were more varied throughout the day, with a high proportion of patrols conducted in the mid morning and early afternoon.

Table 6.5- A comparison between the results of shore patrols conducted in the St Lucia (SL) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	12	731
Total distance patrolled (km)	48	2395
Mean distance patrolled (km)	4.0(1.4)	3.3(2.1)
Anglers.km^{-1*}	5.2(5.6)	4.7(4.6)
Time on patrol (hours)	16.1	1245.3
Mean time on patrol (hours)	1.3(0.7)	1.7(0.9)
Number of anglers checked	229	8604
Number of fish recorded	165	4996
Number of fish recorded per angler	0.6	0.6
Number of species recorded	17	25
CPUE (fish.angler^{-1}.hour^{-1})*	0.18(0.35)	0.17(0.47)

*Averaged per patrol



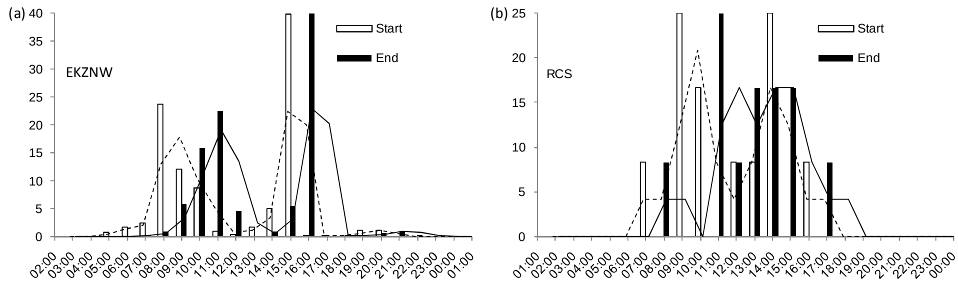


Figure 6.4- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in the St Lucia (SL) zone from this study (RCS) and those by EKZNW during 2009-10.

Catch composition recorded on shore patrols by EKZNW in the SL zone was very similar to that recorded in the current study (Table 6.6). Only *Pomadasys commersonni* seemed to be less important in catches in the current study than it was on EKZNW shore patrols. The similar catch composition recorded in this study and by EKZNW may be a direct result of the length of the entire SL zone (~7km), which enables better overall coverage.

Table 6.6- Catch composition in the St Lucia (SL) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		NMLS	
St Lucia		St Lucia	
17 species 165 fish		25 species 4996 fish	
Pomatomus saltatrix	78%	*Pomatomus saltatrix*	92%
Trachinotus botla	10%	*Lichia amia*	3%
Lichia amia	6%	*Trachinotus botla*	2%
Trachinotus africanus	3%	*Trachinotus africanus*	1%
Pomadasys furcatum	<1%	*Pomadasys commersonni*	<1%
OTHER	3%	OTHER	2%

Mtunzini (MT) Zone

A summary of comparisons between this study and EKZNW shore patrols in the MT zone during 2009-10 are shown in Table 6.7. The mean distance patrolled in the current study (5.4 ±4.0 $km.patrol^{-1}$) was double the average distance patrolled by EKZNW (2.6 ±2.0 $km.patrol^{-1}$) (Table 6.7). However, the average number of anglers checked per kilometre on EKZNW shore patrols (3.0 ±6.0 $anglers.km^{-1}$) was similar to that recorded in the current study (2.8 ±4.1 $anglers.km^{-1}$) (Table 6.7). The average time spent on patrol was higher on EKZNW shore patrols (1.2 ±1.4 $hours.patrol^{-1}$) than in the current study (0.7 ±0.5 $hours.patrol^{-1}$) (Table 6.7). The average number of fish recorded per angler checked in the current study (0.3 $fish.angler^{-1}$) was identical to that recorded on EKZNW shore patrols (0.3 $fish.angler^{-1}$) (Table 6.7). The average CPUE in the current study (0.1 ±0.31 $fish.angler^{-1}.hour^{-1}$) was slightly higher than that recorded on EKZNW shore patrols (0.08 ±0.19 $fish.angler^{-1}.hour^{-1}$) (Table 6.7).

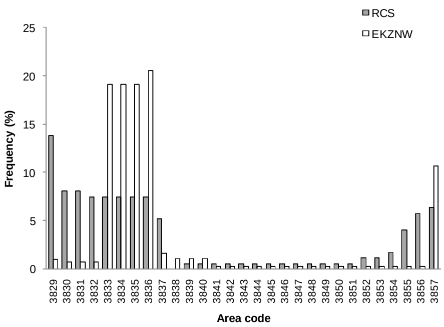
Spatially, shore patrol effort in the MT zone by EKZNW was only focussed at two areas, namely Amatikulu River Mouth (i.e. 3857) and at the Umlalazi Nature Reserve (i.e. 3833-3836) (Fig. 6.5). Although sampling effort in the current study also focused on these two areas, shore patrols were also conducted further away from the major access points where more local subsistence fishers were encountered (i.e. 3829-3832 and 3852-3856)

Temporally, the highest proportion of shore patrols by EKZNW were started in the early morning between 07h00 and 08h00 with a gradual decrease throughout the day (Fig. 6.5). A number of night patrols were also conducted. In contrast, the majority of shore patrols in the current study were started from 09h00 onwards and ended before 18h00.

Table 6.7- A comparison between the results of shore patrols conducted in the Mtunzini (MT) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	26	402
Total distance patrolled (km)	139	1033
Mean distance patrolled (km)	5.4(4.0)	2.6(2.0)
Anglers.km^{-1*}	2.8(4.1)	3.0(6.0)
Time on patrol (hours)	18.5	487.1
Mean time on patrol (hours)	0.7(0.5)	1.2(1.4)
Number of anglers checked	197	2038
Number of fish recorded	86	584
Number of fish recorded per angler	0.3	0.3
Number of species recorded	12	39
CPUE (fish.angler^{-1}.hour^{-1})*	0.1(0.31)	0.08(0.19)

*Averaged per patrol



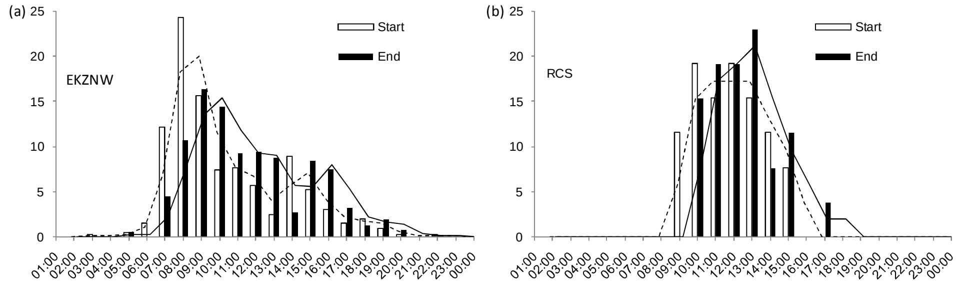


Figure 6.5- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in the Mtunzini (MT) zone from this study (RCS) and those by EKZNW during 2009-10.

Catch composition in the MT zone recorded during the current study was quite different to that recorded on EKZNW shore patrols (Table 6.8). In particular, two species (i.e. *Rhizoprionodon acutus* and *Carcharhinus obscurus*) that are usually 'released' by anglers were recorded as important in catches on EKZNW shore patrols. This highlights the fact that EKZNW staff in this zone may be recording fish that are released, which is not a true representation of harvest rates. Interestingly, *P. saltatrix* was not as important in catches on EKZNW shore patrols as it was in the current study. Furthermore, the overall number of species recorded in MT on EKZNW shore patrols was far higher than that recorded in the current study, again suggesting recording of released fish.

Table 6.8- Catch composition in the Mtunzini (MT) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		NMLS	
Mtunzini		Mtunzini	
12 species 86 fish		39 species 584 fish	
Pomatomus saltatrix	71%	*Pomatomus saltatrix*	21%
Trachinotus botla	7%	*Rhizoprionodon acutus*	14%
Rhabdosargus holubi	7%	*Trachinotus africanus*	8%
Argyrosomus thorpei	4%	*Trachinotus botla*	7%
Pomadasys commersonni	2%	*Carcharhinus obscurus*	6%
OTHER	9%	OTHER	43%

Ballito (BT) Zone

A summary of comparisons between this study and EKZNW shore patrols in the BT zone during 2009-10 are shown in Table 6.9. The average distance patrolled in the current study (5.6 ±1.8 km.patrol^{-1}) was higher than the average distance patrolled by EKZNW (4.3 ±5.6 km.patrol^{-1}) (Table 6.9). Similarly, the average number of anglers checked per kilometre in the current study (3.1 ±3.5 anglers.km^{-1}) was slightly higher than that recorded on EKZNW shore patrols (2.6 ±5.2 anglers.km^{-1}) (Table 6.9). The average time spent on patrol was also higher in the current study (1.4 ±0.6 hours.patrol^{-1}) than on EKZNW shore patrols (1.2 ±1.6 hours.patrol^{-1}) (Table 6.9). The average number of fish recorded per angler checked in the current study (0.8 fish.angler^{-1}) was similar to that recorded on EKZNW shore patrols (0.7 fish.angler^{-1}) (Table 6.9). In contrast, the average CPUE in the current study (0.23 ±0.38 fish.angler^{-1}.hour^{-1}) was higher than that recorded on EKZNW shore patrols (0.19 ±0.37 fish.angler^{-1}.hour^{-1}) (Table 6.9).

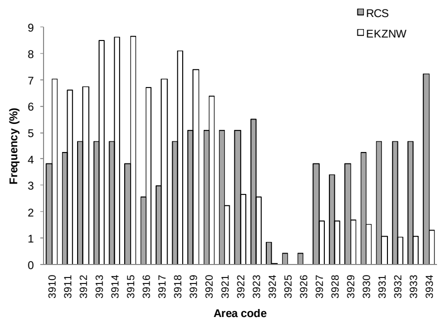
Spatially, shore patrol effort in the BT zone by EKZNW was almost identical to that conducted in the current study (Fig. 6.6). The only discrepancy being the greater frequency of patrols conducted in the current study from the Tongaat River (i.e. 3924) to Umdloti River (3934).

Temporally, shore patrols by EKZNW in the BT zone were mainly conducted in the morning and early afternoon, with a relatively high number of night patrols (Fig. 6.6). Shore patrol effort in the current study was almost identical to EKZNW, except that a larger proportion of patrols were conducted in the afternoon. No night patrols were conducted in the current study.

Table 6.9- A comparison between the results of shore patrols conducted in the Ballito (BT) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	36	1347
Total distance patrolled (km)	202	5752.5
Mean distance patrolled (km)	5.6(1.8)	4.3(5.6)
Anglers.km^{-1*}	3.1(3.5)	2.6(5.2)
Time on patrol (hours)	49.2	1593.4
Mean time on patrol (hours)	1.4(0.6)	1.2(1.6)
Number of anglers checked	537	10162
Number of fish recorded	653	7497
Number of fish recorded per angler	0.8	0.7
Number of species recorded	30	34
CPUE (fish.angler^{-1}.hour^{-1})*	0.23(0.38)	0.19(0.37)

*Averaged per patrol



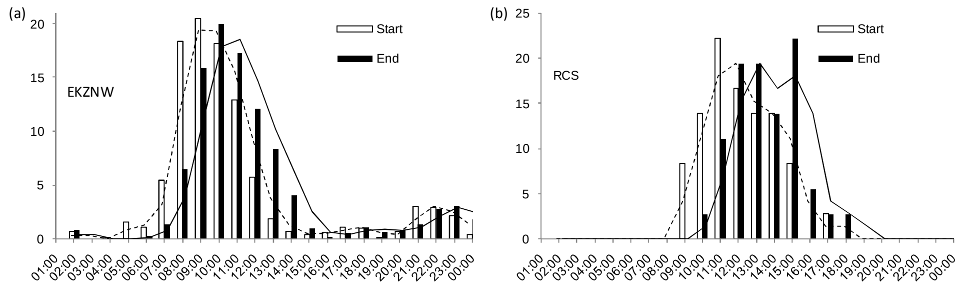


Figure 6.6- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in the Ballito (BT) zone from this study (RCS) and those by EKZNW during 2009-10.

Catch composition recorded on shore patrols by EKZNW in the BT zone were very similar to that recorded in the current study (Table 6.10). However, *P. saltatrix* and *Liza spp.* were more important in catches recorded by EKZNW than they were in the current study. Similarly, *Kuhlia mugil* and *Monodactylus falciformis* were more important in the current study than they were in EKZNW shore patrols. Less well-known fish species again seemed to be under-reported in EKZNW shore patrols.

Table 6.10- Catch composition in the Ballito (BT) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		NMLS	
Ballito		Ballito	
30 species 653 fish		34 species 7497 fish	
Sarpa salpa	55%	*Sarpa salpa*	47%
Diplodus capensis	20%	*Diplodus capensis*	30%
Monodactylus falciformis	7%	*Pomatomus saltatrix*	9%
Neoscorpis lithophilus	6%	*Neoscorpis lithophilus*	5%
Kuhlia mugil	3%	*Liza spp*	2%
OTHER	9%	OTHER	8%

Durban (DB) Zone

A summary of comparisons between this study and EKZNW shore patrols in the DB zone during 2009-10 are shown in Table 6.11. The mean distance patrolled in the current study (5.8 ±2.7 $km.patrol^{-1}$) was considerably higher than the average distance patrolled by EKZNW (1.6 ±0.9 $km.patrol^{-1}$) (Table 6.11). Similarly, the average number of anglers checked per kilometre in the current study (7.9 ±17.2 $anglers.km^{-1}$) was higher than that recorded on EKZNW shore patrols (5.5 ±5.9 $anglers.km^{-1}$) (Table 6.11). The average time spent on patrol was also higher in the current study (1.5 ±0.6 $hours.patrol^{-1}$) than on EKZNW shore patrols (1.0±1.5 $hours.patrol^{-1}$) (Table 6.11). The average number of fish recorded per angler checked in the current study (0.7 $fish.angler^{-1}$) was more than double that recorded on EKZNW shore patrols (0.3 $fish.angler^{-1}$) (Table 6.11). Similarly, the average CPUE in the current study (0.17 ±0.19 $fish.angler^{-1}.hour^{-1}$) was higher than that recorded on EKZNW shore patrols (0.12 ±0.44 $fish.angler^{-1}.hour^{-1}$) (Table 6.11).

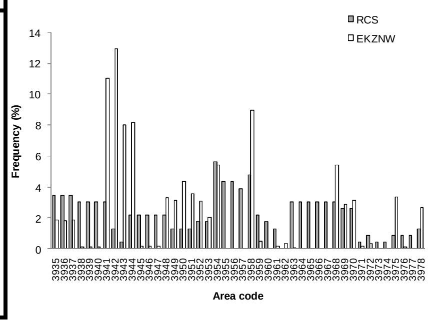
Spatially, shore patrol effort in the DB zone by EKZNW was very focussed at popular beach access points, such as Umhlanga (i.e. 3941-3944), Blue Lagoon (i.e. 3954), Durban piers (i.e. 3958/9) and Ansteys (i.e. 3968) (Fig. 6.7). In contrast, shore patrol effort in the current study was more evenly distributed across the whole of the Durban zone.

Temporally, shore sampling effort by EKZNW in the DB zone was evenly distributed throughout the day with some night patrols (Fig. 6.7). Although no night patrols were conducted in the current study, the remainder of the sampling effort for the Durban zone was identical to that of EKZNW.

Table 6.11- A comparison between the results of shore patrols conducted in the Durban (DB) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	35	2049
Total distance patrolled (km)	202	3250
Mean distance patrolled (km)	5.8(2.7)	1.6(0.9)
Anglers.km^{-1*}	7.9(17.2)	5.5(5.9)
Time on patrol (hours)	53.7	2037.32
Mean time on patrol (hours)	1.5(0.6)	1.0(1.5)
Number of anglers checked	902	15863
Number of fish recorded	967	5251
Number of fish recorded per angler	0.7	0.3
Number of species recorded	42	49
CPUE (fish.angler^{-1}.hour^{-1})*	0.17(0.19)	0.12(0.44)

*Averaged per patrol



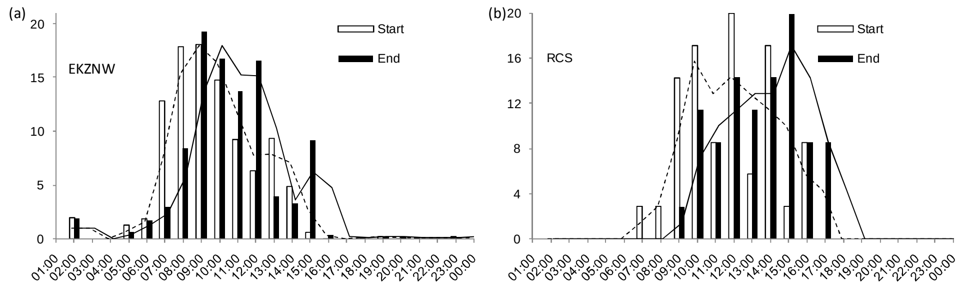


Figure 6.7- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in the Durban (DB) zone from this study (RCS) and those by EKZNW during 2009-10.

Catch composition in the DB zone recorded on shore patrols conducted by EKZNW were similar to that recorded in the current study (Table 6.12). As in most of the other zones described, *P. saltatrix* was more important in catches recorded by EKZNW than they were in the current study. *Pagellus bellottii natalensis* was also more important in catches on EKZNW shore patrols. This was because of the high sampling effort on the Durban piers where this fish species is mostly caught. A similar bias was recorded by Joubert (1981a) on south pier. Although *S. salpa* was the most numerous species in both data sets, it made up a much higher percentage contribution in the current study. Interestingly, *Pomadasys olivaceum* was not as important in catches in EKZNW shore patrol data as it was in the current study. This was despite relatively high numbers of this species being recorded on the Durban piers in the current study. This again confirms the fact that less well-known fish species are not frequently recorded by EKZNW.

Table 6.12- Catch composition in the Durban (DB) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		NMLS	
Durban 42 species 967 fish		Durban 49 species 5251 fish	
Sarpa salpa	41%	*Sarpa salpa*	29%
Pomadasys olivaceum	12%	*Diplodus capensis*	18%
Diplodus capensis	9%	*Pomatomus saltatrix*	14%
Monodactylus falciformis	8%	*Pagellus bellottii natalensis*	8%
Pomatomus saltatrix	7%	*Monodactylus falciformis*	5%
OTHER	23%	OTHER	26%

Kingsburgh (KB) Zone

A summary of comparisons between this study and EKZNW shore patrols in the KB zone during 2009-10 are shown in Table 6.13. The mean distance patrolled in the current study (4.8 ±2.6 km.patrol^{-1}) was considerably higher than the average distance patrolled by EKZNW (1.9 ±1.5 km.patrol^{-1}) (Table 6.13). In contrast, the average number of anglers checked per kilometre in the current study (5.9 ±12.2 anglers.km^{-1}) was considerably lower than that recorded on EKZNW shore patrols (15.2 ±16.0 anglers.km^{-1}) (Table 6.13). The average time spent on patrol was higher in the current study (1.3 ±0.9 hours.patrol^{-1}) than on EKZNW shore patrols (1.0 ±1.2 hours.patrol^{-1}) (Table 6.13). The average number of fish recorded per angler checked in the current study (0.8 fish.angler^{-1}) was more than twofold higher than that recorded on EKZNW shore patrols (0.3 fish.angler^{-1}) (Table 6.13). Similarly, the average CPUE in the current study (0.14 ±0.20 fish.angler^{-1}.hour^{-1}) was higher than that recorded on EKZNW shore patrols (0.12 ±0.32 fish.angler^{-1}.hour^{-1}) (Table 6.13).

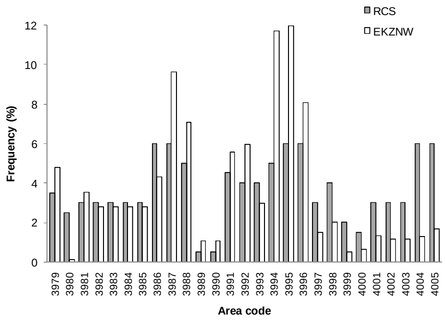
Spatially, shore patrol effort in the KB zone by EKZNW was very similar to the shore patrol effort in the current study, with a large majority of the effort focused around popular access points such as Nyoni Rocks (3987-3988) and Winkelspruit (3994-3996) (Fig. 6.8). The only discrepancy was the lack of shore patrol effort by EKZNW at 3980 (Mbokodweni River).

Temporally, shore patrols by EKZNW in the KB zone were mainly conducted in the morning and early afternoon (Fig. 6.8). Shore patrol effort in the current study was similar to EKZNW, but with a larger proportion of patrols conducted in the afternoon.

Table 6.13- A comparison between the results of shore patrols conducted in the Kingsburgh (KB) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	36	812
Total distance patrolled (km)	174	1556
Mean distance patrolled (km)	4.8(2.6)	1.9(1.5)
Anglers.km^{-1*}	5.9(12.2)	15.2(16.0)
Time on patrol (hours)	47.4	787.3
Mean time on patrol (hours)	1.3(0.9)	1.0(1.2)
Number of anglers checked	615	18352
Number of fish recorded	911	5001
Number of fish recorded per angler	0.8	0.3
Number of species recorded	30	22
CPUE (fish.angler^{-1}.hour^{-1})*	0.14(0.20)	0.12(0.32)

*Averaged per patrol



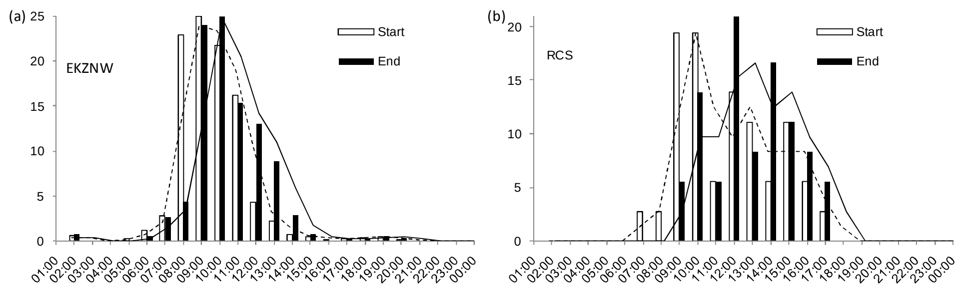


Figure 6.8- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in the Kingsburgh (KB) zone from this study (RCS) and those by EKZNW during 2009-10.

Catch composition in the KB zone recorded on shore patrols by EKZNW was almost identical to that recorded in the current study (Table 6.14). The only discrepancy was the lower relative abundance of *Rhabdosargus holubi* and the higher relative abundance of *Monodactylus falciformis* in the EKZNW shore patrol data compared to the current study.

Table 6.14- Catch composition in the Kingsburgh (KB) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		NMLS	
Kingsburgh		Kingsburgh	
30 species 911 fish		49 species 5251 fish	
Pomatomus saltatrix	29%	*Pomatomus saltatrix*	27%
Sarpa salpa	21%	*Sarpa salpa*	24%
Diplodus capensis	17%	*Diplodus capensis*	21%
Pomadasys olivaceum	15%	*Pomadasys olivaceum*	13%
Rhabdosargus holubi	8%	*Monodactylus falciformis*	5%
OTHER	10%	OTHER	11%

Scottburgh (SB) zone

A summary of comparisons between this study and EKZNW shore patrols in the SB zone during 2009-10 are shown in Table 6.15. The mean distance patrolled in the current study (6.0 ±2.7 $km.patrol^{-1}$) was similar to the average distance patrolled by EKZNW (6.4 ±9.5 $km.patrol^{-1}$) (Table 6.15). The average number of anglers checked per kilometre in the current study (3.5 ±4.9 $anglers.km^{-1}$) was considerably lower than that recorded on EKZNW shore patrols (9.8 ±16.2 $anglers.km^{-1}$) (Table 6.15). Similarly, the average time spent on patrol was considerably lower in the current study (1.6 ±0.9 $hours.patrol^{-1}$) than on EKZNW shore patrols (3.4 ±2.7 $hours.patrol^{-1}$) (Table 6.15). Surprisingly, the average number of fish recorded per angler checked in the current study (0.8 $fish.angler^{-1}$) was double that recorded on EKZNW shore patrols (0.4 $fish.angler^{-1}$) (Table 6.15). Similarly, the average CPUE in the current study (0.18 ±0.33 $fish.angler^{-1}.hour^{-1}$) was higher than that recorded on EKZNW shore patrols (0.13 ±0.65 $fish.angler^{-1}.hour^{-1}$) (Table 6.15).

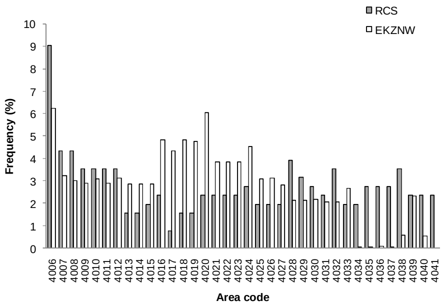
Spatially, shore patrol effort in the SB zone by EKZNW was very similar to the shore patrol effort in the current study, with a large majority of the patrolling effort focused around popular access points such as Umkomaas River (4006) and Park Rynie (4020) (Fig. 6.9). There was however, a distinct lack of EKZNW shore patrol effort from 4034 to 4041 (i.e. Bazley to Ifafa).

Temporally, EKZNW shore patrols in the SB zone were mainly started in the morning (i.e. 08h00) and ended some time in the afternoon (i.e. 14h00) (Fig. 6.9). This potentially represents a bias in the EKZNW shore patrol data with few patrols being conducted before 08h00 and after 14h00. In contrast, shore patrol effort in the current study was temporally more varied, with patrols of different duration and often ending later than 18h00 (Fig. 6.8).

Table 6.15- A comparison between the results of shore patrols conducted in the Scottburgh (SB) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	35	326
Total distance patrolled (km)	211	2093
Mean distance patrolled (km)	6.0(2.7)	6.4(9.5)
Anglers.km^{-1*}	3.5(4.9)	9.8(16.3)
Time on patrol (hours)	52.9	1090.7
Mean time on patrol (hours)	1.6(0.85)	3.4(2.74)
Number of anglers checked	571	2756
Number of fish recorded	722	1064
Number of fish recorded per angler	0.8	0.4
Number of species recorded	31	22
CPUE (fish.angler^{-1}.hour^{-1})*	0.18(0.33)	0.13(0.65)

*Averaged per patrol



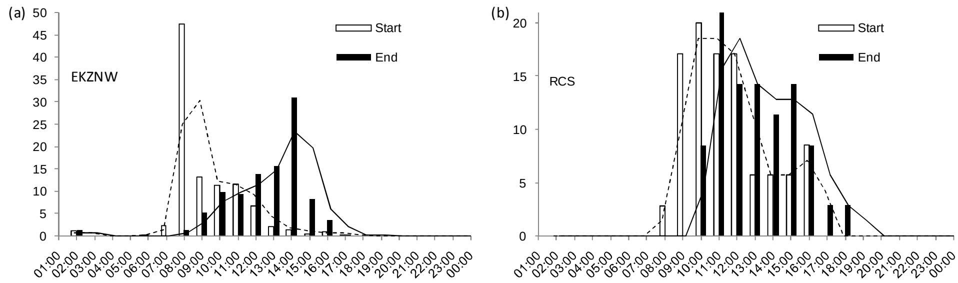


Figure 6.9- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in the Scottburgh (SB) zone from this study (RCS) and those by EKZNW during 2009-10.

Catch composition in the SB zone recorded on EKZNW shore patrols was similar to that recorded in the current study (Table 6.16). Again, *P. saltatrix* was considerably more important in catches recorded by EKZNW, while relatively few were recorded in the current study. *S. salpa* was the most abundant species recorded in the current study but comprised a much smaller percentage in the EKZNW shore patrol data. Furthermore, *N. lithophilus* was not as important in catches recorded in EKZNW shore patrol data as they were in the current study.

The discrepancies between the two data sets from the SB zone suggest that there may be biases in the manner in which EKZNW conducts shore patrols in this zone. This issue should be further investigated.

Table 6.16- Catch composition in the Scottburgh (SB) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		NMLS	
Scottburgh 31 species 722 fish		Scottburgh 22 species 1064 fish	
Sarpa salpa	41%	*Pomatomus saltatrix*	38%
Diplodus capensis	22%	*Diplodus capensis*	24%
Rhabdosargus holubi	17%	*Sarpa salpa*	22%
Liza spp	5%	*Rhabdosargus holubi*	3%
Neoscorpis lithophilus	3%	*Liza spp*	3%
OTHER	12%	OTHER	10%

Trafalgar (TF) Zone

A summary of comparisons between this study and EKZNW shore patrols in the TF zone during 2009-10 are shown in Table 6.17. The mean distance patrolled in the current study (4.9 ±1.7 km.patrol^{-1}) was considerably higher than the average distance patrolled by EKZNW (0.3 ±0.1 km.patrol^{-1}) (Table 6.17). Consequently, the average number of anglers checked per kilometre in the current study (1.4 ±1.4 anglers.km^{-1}) was substantially lower than that recorded on EKZNW shore patrols (12.8 ±20.4 anglers.km^{-1}) (Table 6.17). The average time spent on patrol was considerably higher in the current study (1.2 ±0.7 hours.patrol^{-1}) than on EKZNW shore patrols (0.2 ±0.6 hours.patrol^{-1}) (Table 6.17). In contrast, the average number of fish recorded per angler checked in the current study (0.2 fish.angler^{-1}) was fourfold lower than that recorded on EKZNW shore patrols (0.8 fish.angler^{-1}) (Table 6.17). Similarly, the average CPUE in the current study (0.09 ±0.25 fish.angler^{-1}.hour^{-1}) was considerably lower than that recorded on EKZNW shore patrols (0.17 ±0.42 fish.angler^{-1}.hour^{-1}) (Table 6.17).

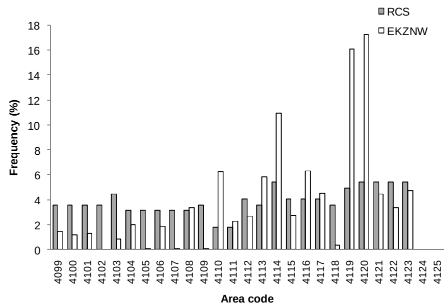
Spatially, EKZNW shore patrol effort in the TF zone was very focussed at popular beach access points, such as Splash Rocks (i.e. 4119-4120) and Glenmore (4114), with relatively little effort elsewhere (Fig. 6.10). Several popular areas, such as Southbroom (4102), Marina Beach (4105), Mpenjati River Mouth (4109) and Ku-Boboyi River Mouth (4118), were poorly patrolled. In contrast, shore patrol effort in the current study was more evenly distributed across the whole of the Trafalgar zone. Areas to south of Port Edward (i.e. 4124 and 4125) were not patrolled by EKZNW and in the current study because they are difficult to access by shore-anglers.

Temporally, shore patrolling by EKZNW was mainly done in the morning with few patrols recorded after 13h00 (Fig. 6.10). Patrols by EKZNW were also very short and generally lasted under an hour. In contrast, shore patrols in the current study were more evenly distributed throughout the day; although, few patrols were conducted before 09h00.

Table 6.17- A comparison between the results of shore patrols conducted in the Trafalgar (TF) zone from this study (RCS) and those by EKZNW during 2009-10. Standard deviation is given in parentheses.

Parameter	RCS	EKZNW
Number of roving creels/shore patrols	37	1183
Total distance patrolled (km)	180	341
Mean distance patrolled (km)	4.9(1.7)	0.3(0.1)
Anglers.km^{-1*}	1.4 (1.4)	12.8 (20.4)
Time on patrol (hours)	42.6	252.6
Mean time on patrol (hours)	1.2(0.7)	0.21(0.6)
Number of anglers checked	238	3794
Number of fish recorded	88	2966
Number of fish recorded per angler	0.2	0.8
Number of species recorded	18	23
CPUE (fish.angler^{-1}.hour^{-1})*	0.09(0.25)	0.17(0.42)

*Averaged per patrol



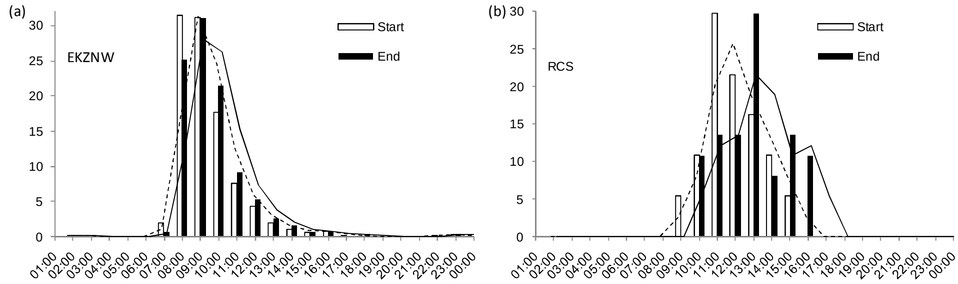


Figure 6.10- Temporal (below) and spatial (above right) comparisons between shore patrols conducted in the Trafalgar (TF) zone from this study (RCS) and those by EKZNW during 2009-10.

Catch composition recorded in the TF zone during shore patrols conducted by EKZNW was quite different to that recorded in the current study (Table 6.18). *P. saltatrix* was again more important in catches recorded by EKZNW than they were in the current study. *S. salpa* was the most abundant species in the current study but made up a much smaller percentage contribution in the EKZNW shore patrol data. Interestingly, *Pachymetopon grande* was not as important in catches in EKZNW shore patrol data as it was in the current study.

Serious spatial and temporal biases exist in the manner in which EKZNW shore patrols are conducted in the TF zone. Most patrols are very short in duration and patrolling effort is concentrated at popular beach access points. While such patrols are probably achieving their objectives in terms of law enforcement and compliance, the resultant catch and effort data are not likely to be representative of the zone as a whole.

Table 6.18- Catalog composition in the Trafalgar (TF) zone from shore patrols conducted in this study (RSC) and by EKZNW during 2009-10. Top five species are indicated with the remaining species included in the "OTHER" category.

RCS		EKZNW	
Trafalgar 18 species 48 fish		Trafalgar 23 species 2966 fish	
Sarpa salpa	40%	*Pomatomus saltatrix*	74%
Pachymetopon grande	17%	*Sarpa salpa*	10%
Diplodus capensis	13%	*Pomadasys olivaceum*	6%
Pomadasys olivaceum	10%	*Diplodus capensis*	3%
Neoscorpis lithophilus	6%	*Neoscorpis lithophilus*	3%
OTHER	14%	OTHER	4%

On the whole, it seems that the zones with fewer access points on the KZN north coast, such as the CV, SL and MT zones, are relatively well managed by EKZNW with the results from the shore patrols adequately representing the true nature of the shore linefishery in these areas. Although there are some inherent biases in spatial and temporal patrolling effort in these zones, these biases have little effect on the overall quality of the catch and effort data collected. Furthermore, any small changes in patrolling effort in these areas will probably have little effect on the overall precision and accuracy of the data collected. On the contrary, the zones with more access points (i.e. DB, KB, SB, and TF) are more affected by sampling bias and thus would benefit from a change in the manner in which patrols are conducted to increase the precision and accuracy of the catch and effort data collected. See discussion below for a more detailed description of improved patrolling requirements.

6.3.2. Offshore boat-based linefishery

Recreational and charter boat linefisheries

In the current study, a total of 223 recreational Access Point Surveys (APS) were completed at 32 skiboat launch sites along the KZN coast (Table 6.19). In contrast, EKZNW visited 30 launch sites and completed a total of 1 651 launch site visits. Although the total number of launch sites visited in the current study was very similar to that conducted by EKZNW, several popular launch sites were not visited as frequently as they should have been by EKZNW (Fig. 6.11). These included Richards Bay, Rocky Bay/Park Rynie, Pennington, Shelly Beach and Port Edward. In contrast, during the current study Sodwana Bay and Cape Vidal were considerably under sampled. However, this was because of logistical constraints and the sampling procedure chosen in the current study (*see* Chapter 4). Overall, inspection frequency by EKZNW needs to be increased on the lower south coast of KZN (i.e. Shelly Beach and Port Edward) and in the Durban Harbour area (i.e. Bluff Yacht Club, Bobbies Angling Club, Fynnlands Angling Club, Rod and Reel Club and Pompano Angling Club). The average number of boats inspected per launch site visit by EKZNW (i.e. 8.0 boats) was far higher than the number inspected per APS in the current study (i.e. 3.6 boats). Despite this difference, CPUE by number and weight was far higher from boats inspected in this study compared to those inspected by EKZNW. It thus appears that EKZNW do not record all fish caught and kept on their inspection forms. This confirms the results found in Chapter 5, whereby EKZNW compliance-orientated skiboat inspections seem to be severely biased towards checking for permit requirements and not thoroughly checking the catch. Interestingly, the number of species recorded in the current study was less than that recorded during EKZNW skiboat inspections. However, this is simply because EKZNW checked considerably more boats in 2009 than in the current study (Table 6.19).

Table 6.19- A comparison of results for the recreational boat linefishery from access-point surveys (APS) conducted in KZN during this study between October 2008 and September 2009 and those conducted by EKZNW during 2009. Note that recreational and charter boat data was combined in the current study for comparative reasons. Standard deviation is given in parentheses.

Parameter	APS	EKZNW
Number of launch sites visited	32	30
Number of recreational access-point surveys/launch site visits completed	223	1651
Total number of boats inspected	795	13202
Average number of boats inspected per access-point survey/launch site visit	3.6	8.0
Number of fish recorded	11458	67094
Number of species recorded	85	97
CPUE ($fish.outing^{-1}$)	13.9 (13.5)	5.1 (10.2)
CPUE ($kg.outing^{-1}$)	19.2 (16.6)	8.4 (20.0)
CPUE ($fish.angler^{-1}.hour^{-1}$)	0.59 (0.55)	0.24 (0.63)
CPUE ($kg.angler^{-1}.hour^{-1}$)	0.91 (0.84)	0.56 (1.21)

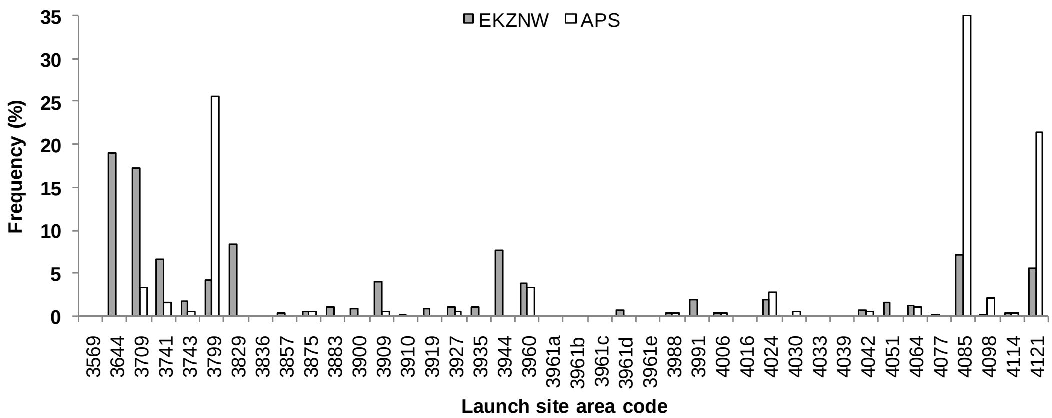


Figure 6.11- Skiboat launch site inspection frequency along the KZN coast by EKZNW during 2009 and from the current study (APS) between October 2008 and September 2009 (*see* Appendix IX for launch site codes).

Catch composition recorded in this study was very similar to that recorded by EKZNW. In both data sets (recreational and charter), *Chrysoblephus puniceus*, *Lethrinus nebulosus* and *Thunnus albacares* were the three most important species caught (Table 6.20). However, the remaining top two species between the two data sets were different. In the boat inspections conducted in this study, C*hrysoblephus anglicus* (6%) and *Pachymetopon aeneum* (4%) were the fourth and fifth most important species respectively. This was in contrast to EKZNW inspections, where *Coryphaena hippurus* (6%) and *Cheimerius nufar* (5%) were the fourth and fifth most important species respectively. However, such differences can be explained by the fact that the majority of the boat inspections conducted in the current study were done at Shelly Beach and Port Edward (Table 6.19) where C. *anglicus* and *P. aeneum* are particularly important in the recreational linefish catches (*see* Chapter 4). Similarly, a high proportion of the boat inspections conducted by EKZNW were done at Sodwana Bay and Cape Vidal where C. *hippurus* is important in catches. *C. nufar* was still an important linefish species in the current study with it being the sixth (2.9%) most abundant species recorded.

Table 6.20- Overall catch composition for the recreational boat linefishery from access-point surveys (APS) conducted in KZN during this study between October 2008 and September 2009 and those conducted by EKZNW during 2009. Top five species are indicated with the remaining species included in the "OTHER" category.

APS		EKZNW	
Overall		Overall	
85 species		97 species	
11458 fish		67094 fish	
Chrysoblephus puniceus	34%	*Chrysoblephus puniceus*	29%
Lethrinus nebulosus	13%	*Lethrinus nebulosus*	10%
Thunnus albacares	11%	*Thunnus albacares*	8%
Chrysoblephus anglicus	6%	*Coryphaena hippurus*	6%
Pachymetopon aeneum	4%	*Cheimerius nufar*	5%
OTHER	32%	OTHER	42%

Commercial boat linefishery

The total number of commercial boat outings inspected during this study was 523 (Table 6.21) (*see* Chapter 4). Comparison of these results with the mandatory returns submitted by commercial operators to the NMLS for the same outings, revealed a variety of discrepancies between the two data sources. Of the 523 commercial outings inspected during the current study, 72 inspected boat outings were not recorded on the NMLS by the commercial operators (i.e. a catch was registered by the APS, but the NMLS data were either zero or missing) (Table 6.21). This represents a direct non-reporting factor of 14%. This value could be far higher considering that not all commercial outings recorded for 2008/9 were analysed and only 10 commercial operators had their fishing outings inspected more than 20 times. Furthermore, those commercial operators that were willing to have their catches regularly inspected are likely to be those that are more responsible in recording all of their fishing outings correctly on the mandatory NMLS catch returns. For the above reasons, only 451 commercial outings from the mandatory NMLS catch returns were directly comparable with the current study. Interestingly, three of the commercial outings inspected in the current study recorded no catch when, according the mandatory commercial NMLS returns, a catch had been made. Of the 451 comparable commercial outings, 12 were recorded by the commercial operators on the wrong date (Table 6.21). CPUE recorded for the 451 commercial outings in the current study (242.3 ±145.4 $kg.outing^{-1}$) was significantly higher (Mann-Whitney U test, $U = 92374.5$, $df = 900$, $p = 0.007$) than CPUE recorded on the mandatory NMLS catch returns (195.8 ±145.4 $kg.outing^{-1}$) for the same fishing outings (Table 6.21). However, if one considers the fact that fish weights recorded by the commercial operators are of gutted fish whereas fish weights from the current study were calculated from length-weight relationships for ungutted fish, CPUE between the NMLS and the current study for the same outings would be more similar. Importantly, it seems that commercial operators do not record outings where no catch was made, which may therefore overestimate overall CPUE estimates in the commercial boat linefishery. Note that CPUE in terms of kg per fisher per hour could not be calculated as several commercial operators did not record the number of hours spent fishing on some of their outings in the mandatory NMLS catch returns.

Table 6.21- An analysis of the accuracy of mandatory NMLS commercial catch returns along the KZN coast compared to boat inspections conducted during the current study (APS) between October 2008 and September 2009. Standard deviation is given in parentheses.

Parameter	No.
Total number of commercial boat outings inspected in the current study	523
Records with a catch registered by the APS, but the NMLS data were either zero or missing	72
Records with a catch registered by the APS and a catch recorded on the NMLS	448
Records with a catch reported to the NMLS when, according to the APS, no catch was made	3
Number of records entered on the wrong date	12
NMLS CPUE ($kg.outing^{-1}$)	195.8 (145.4)
APS CPUE ($kg.outing^{-1}$)	242.3 (193.1)

The total weight of fish recorded during 451 commercial outings inspected during the current study was 110 493 kg (Table 6.22). This was far higher than the total weight of fish recorded by commercial operators for the same outings (i.e. 88 534 kg) (Table 6.22). However, this again could be due to the weight differences of gutted and ungutted fish as described above. Furthermore, it was noticed that commercial skippers frequently do not report undesirable fish catches, such as *Galeichthys trowi*, which are given to the crew.

The top five species that comprised the bulk of the catch by weight recorded during 451 commercial outings in the current study included *Chrysoblephus punic*eus (53.3%), *Cheimerius nufar* (25.5%), *Epinephelus spp.* (5.7%), *Lethrinus nebulosus* (3.1%) and *Atractoscion aequidens* (2.7%) (Table 6.22). The top five species by weight recorded for the same 451 commercial outings in the mandatory NMLS catch returns were *Chrysoblephus punic*eus

(72.2%), *Epinephelus spp.*(7.8%), *Cheimerius nufar* (4.7%), *Atractoscion aequidens* (3.5%) and *Polyamblyodon germanum* (2.6%) (Table 6.22). *C. punic*eus was the most important species reported in both the APS and in catches reported to the NMLS, comprising more than 50% of catches by weight. However, there was a big discrepancy in reported catches of some other species, particularly *C. nufar*, *L. nebulosus*, *Dinoperca petersi*, *Pachymetopon aeneum*, *P. germanum* and *P. grande*. These differences are difficult to interpret but could be due to a variety of different reasons. *C. nufar* is often lumped together with *C. puniceus* in commercial catches and weighed together, which could account for the differences observed between these two species. In the case of *P. aeneum*, *P. grande* and *P. germanum*, this is likely to be a case of misidentification of these very similar looking species, either by the commercial operator and/or by the survey clerks. Both *D. petersi* and *L. nebulosus* seemed to be considerably unreported by commercial operators in their mandatory NMLS catch returns, but the reasons for this are not known. Overall, from the analysis of catch composition between the two data sources it is evident that not all commercial operators record all fish caught on a particular outing. In many cases they only record the most common species and either add the weights of the less common species to these fish groups (e.g. “red fish”, “bream”, or “rockcod”) or simply do not record them. Although fish weights that are recorded on the NMLS catch returns are of ungutted fish, the overall weights of several species were higher than what was recorded in the current study. This highlights the fact that several commercial operators may also be over-reporting their catch for various reasons. This behaviour may be linked to the commercial operators who are under preforming in the linefishery since they fear loosing their right and subsequently over report their catches.

Table 6.22- A comparison of catch composition from commercial boats inspected during access-point surveys conducted in this study (APS) with those reported in the mandatory NMLS catch returns between October 2008 and September 2009.

Species	APS		NMLS	
	kg	%	kg	%
Aprion virescens	7	0.01	0	0
Argyrosomus spp.	1406	1.27	2204	2.49
Atractoscion aequidens	2979	2.70	3103	3.51
Bodianus bilunulatus	1	<0.01	0	0
Boopsoidea inornata	15	0.01	0	0
Cheimerius nufar	28143	25.47	4134	4.67
Chrysoblephus anglicus	2075	1.88	2162	2.44
Chrysoblephus cristiceps	31	0.03	64	0.07
Chrysoblephus lophus	21	0.02	0	0
Chrysoblephus puniceus	58859	53.27	63872	72.15
Coryphaena hippurus	967	0.88	984	1.11
Cymatoceps nasutus	1122	1.02	1293	1.46
Dinoperca petersi	807	0.73	1	<0.01
Epinephelus spp.	6298	5.70	6868	7.76
Euthynnus affinis	5	<0.01	0	0
Lethrinus nebulosus	3386	3.07	134	0.15
Lutjanus spp.	98	0.09	0	0
Pachymetopon aeneum	2644	2.39	299	0.34
Pachymetopon grande	121	0.11	0	0
Paracaesio xanthura	145	0.13	0	0
Parupeneus spp.	3	<0.01	0	0
Plectorhinchus spp.	55	0.05	61	0.07
Polyamblyodon germanum	4	<0.01	2287	2.58
Polysteganus coeruleopunctatus	322	0.29	40	0.05
Polysteganus praeorbitalis	537	0.49	445	0.50
Porcostoma dentata	8	<0.01	0	0
Pristipomoides filamentosus	158	0.14	217	0.25
Scomberomorus commerson	5	<0.01	51	0.06
Seriola lalandi	17	0.02	17	0.02
Thunnus albacares	254	0.23	283	0.32
Unidentified spp.	0	0	5	0.01
Total	110493	-	88524	-

6.4. DISCUSSION

6.4.1. Shore linefishery

In recent years, there has been some criticism of the data collected by EKZNW shore patrols for the KZN recreational shore linefishery. Mann-Lang (1996) identified nine sources of potential bias associated with the EKZNW shore patrols, which have various affects on the quality of the data collected. Most of these biases have stemmed from the manner in which the data has been collected and to some degree from historical and logistical problems associated with the establishment and design of the monitoring system (Mann-Lang 1996). Over the years there have been several initiatives implemented that were aimed at decreasing the biases associated with the shore patrols. For example, EKZNW shore patrol staff were required to complete fish identification courses, which has subsequently decreased the incorrect identification of fish species. However, from the results presented above, it appears that several traditional biases, including spatial bias, temporal bias and compliance-orientated bias, are still major problems affecting the quality of recreational shore patrol data.

Despite these problems associated with the collection of recreational shore linefishery catch and effort data by EKZNW, the NMLS has provided a substantial amount of long-term catch and effort data, which has been used for many purposes (e.g. tracking interannual trends in catch and effort of various species and sectors, determining seasonal trends in abundance or availability of particular species and the National Spatial Biodiversity Assessment) (van der Elst and Adkin 1988; van der Elst and de Freitas 1988; Pradervand and Govender 1999; Lombard *et al.* 2004; Singh 2004; Pradervand *et al.* 2007b). Although many scientists have criticised the quality of this data, what is the actual precision and accuracy of data required? As Mann-Lang (1996) describes: are scientific data with a high level of accuracy and precision required for stock assessments or are general trends with a lower level of accuracy sufficient to make reliable management decisions? It is obvious from the results presented that several of the zones along the KZN coast are patrolled in an effective manner (e.g. Ballito, Mtunzini, St Lucia), while others do appear to have several sampling biases (e.g. Trafalgar and Scottburgh). In general, though, from comparisons between the two datasets it seems that the NMLS shore patrol data does in fact give a relatively good indication of general trends in the shore linefishery. However, it must be acknowledged that these data are only useful for describing broad trends in the fishery and on their own are not sufficient for undertaking detailed species-specific stock assessments.

Taking into account the estimates of total annual angling effort in the KZN shore linefishery (i.e. 759 682-1 287 548 angler-days.annum^{-1}; *see* Chapters 2 and 3), the number of angler outings recorded during EKZNW marine shore patrols (104 226 angler outings) during 2009 represents approximately 8-14% coverage of the total shore-angling effort in KZN. This value was in contrast to the current study, where the number of angler outings recorded during marine shore patrols (i.e. 5048 angler outings) represented only about 0.5-0.7% of the total shore-angling effort. However, even though sampling effort was substantially lower in the current study compared to EKZNW shore patrols, comparison of the two data sets revealed some similar and encouraging results. The total coverage of shore-angling effort along the KZN coast by EKZNW is therefore considered to be a reasonable estimate of true catch and effort trends along the coast. Furthermore, any further increase in patrolling effort by EKZNW using the current compliance-focussed strategy is unlikely to have much effect on the overall quality of the data collected. Since there are unavoidable biases associated with the current shore patrol strategy used by EKZNW, a possible reduction in the number of patrols but an associated increase in the accuracy and precision of how catch and effort data are collected, may allow the NMLS shore patrol data to become more useful for effective long-term monitoring of the KZN shore linefishery.

In order to achieve greater accuracy and precision, it is suggested that a proportion of the shore patrol data collected by EKZNW should have as its only aim, the collection of scientifically robust data without the added bias of law enforcement. This data should be representative of the fishery and thus be scalable so that estimation of total catch and effort is possible. Furthermore, independent assessments such as the current study could then be used to periodically review and validate the data collected. An efficient system of random-stratified shore patrols during which length frequency measurements are also taken would eliminate a large amount of the inherent biases found in the current EKZNW shore patrol system. Furthermore, the collection of length frequency data would provide important input for stock assessment models, which normally involve dedicated, time-consuming and expensive data collection procedures.

The proposed plan for scientific shore patrols is as follows: two EKZNW officials in each zone (i.e. 30 officials in total for KZN) would be properly trained in basic aspects of scientific data collection. This training would include datasheet completion procedures, sampling protocol and fish identification. Such a system will also provide valuable skills to EKZNW staff members. These staff members could then also be allowed to transfer between zones by swapping with other staff members from other areas with the same training. These two officials would be required to spend 12 days per month conducting patrols with their primary aim being scientific data collection. Five of these days would be required to be over the weekend or on a public holiday, with peak school holiday periods (i.e. when the school holidays of all nine South African provinces coincided) being included as weekend days. The other five days would be normal weekdays. On the remaining two sampling days, night patrols could be conducted as they are in the Mtunzini and Ballito zones (*see* above). During a normal “scientific sampling day”, three individual patrols should be undertaken as they were in the current study; a morning patrol, randomly timed between 06h00 and 10h00, a midday patrol between 10h00 and 14h00 and an afternoon patrol between 14h00 and 18h00. Each zone should be subdivided into sampling sites that are equal in length according to the proportion of the zone that can be effectively patrolled in a four-hour period by foot or vehicle. On a particular “scientific sampling day”, patrols should begin randomly in one of the three sampling sites and be undertaken in a random direction (north or south). The specific sampling dates and sites, direction of patrol and patrol times should be predetermined the month prior to the sampling period. The distance patrolled in each patrol would be standard according to the length of the predetermined sampling sites. All anglers encountered during a patrol must be inspected for catch and effort data. In instances where there are too many anglers to inspect, every 10th angler should be inspected and the total number of anglers on the patrol must be counted. Time spent on a patrol should be a minimum of two hours with the maximum being four hours. All fish caught must be correctly identified and measured with specially designed measuring boards. Released fish should be recorded as such on the patrol form (i.e. separate from kept fish).

Overall, with improvements in standard patrolling protocols in several zones and the adoption of the scientific sampling procedure described above, the NMLS can become a very useful management tool that can continue to provide necessary law enforcement as well as accurate scientific data for reliable management decisions. Recommendations for the improvement of data collected by EKZNW for the KZN shore-based recreational linefishery are described below:

1. A scientific sampling procedure as described above needs to be developed in consultation with ORI and MCM and adopted by EKZNW to increase the accuracy and precision of the recreational catch and effort data collected in the shore linefishery. This has a secondary benefit for EKZNW in that monitoring of the recreational shore linefishery will be more time and cost effective and thus allow the remaining EKZNW staff members to focus on law enforcement.
2. With the increased focus on law enforcement, EKZNW has the opportunity to develop an alternate monitoring system where the total number of violations and transgressors can be recorded. However, such a system and its possible benefits need to be carefully analysed, possibly in consultation with MCM and ORI. Other relevant parties such as the South African Marine Linefish Management Association (SAMLMA) and the Marine Linefish Research Group (MLRG) can also be consulted to debate and streamline such planning.
3. Occasional surveys, such as the current study, should be repeated periodically (5-10 years) to validate the recreational catch and effort data collected by EKZNW and to collect associated socio-economic angler information.
4. Fish numbers and lengths need to be recorded accurately. Officials conducting shore patrols need to physically inspect catches and must measure all fish caught to the nearest centimetre using a measuring board. This process will add valuable length frequency data to the recreational NMLS system, which can then be used to undertake accurate stock assessments on certain priority linefish species.

5. EKZNW shore patrols need to make allowance for distinction between kept and released fish to enable better quantification of overall CPUE and harvest rates.

6.4.2. Offshore boat-based linefishery

Recreational and charter boat linefisheries

Considering the differences in sampling effort, there were some interesting differences found between catch and effort data collected in this study and by EKZNW. EKZNW seemed to considerably under-report the total catch made on each vessel checked. This problem is either because the anglers themselves did not show the EKZNW officials all of their catch or simply because EKZNW did not physically check the catch and relied on the anglers to report what they had caught. The latter might be because EKZNW appear to be more focused on checking for permit requirements than they are for checking compliance with linefish regulations. This fact is further emphasised by the large number of boat-fishers that exhibited compliance with the requirement for a fishing permit and the associated large number of boat-fishers that admitted to violating catch restrictions on certain fish species (*see* Chapter 5). Another possible reason why CPUE was lower for EKZNW inspection data could be because EKZNW officials seldom record non-target species on their catch returns. For example, *Scomber japonicus*, a commonly caught bait species used by recreational boat-fishers while targeting gamefish, are often not recorded on the inspection forms by EKZNW. In the current study, all fish that were caught, including the bait species, were recorded. An unfortunate bias associated with the collection of catch and effort data by EKZNW is the fact that they estimate the weight of fish kept by anglers either by asking the anglers themselves or by guessing. This has the potential to seriously bias the weight estimate of fish caught. In the current study, all fish weights were calculated from standard length-weight relationships and were thus assumed to be fairly accurate.

Catch composition of recreational boat-fishers recorded in this study and by EKZNW was fairly similar. Although the fourth and fifth most important species did differ between the two data sets, this is likely to be an artifact of sampling effort. For example, the Sodwana and Cape Vidal launch sites, which are located within MPAs situated in the iSimangaliso Wetland Park where bottom fishing is prohibited, were sampled the most frequently by EKZNW (Fig. 6.11). For this reason a large proportion of the catch was comprised of gamefish, such as *Coryphaena hippurus*. In contrast, in the current study the popular launch sites on the lower south coast of KZN (Shelly Beach and Port Edward) were sampled the most and can thus explain the high percentage contributions of *C. anglicus* and *P. aeneum* in catches.

Overall, despite the under-reporting of the catch by EKZNW and the spatial bias in sampling, it seems that EKZNW boat inspections are a fairly reasonable representation of the recreational offshore boat-based linefishery in KZN. The fact that only 0.6% of the total annual boat angling effort was sampled in the current study compared to 5% by EKZNW shows that it is not difficult to obtain good quality data from fewer inspections that are conducted properly on a random basis. Nevertheless, the problems that do exist need to be addressed to develop more effective long-term management of the KZN recreational boat-based line fishery.

As in the shore linefishery, greater accuracy and precision of catch and effort data collected by EKZNW can be achieved through a more scientific approach with less emphasis on compliance, which will ultimately decrease the sampling effort needed by EKZNW to acquire better data. A proposed plan for scientific boat inspections is very similar to the one described above for the shore linefishery. The same two staff members trained for scientific shore patrols would conduct the boat inspections. These two officials would be required to spend at least eight days per month, over and above shore patrols, conducting boat inspections, with their primary aim being scientific data collection. Four of these days would be required to be over the weekend or on public holidays. During a normal “scientific sampling day”, three individual launch site inspections should be undertaken as they were in the current study; a morning inspection, randomly timed between 06h00 and 10h00, a midday inspection between 10h00 and 14h00 and an afternoon inspection between 14h00 and 18h00. Zones with only one launch site, such as Cape Vidal and Sodwana, could have a launch site inspection conducted throughout the day with its sole purpose being scientific data collection. Other zones with multiple launch sites can be inspected on a probability basis. In other words, using the Boat Launch Site Monitoring System (BLSMS), launch site usage (i.e. number of launches per year) can be used to develop the sampling strategy. In this way, launch sites that are used more frequently should be sampled more often than those utilised less frequently. Furthermore, any changes in usage patterns at certain launch sites can be identified through the BLSMS and incorporated into the sampling strategy. As launching of boats is more weather dependent, inspections should be limited to when boats have gone to sea. The specific sampling dates, launch sites and inspection times should be predetermined the month prior to the sampling period with alternative dates set in case of inclement weather conditions. Note that currently boat launch site inspection times (i.e. what time a launch site inspection is started and concluded) are not recorded by EKZNW. This would be a valuable addition to the system as temporal inspection frequencies can then be described as they were done in the shore linefishery above. This would also provide useful data for validating launches recorded on the BLSMS register. All vessels encountered during a launch site inspection should be inspected for catch and effort data, while those that are not inspected (i.e. still out at sea) should be counted by counting the number of trailers and added to the total number of vessels fishing during that launch site inspection. Furthermore, fishing vessels should be classified into the different offshore sectors by their vessel registration numbers (i.e. recreational, charter and commercial). Time spent on launch site inspections should be a minimum of two hours and a maximum of four hours (depending on the number of boats out). All fish caught on each vessel checked must be correctly identified, counted and measured to the nearest centimetre with a measuring board. Recommendations for the improvement of data collected by EKZNW for the KZN boat-based recreational linefishery are described below:

1. A scientific sampling procedure as described above needs to be developed in consultation with ORI and MCM and adopted by EKZNW to increase the accuracy and precision of the recreational boat-based catch and effort data collected. This has a secondary benefit for EKZNW in that monitoring of the recreational boat-based linefishery will be more time and cost effective and thus allow the remaining EKZNW staff members to focus on law enforcement.
2. With the increased focus on law enforcement, EKZNW has the opportunity to develop an alternate system where the total number of violations and transgressors can be recorded (*see* shore linefishery above).
3. Inspections of recreational vessels needs to be increased at certain popular launch sites (i.e. Bluff Yacht Club, Bobbies Angling Club, Fynnlands Angling Club, Rod and Reel Club, Pompano Angling Club, Rocky Bay/Park Rynie Skiboat Club, Umkomaas Skiboat Club, etc.).
4. Occasional surveys, such as the current study, should be repeated periodically (5-10 years) to validate the recreational catch and effort data collected by EKZNW and collect associated socio-economic angler information.
5. Fish numbers and lengths need to be recorded accurately. Officials conducting boat inspections need to physically inspect hatches on the vessels and not simply rely on information provided by anglers. It is recommended that all fish species caught are counted and measured to the nearest centimetre using a suitable measuring board. Weights can then subsequently be calculated. This process will add valuable length frequency data to the recreational NMLS system, which can then be used to undertake accurate stock assessments on certain priority linefish species.

Commercial boat linefishery

Comparisons between commercial catch and effort data collected in this study with mandatory NMLS catch returns submitted by commercial operators revealed some interesting results. There seemed to be a strong degree of under-reporting of the number of boat outings and weight of fish caught and kept by many of the vessels checked during the current study. Similar trends were also reported by Sauer *et. al.* (1997) during the national marine linefish survey conducted between 1994-96. There are a number of possible reasons for the deliberate under-reporting of catches by commercial fishermen the most obvious of which are fishing levies and tax implications.

However, although the commercial NMLS catch and effort data suffers from several biases associated with mandatory catch returns (i.e. deliberate misreporting, unintentional misreporting, apathy and memory recall) (*see* Mann-Lang 1996), it still gives a reasonable representation of catches made. This is confirmed by the fact that catch composition and CPUE estimates calculated from vessels checked in this study and from the NMLS were very similar. Fortunately, the current rights allocation process has rigorous exclusionary criteria, and clearly describes that rights will be withdrawn from those fishermen who fail to submit returns or who continually under-perform in the fishery. Although this may prompt inactive/under-performing vessels to submit false or incorrect data in order to meet the certain requirements (as found by Sauer *et al.* 1997), the Linefish Observer Program can be used to validate returns of individual rights holders and can easily identify those commercial fishers that submit false/incorrect catch returns. However, before this can happen it is recommended that the current Linefish Observer Program in KZN be improved. At least one more observer needs to be deployed to service the central region of KZN (i.e. Tugela to Umkomaas). This would ensure better coverage of commercial outings throughout the province as current observer effort is focussed on the Richards Bay/Mtunzini area (north coast) and the Shelly beach/ Port Edward area (lower south coast).

Recommendations:

1. A large-scale analysis of the mandatory commercial NMLS catch returns for each vessel operating along the KZN coast and comparison with the results collected by the Linefish Observer Program is needed. Rights holders found to be deliberately reporting false/incorrect information should be warned and/or even have their rights withdrawn as outlined in the Traditional Linefish Policy.
2. Commercial operators must report all fishing outings, even when no catch is made.

3. Commercial operators must avoid lumping particular species together (e.g. “rockcods”, “redfish”, “bream”, etc.), as this precludes species-specific analyses. It is recommended that all fish species caught and kept by a commercial operator on a specific boat outing must be recorded. Species that are not sold and are given to the crew (i.e. non-target species) must also be recorded.
4. At least three linefish observers need to be deployed along the KZN coast in order to supply adequate, long-term indices of catch and effort data and accurate length frequency data. These data can then be periodically used to validate commercial catch returns submitted to the NMLS.
5. A compulsory commercial skipper training course on fish ID, barotrauma treatment, completion of catch returns, etc.

6.4.3. Conclusion

Comparison of the results of this study with the long-term monitoring data stored on the NMLS showed that while the NMLS data is limited by a number of biases, it still provides a valuable system for monitoring long-term trends in the KZN linefishery. With a number of changes to the current system of data collection, the quality of data collected and entered onto the NMLS could be greatly improved. The changes recommended in this study would also improve the cost efficiency of the current system. Furthermore, the reliance on fewer EKZNW staff to collect recreational catch and effort data would allow more time for the rest of the staff to focus on law enforcement, especially for the commercial linefish sector of KZN.

CHAPTER 7

GENERAL CONCLUSIONS AND RECOMMENDATIONS

This study has shown the magnitude and importance of the shore and offshore linefisheries to the province of KZN. From the analyses of participation within the two linefisheries, it appears that there have been relatively few new entrants into the marine linefishery of KZN since 1994-96. There was however, a slight shift in angler participation recorded between the different sectors (i.e. reduced commercial and increased charter participation) in the offshore boat-based linefishery. The annualised rate of increase of 6% predicted by van der Elst (1993b) has therefore not been realised. It appears that total participation in the shore and offshore linefisheries has grown at a slower rate than the population growth rate, similar to the predictions made by McGrath *et al.* (1997). Furthermore, fishing is a sport in which most participants begin young and continue throughout their lives. Understanding the three distinctive groups of anglers that exist, i.e. (1) those that fish permanently or relatively frequently year after year (making up a large proportion of the anglers sampled); (2) those that fish sporadically (i.e. sometimes going a year or several years between fishing trips, and/or others that fish for some period of time and then totally stop fishing); and (3) those that have never fished, but still show some interest in fishing, and given the right opportunities or circumstances, may become active anglers (Pollock *et al.* 1994); it would appear that growth in the KZN linefishery will remain slow. This trend is important for management as it allows prediction of angler numbers and responsible action to ensure sustainable utilization of linefish resources.

In contrast to total participation, total angler effort in both the shore and offshore linefisheries has decreased substantially since 1994-96. Three main reasons were proposed as to why angler effort has decreased, namely (1) changes in fishery/environmental management (i.e. beach vehicle ban, reduction of commercial linefish effort, the promulgation of new linefish regulations, etc.), (2) declining catch rates and (3) increasing costs (i.e. economic limitations). From this, it can be concluded that the management measures implemented since the declaration of a crisis in the linefishery in December 2000 (Government Gazette No. 21949), have been partially effective in reducing fishing pressure on KZN's marine linefish resources. This is particularly important since previous management efforts have failed to reduce angler catch and effort and the KZN linefishery has historically been heavily overexploited (Brouwer *et al.* 1997; Mann-Lang *et al.* 1997; Mann *et al.* 1997a; Sauer *et al.* 1997; Penney *et al.* 1999).

Management of the charter boat sector was identified as an important gap in the current management regime. As this sector has both recreational and commercial objectives, it poses an enormous threat to biological sustainability, resource management, tourism and socio-economic development in KZN. While the reduction in commercial fishing effort was imperative, since charter boat fishing is subsidised by paying customers, the uncontrolled increase in charter fishing effort will result in fish stocks being driven beyond the bio-economic equilibrium and thus effectively limit any stock rebuilding from taking place. Furthermore, unless there is rationalisation (i.e. capping) of the number of charter boats operating at launch sites along the KZN coast, the economic viability of individual operators is likely to be compromised. Although a thorough assessment of the charter fishery was completed in 2003-04 (Pradervand and van der Elst 2008), this sector has been allowed to continually grow without any management intervention. It is thus recommended that management of the entire KZN charter boat linefishery should urgently be reviewed and this sector must officially be recognised in terms of the Marine Living Resources Act (No. 18 of 1998). Management efforts should be focused on bringing this growing sector under control, both for economic reasons and to ensure the continued sustainable use of KZN's linefish resources.

The opportunity exists to develop a policy for the allocation and management of rights for the charter boat sector, similar to that used to regulate the traditional commercial linefishery. A limited (set) number of rights should be allocated to proven and established charter boat operators based on a strict application procedure. This procedure should include certain evaluative/exclusionary criteria (e.g. viable number of operators per launch site, transformation, crew empowerment, job creation and compliance with applicable laws and regulations), as was done in the commercial linefishery. Charter operators can then be regularly assessed through analysis of data collected on the Boat Launch Site Monitoring System (BLSMS), EKZNW skiboat inspections (NMLS) and MCM's Linefish Observer Programme. This process will allow the allocation of rights to deserving applicants based on individuals who have been historically associated with the charter boat fishery. Furthermore, total allowable effort (TAE) for the charter fishery should be set at a level not exceeding current effort levels. Charter operators should be allowed to sell marine recreational angling permits directly to their clients or have a special permit which covers their clients on a fishing outing/event. Importantly, the charter boat sector must be managed in accordance with recreational linefish regulations. In other words, fish caught on a charter vessel cannot be sold and should belong to the individual angler who caught them. Ultimately, recognition of the charter boat sector will ensure better allocation and optimum utilisation of KZN's marine linefish resources.

Although not specifically addressed in this study, it was observed that there are a growing number of recreational boat anglers that are using jetskis and paddle-skis as fishing craft. Jetskis are managed under the same legislation and methods as skiboats and this change in vessel type is not currently seen as a threat to the recreational boat-based linefishery. However, paddle-skis, which are considerably cheaper than jetskis or skiboats and are not limited to launching through registered launch sites (except in the iSimangaliso Wetland Park), have become increasingly popular over the past 10 yeas. A recent study by Pradervand *et al.* (2007a) suggested that catches made on paddle-skis consisted primarily of migratory gamefish species and this fishery was considered to have a relatively low impact on the linefishery as a whole. Nevertheless, it is recommended that this sector of the boat-based linefishery should be carefully monitored by EKZNW during routine shore patrols but using the boat inspection procedure.

Analysis of CPUE, catch composition and total catch in both the shore and offshore linefisheries of KZN suggested that both fisheries are currently in a relatively stable condition. However, further analysis of species-specific CPUE suggests otherwise. In comparison to the catches recorded throughout the most part of the 20^{th} century (van der Elst and Garratt 1984; van der Elst and de Freitas 1988; Penney *et al.* 1999), current catch trends suggest that linefish resources have been fished to very low levels which are ‘superficially’ sustainable at current fishing effort levels. While CPUE trends of many species in the current study were encouraging (e.g. inshore species such as *Diplodus capensis, Pomadasys olivaceum, Rhabdosargus holubi* and offshore species such as *Chrysoblephus puniceus, Lethrinus nebulosus, Thunnus albacares*), current catches are reflecting a gradual transition in landings, from long-lived, high trophic level, piscivorous fish (e.g. inshore species such as Ar*gyrosomus japonicus, Pomatomus saltatrix, Rhabdosargus sarba* and offshore species such as *Cymatoceps nasutus, Petrus rupestris, Polysteganus praeorbitalis*) to more short-lived, lower trophic level species. This transition has been further exacerbated by the fact that anglers’ knowledge and compliance with the current regulations is limited and policing by EKZNW is more focused on permit requirements rather than on enforcing species-specific linefish regulations.

While there have been several angler education initiatives implemented in KZN over the years, which included the “Marine Conservation Dos and Don’ts” pamphlets implemented by MCM and more recently several pamphlets and brochures implemented by EKZNW, these have had several limitations (e.g. only available in English and/or limited distribution or availability). Since regulations on certain fish species have changed several times in the past decade (*see* Chapter 1), a well-designed angler education programme should be implemented as soon as

possible, possibly through fishing tackle shops and/or at the Post Office where angling permits are sold. Furthermore, EKZNW needs to invest in better training of responsible field staff, teaching them to identify common angling species correctly and ensuring that they have a thorough knowledge of the associated fishing regulations and permit requirements. In this way, those anglers that disobey fishery regulations can be effectively prosecuted and a clear example can be sent out to the rest of the fishing community. A logical follow on from this is to ensure suitable training of prosecutors and magistrates in the relevant environmental legislation and furthermore to ensure that they understand the rationale behind the fishing regulations. It is only through such judiciary training that transgressors and poachers will be dealt with effectively.
Additional options that can help strengthen compliance with the MLRA in KZN include the appointment and training of honorary inspectors and encouraging self-regulation through peer-pressure. The recent publication (2010) of the magistrate's bench-book for environmental crime is a positive response in this regard.

Certain fishing regulations have been in place since as early as the 1860s (van der Elst and Garratt 1984; van der Elst 1989). However, effective conservation and management of linefish resources only really began in the early 1980s after research was conducted on several species of economic importance (e.g. *P. undulosus* (Ahrens 1964); *Cheimerius nufar* (Garratt 1985); *Chrysoblephus puniceus* (Garratt 1985)). Despite management measures that have been introduced over the years, several linefish species are now considered to be overexploited (e.g. *Argyrosomus* japonicus (Griffiths 1997), *A. thorpei* (van der Elst *et al.* 1990; Fennessy 1994), *Atractoscion aequidens* (Griffiths and Hecht 1995; Hutton *et al.* 2001), *C. puniceus* (Punt *et al.* 1993), *Polysteganus praeorbitalis* (Garratt *et al.* 1994; Mann *et al.* 2005), *C. nasutus* (Buxton and Clarke 1989) and *P. rupestris* (Smale and Punt 1991)), while this study has further highlighted several species that are showing signs of overexploitation in KZN (e.g. *Rhabdosargus sarba*, *Scomberomorus commerson*). Thus, it is important to consider alternate management measures that offer more effective protection to fish and at the same time are easily understood by all anglers in the linefishery. This is not to say that the management measures that have been put in place have been ineffective (the fishery would probably be in a much worse state if management intervention had not been implemented), but rather that additional options exist to mitigate the impacts of overfishing and allow for sustainable resource utilization.

Although 'slot limits', which encourage the release of smaller and larger, older individual fish by having a prescribed upper and lower size limit (Nordwall *et al.* 2000; Powell *et al.* 2010), provide a possible better alternative to minimum legal size limits (Powell *et al.* 2010), this management option is generally not considered to be viable for the KZN linefishery. This is firstly because most recreational fishers are trophy fishers who generally target bigger fish and secondly because commercial fishers prefer catching larger fish as they are paid per kilogram and larger fish generally command a higher price per kg than smaller fish (Brouwer 1997). Nonetheless, slot limits have been introduced in South Africa for *Argyrosomus spp.* (*see* Appendix X); but, the jury is still out as to whether this option really works, particularly since there are high mortalities associated with catch and release (i.e. barotrauma, shark predation, and post-release stress) (Wilson and Burns 1996; Cooke and Philipp 2003; Cooke *et al.* 2006; Danylchuk *et al.* 2008; Sumpton *et al.* 2008; O' Toole *et al.* 2010; Sumpton *et al.* 2010). Furthermore, communication with several commercial skippers during the current study revealed that many of them kept more than one fish over the slot limit of 110 cm per person per day (*see* Appendix X) as it was a “waste” to release such big fish that would fetch a good market price. This is also exacerbated by the fact that large *A. japonicus* are often caught in high numbers at night during spawning aggregations that occur on certain reef pinnacles and wrecks off KZN.

Another management measure that may offer one of the few practical management options for the sustainable conservation and utilization of marine resources in KZN, and probably the rest of South Africa as well, is marine protected areas (MPAs). MPAs have been shown to protect populations of fish species vulnerable to overfishing (Buxton 1993; Roberts and Polunin 1993; Roberts 1995; Russ and Alcala 1996; Roberts *et al.* 2001; Attwood 2002; Gell and Roberts 2003; Byers and Noonburg 2007; Gotz *et al.* 2008). This is particularly important when conventional management methods, such as minimum legal size and daily bag limits, are less effective. Furthermore, conventional management methods often require much information on the biology of stocks and are relatively expensive and difficult to enforce (Roberts and Polunin 1993; Attwood *et al.* 1997). As a management tool, MPAs allow for a simplified method of enforcement and management of a resource (Roberts and Polunin 1993; Attwood *et al.* 1997). Further advantages of MPAs are discussed at length by Roberts & Polunin (1993) and Attwood *et al.* (1997). Since MPAs were accepted by most KZN anglers and few had fished in an MPA illegally (Chapter 3 and 5), it seems a logical step to increase the number and/or size of MPAs along the KZN coast to assists in the rebuilding of depleted linefish stocks. However, more recent studies have highlighted the shortcomings of MPAs without careful large-scale marine spatial planning and effective stakeholder participation (Agardy *et al.* 2011). The recent ‘Sea

Plan’[*] initiative conducted by EKZNW has made encouraging progress in this regard (Livingstone 2010). This has the potential to increase the efficacy of management, as well as providing an overall biodiversity protection role (Gell and Roberts 2003), which will directly contribute to an ecosystem approach to fisheries management (EAF). Furthermore, exploited areas adjacent to the MPAs can be repopulated as a result of spillover/emigration (Russ and Alcala 1996; Roberts *et al.* 2001) and/or egg and larval dispersal (Cudney-Bueno *et al.* 2009; Pelc *et al.* 2009).

Overall, linefish surveys such as those conducted during this study provide valuable information that can be used to independently validate other data sources. They also provide independent estimates of catch and effort, which are particularly important in a dynamic fishery, while also providing a “snap shot” for future data comparisons. Since no other independent linefish assessments have been conducted in KZN in over a decade, it is vital that research such as this continues to be done to strengthen the efficacy of management and identify problems that have or may arise.

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[*] Sea Plan is an initiative lead by EKZNW to spatially map the marine biodiversity and habitats of the KZN coast from the shore out to the boundary of the Exclusive Economic Zone (EEZ) with the intention of identifying suitable sites for establishment of MPAs. For further reading, consult Livingstone (2010).

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APPENDICES

Appendix I- Number of anglers participating in the KZN shore linefishery (after Pradervand *et al.* 2003).

Interviewees outings per year	No. of interviewees in sample	Mean outings per year	% of sample	Total number of outings by anglers	Calculated total number of anglers
1-10	291	4.76	27.74	210741.15	44278.46
11-20	119	15.13	11.34	86179.37	5694.25
21-30	97	25.63	9.25	70247.05	2740.93
31-40	58	36.90	5.53	42003.39	1138.41
41-50	94	48.33	8.96	68074.46	1408.54
51-60	108	59.81	10.30	78213.21	1307.59
61-70	7	66.57	0.67	5069.37	76.15
71-80	31	72.55	2.96	22450.09	309.45
81-90	19	85.47	1.81	13759.73	160.98
91-100	29	97.31	2.76	21001.69	215.82
101-110	5	105.80	0.48	3620.98	34.22
111-120	74	120.00	7.05	53590.53	446.59
121-130	3	127.00	0.29	2172.59	17.11
131-140	2	140.00	0.19	1448.39	10.35
141-150	16	147.00	1.53	11587.14	78.82
151-160	1	160.00	0.10	724.20	4.53
161-170	2	169.00	0.19	1448.39	8.57
171-180	38	180.00	3.62	27519.46	152.89
181-190	0	0.00	0.00	0.00	0.00
191-200	5	199.20	0.48	3620.98	18.18
201-210	0	0.00	0.00	0.00	0.00
211-220	0	0.00	0.00	0.00	0.00
221-230	0	0.00	0.00	0.00	0.00
231-240	38	240.00	3.62	27519.46	114.66
241-250	1	250.00	0.10	724.20	2.90
251-260	0	0.00	0.00	0.00	0.00
261-270	0	0.00	0.00	0.00	0.00
271-280	0	0.00	0.00	0.00	0.00
281-290	0	0.00	0.00	0.00	0.00
291-300	9	300.00	0.86	6517.77	21.73
201-310	0	0.00	0.00	0.00	0.00
311-320	0	0.00	0.00	0.00	0.00
321-330	1	330.00	0.10	724.20	2.19
331-340	0	0.00	0.00	0.00	0.00
341-350	1	350.00	0.10	724.20	2.07
Total	**1049**		**100**	**759682**	**58245.39**

Appendix II- Number of shore-anglers belonging to the KwaZulu-Natal Coast Anglers Union between 2000 and 2010.

Year	KZNCAU
2000	1235
2001	1380
2002	1526
2003	1427
2004	1250
2005	1212
2006	1200
2007	1186
2008	1141
2009	1060
2010	998

Appendix III- Catch composition of shore-anglers recorded along the KZN coast during 406 roving-creel surveys conducted between February 2009 and January 2010 (arranged in alphabetical order by family name). Note that for fish species that were released their CPUE was not calculated.

Family	Species	Common Name	# Caught	# Kept	%	CPUE #*	g Kept	%	CPUE weight**
Albulidae	*Albula vulpes*	Bonefish	3	2	0.07	0.001	3937	0.41	0.001
Ariidae	*Galeichthys trowi*	Natal seacatfish	6	0	0	0	0	0	0
Belonidae	*Strongylura leiura*	Garfish	2	0	0	0	0	0	0
Blenniidae	*Scartella emarginata*	Maned blenny	2	0	0	0	0	0	0
Carangidae	*Caranx ignobilis*	Giant kingfish	4	1	0.03	<0.001	1180	0.12	<0.001
	Caranx melampygus	Bluefin kingfish	1	1	0.03	<0.001	140	0.01	<0.001
	Caranx sem	Blacktip kingfish	13	7	0.24	0.002	15497	1.60	0.005
	*Decapterus spp.****	Slender scad	1	1	0.03	<0.001	66	0.01	<0.001
	Lichia amia	Garrick	22	22	0.77	0.008	130179	13.48	0.045
	Trachinotus africanus	Southern pompano	24	16	0.56	0.005	16717	1.73	0.006
	Trachinotus baillonii	Smallspotted pompano	16	16	0.56	0.005	1573	0.16	0.001
	Trachinotus botla	Largespotted pompano	144	80	2.78	0.027	18803	1.95	0.006
Carcharhinidae	*Carcharhinus limbatus*	Blacktip shark	5	0	0	0	0	0	0
	Carcharhinus obscurus	Dusky shark	11	0	0	0	0	0	0
	Carcharhinus plumbeus	Sandbar shark	3	0	0	0	0	0	0
	Carcharhinus sealei	Blackspot shark	6	1	0.03	<0.001	157	0.02	<0.001
	Mustelus mustelus	Smooth-hound shark	4	1	0.03	<0.001	3207	0.33	0.001
	Rhizoprionodon acutus	Milkshark	3	1	0.03	<0.001	884	0.09	<0.001
Clinidae	*Clinus woodi*	Oldman klipfish	1	0	0	0	0	0	0
Dasyatidae	*Dasyatis chrysonota*	Blue stingray	1	0	0	0	0	0	0
	Gymnura natalensis	Diamond/Butterflyray	3	1	0.03	<0.001	6119	0.63	0.002
	Himantura uarnak	Honeycomb stingray	1	0	0	0	0	0	0
	Himantura gerrardi	Sharpnose stingray	5	2	0.07	0.001	1440	0.15	<0.001
Dichistiidae	*Dichistius capensis*	Galjoen	1	1	0.03	<0.001	1541	0.16	0.001
	Dichistius multifasciatus	Banded galjoen	40	33	1.15	0.011	13906	1.44	0.005
Dinopercidae	*Dinoperca petersi*	Cavebass/Lantern fish	17	2	0.07	0.001	843	0.09	<0.001
Drepanidae	*Drepane longimanus*	Concertina-fish	1	1	0.03	<0.001	601	0.06	<0.001
Elopidae	*Elops machnata*	Springer/Tenpounder	3	0	0	0	0	0	0
Haemulidae	*Plectorhinchus chubbi*	Dusky rubberlip	1	1	0.03	<0.001	811	0.08	<0.001
	Plectorhinchus flavomaculatus	Lemonfish	2	1	0.03	<0.001	244	0.03	<0.001
	Pomadasys commersonni	Spotted grunter	46	17	0.59	0.006	18630	1.93	0.006
	Pomadasys furcatum	Grey grunter	19	4	0.14	0.001	588	0.06	<0.001
	Pomadasys multimaculatum	Cock grunter	1	1	0.03	<0.001	3290	0.34	0.001
	Pomadasys olivaceum	Pinky/Olive grunt	398	186	6.47	0.064	5451	0.56	0.002
Hemiramphidae	*Hemiramphus far*	Spotted halfbeak	1	1	0.03	<0.001	167	0.02	<0.001
Kuhliidae	*Kuhlia mugil*	Barred flagtail	17	14	0.49	0.005	1840	0.19	0.001
Kyphosidae	*Kyphosus bigibbus*	Grey chub	1	1	0.03	<0.001	299	0.03	<0.001
	Kyphosus cinerascens	Blue chub	1	1	0.03	<0.001	497	0.05	<0.001
Labridae	*Thalassoma purpureum*	Surge wrasse	7	1	0.03	<0.001	330	0.03	<0.001
	*Thalassoma spp.****	Unspecified wrasse	20	2	0.07	<0.001	730	0.08	<0.001
Leiognathidae	*Leiognathus equula*	Slimy	1	0	0	0	0	0	0
Lutjanidae	*Lutjanus argentimaculatus*	River snapper	3	0	0	0	0	0	0
	Lutjanus rivulatus	Speckled snapper	8	0	0	0	0	0	0
Monodactylidae	*Monodactylus argenteus*	Natal moony	11	11	0.38	0.004	1296	0.13	<0.001
	Monodactylus falciformis	Cape moony	161	123	4.28	0.042	16507	1.71	0.006
Mugilidae	*Mugil cephalus*	Flathead mullet	1	1	0.03	<0.001	1238	0.13	<0.001
	*Liza spp.****	Unspecified mullet	78	68	2.37	0.023	20364	2.11	0.007
	Liza tricuspidens	Striped mullet	11	11	0.38	0.004	7822	0.81	0.003
Mullidae	*Parupeneus rubescens*	Blacksaddle goatfish	1	0	0	0	0	0	0
Muraenidae	*Gymnothorax spp.****	Unspecified eel	23	2	0.07	<0.001	805	0.08	<0.001
Platycephalidae	*Platycephalus indicus*	Bartail flathead	2	0	0	0	0	0	0
Pleuronectidae	*Paralichthodes algoensis*	Measles flounder	1	1	0.03	<0.001	217	0.02	<0.001
Plotosidae	*Plotosus lineatus*	Striped eel-catfish	1	0	0	0	0	0	0
	Plotosus nkunga	Eel-catfish	6	3	0.10	0.001	2080	0.22	0.001
Polynemidae	*Polydactylus plebeius*	Striped threadfin	7	3	0.10	0.001	957	0.10	<0.001
Pomacentridae	*Abudefduf sordidus*	Spot damsel	16	8	0.28	0.003	1419	0.15	<0.001
Pomatomidae	*Pomatomus saltatrix*	Elf/shad	673	423	14.72	0.145	195418	20.23	0.067
Rhinobatidae	*Rhinobatos annulatus*	Lesser guitarfish	26	2	0.07	0.001	1708	0.18	0.001
	Rhynchobatus djiddensis	Giant guitarfish	2	0	0.00	0	0	0	0
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	12	7	0.24	0.002	19008	1.97	0.007
	Argyrosomus thorpei	Squaretail kob	11	10	0.35	0.003	7379	0.76	0.003
	Otolithes ruber	Snapper kob	37	9	0.31	0.003	3214	0.33	0.001
Scombridae	*Scomberomorus plurilineatus*	Natal snoek	1	1	0.03	<0.001	2572	0.27	0.001
Scorpididae	*Neoscorpis lithophilus*	Stonebream	148	86	2.99	0.029	38546	3.99	0.013
Serranidae	*Epinephelus andersoni*	Catface rockcod	29	3	0.10	0.001	2688	0.28	0.001

	Epinephelus marginatus	Yellowbelly rockcod	15	3	0.10	0.001	3246	0.34	0.001
	*Epinephelus spp.****	Unspecified rockcod	6	0	0	0	0	0	0
Sillaginidae	*Sillago sihama*	Silver sillago	6	3	0.10	0.001	705	0.07	<0.001
Sparidae	*Acanthopagrus berda*	Perch	1	1	0.03	<0.001	309	0.03	<0.001
	Cymatoceps nasutus	Black musselcracker	1	1	0.03	<0.001	425	0.04	<0.001
	Diplodus hottentotus	Zebra	20	15	0.52	0.005	6855	0.71	0.002
	Diplodus capensis	Blacktail	1030	417	14.51	0.143	106289	11.01	0.036
	Lithognathus mormyrus	Sand steenbras	27	14	0.49	0.005	539	0.06	<0.001
	Pachymetopon grande	Bronze bream	58	51	1.78	0.017	75000	7.77	0.026
	Pagellus bellottii natalensis	Sand-soldier	24	24	0.84	0.008	1758	0.18	0.001
	Rhabdosargus holubi	Cape stumpnose	198	142	4.94	0.049	24437	2.53	0.008
	Rhabdosargus sarba	Natal stumpnose	9	7	0.24	0.002	13010	1.35	0.004
	Sarpa salpa	Strepie/karranteen	1202	999	34.77	0.342	135061	13.98	0.046
	Sparodon durbanensis	Brusher	5	5	0.17	0.002	25244	2.61	0.009
Sphyrnidae	*Sphyrna lewini*	Scalloped hammerhead	7	0	0	0	0	0	0
	Sphyrna zygaena	Smooth hammerhead	2	0	0	0	0	0	0
Teraponidae	*Terapon jarbua*	Thornfish	6	0	0	0	0	0	0
Tetraodontidae	*Amblyrhynchotes honckenii*	Evileye blaasop/Toby	182	0	0	0	0	0	0

* Fish.angler^{-1}.hour^{-1}
** Kg.angler^{-1}.hour^{-1}
*** Species that were only identifiable to genus level in the field.

Appendix IV- Shore-angling questionnaire.

Questionnaire no.____________________________ Interviewer:____________________________________

Section A: (to be completed by interviewer)

Zone:_____________Locality_________________________Date:______________ Rodsused_______ Weather (scale 1-3, 1 being good)__________AnglerCode (M / F) I / B / W / C / Estimated Angler age:___________________________

Method: Bait / Fly / Lure / Handline? Bait: Pilchard________Squid_________Other_________________________

Section B: (Catch and Effort)

What time did you start fishing?_________ What time do you anticipate you will stop fishing?_________Time now?________

How many times have you gone fishing in the last 7 days?_______, month?_______ and in the last 12 months? __________

Do you ever fish at night?_______, What percentage of your outings? ____

Which fishing club do you belong to?_____________________________Years fishing?_____________________________

Section C: (Attitude to management)

Do you collect any bait yourself? Y / N If Y, Specify?____

Which of the following regulations, in your opinion, are effective in managing our fish stocks? (Y/N) MinimumSizelimits?_____ Baglimits___________Closedseasons?____________MarineReserves?___________ BeachVehicleBan?_______________

Ever kept undersize fish?_________More than your bag limit?__________Kept fish in a closed season?________________

Fished in a closed area?_____________Driven on the beach illegally?____

Have you ever sold your catch? Y / N, how many times in the last 12 months?_____________________________________

What type of fish are you targeting? (List top 3)____

	Target 1	Target 2	Target 3	
Species:				Score______
Minimum size				9
Bag limit:				
Closed season:				

Have you ever been checked by a fisheries inspector/EKZNW? Y / N If Y, how often in the last 12 months?______________

Do you think that EKZNW does a good job managing the shore fishery in KZN? Y / N, Why?_________________________

How/Where did you find out about the fishing regulations?____

Section D (Economics)

What is your occupation?________________ Employed_________Unemployed________Retired_________Scholar_______

Where do you live ?____Nationality_________________________________

Are you on a day?_______, overnight/ wknd?_______,or longer trip/holiday (i.e. staying away from home)?_____________

If on a overnight/ wknd or longer trip/holiday, where are you staying?____

How far did you travel to come fishing today (Kilometers one way)?____

How much did you spend on bait for this fishing outing?____

What is the estimated value of your R&S fishing tackle? (i.e. what would they sell for?)_______________________________

Why do you fish (rank)? Recreation_______Competition_______Livelihood_______Other____________________________

What do you normally do with your catch (rank)? Eat_____GiveAway_____Release______Sell______Other_____________

Section E (General)

Have you ever caught a tagged fish? Y / N, If Y, did you report the tag to? ORI / EKZNW / Other_______________________

Did you receive feedback from ORI?____

Compared to 10 years ago, do you fish more or less often today? More / Less / Same / <10, why?______________________

Do you think fishing has deteriorated over the years? Y / N / UNSURE, if yes what is the cause of this decline? Pollution________Siltation__________Seinenetting_________Gillnetting_________ Trawling______________ Overfishing (commercial) ______Overfishing (recreational) _______ClimateChange_______Other______________________

Do you participate in any other form of fishing? Y / N, If Y, specify? Estuary______Skiboat________Spearfishing________ Cast-netting_______Marineaquariumfishing_______Freshwater________Other_____________________________________

Do you have a recreational fishing permit? Y / N In possession? Y / N / UNSURE / Bought at: P.O. / EKZNW / OTHER

License Types?____

Comments:

Appendix V- Catch composition of 523 commercial boats checked along the KZN coast during 390 access-point surveys conducted between October 2008 and September 2009 (arranged in alphabetical order by family name). Note that released fish were not included in CPUE calculations.

Family	Species	Common Name	# Kept	%	CPUE #*	g kept	%	CPUE weight**
Carangidae	*Caranx spp.****	Unspecified kingfish	1	<0.01	<0.001	2000	<0.01	0.001
	Seriola lalandii	Giant yellowtail	3	<0.01	0.001	32000	0.03	0.010
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	181	0.11	0.059	1036000	0.84	0.339
Dinopercidae	*Dinoperca petersi*	Cavebass	526	0.33	0.172	897000	0.73	0.293
Haemulidae	*Plectorhinchus chubbi*	Dusky rubberlip	1	<0.01	<0.001	3000	<0.01	0.001
	*Plectorhinchus spp.****	Unspecified rubberlip	17	0.01	0.006	52000	0.04	0.017
Labridae	*Bodianus bilunulatus*	Saddleback hogfish	1	<0.01	<0.001	1000	<0.01	<0.001
Lethrinidae	*Lethrinus nebulosus*	Blue emperor	7934	4.93	2.595	4050000	3.29	1.325
Lutjanidae	*Aprion virescens*	Green jobfish	1	<0.01	<0.001	7000	0.01	0.002
	Lutjanus sanguineus	Blood snapper	15	0.01	0.005	22000	0.02	0.007
	*Lutjanus spp.****	Unspecified snapper	47	0.03	0.015	76000	0.06	0.025
	Paracaesio xanthura	Protea bream	79	0.05	0.026	150000	0.12	0.049
	Pristipomoides filamentosus	Rosy jobfish	110	0.07	0.036	164000	0.13	0.054
Mullidae	*Parupeneus spp.****	Unspecified goatfish	5	<0.01	0.002	6000	<0.01	0.002
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	148	0.09	0.048	709000	0.58	0.232
	Argyrosomus thorpei	Squaretail kob	743	0.46	0.243	749000	0.61	0.245
	Atractoscion aequidens	Geelbek	588	0.37	0.192	3017000	2.45	0.987
Scombridae	*Euthynnus affinis*	Eastern little tuna	2	<0.01	0.001	5000	<0.01	0.002
	Scomberomorus commerson	King mackerel	2	<0.01	0.001	5000	<0.01	0.002
	Thunnus albacores	Yellowfin tuna	43	0.03	0.014	254000	0.21	0.083
Serranidae	*Epinephelus albomarginatus*	Captain fine rockcod	439	0.27	0.144	1096000	0.89	0.359
	Epinephelus andersoni	Catface rockcod	1053	0.65	0.344	3848000	3.12	1.259
	Epinephelus marginatus	Yellowbelly rockcod	246	0.15	0.080	1560000	1.27	0.510
	Epinephelus rivulatus	Halfmoon rockcod	910	0.57	0.298	311000	0.25	0.102
Sparidae	*Boopsoidea inornata*	Fransmadam	36	0.02	0.012	16000	0.01	0.005
	Cheimerius nufar	Santer	36045	22.42	11.791	30982000	25.15	10.135
	Chrysoblephus anglicus	Englishman	1509	0.94	0.494	2595000	2.11	0.849
	Chrysoblephus cristiceps	Dageraad	15	0.01	0.005	37000	0.03	0.012
	Chrysoblephus lophus	False englishman	24	0.01	0.008	29000	0.02	0.009
	Chrysoblephus puniceus	Slinger	106031	65.95	34.685	65320000	53.02	21.367
	Cymatoceps nasutus	Black musselcracker	140	0.09	0.046	1456000	1.18	0.476
	Diplodus hottentotus	Zebra	1	<0.01	<0.001	1000	<0.01	<0.001
	Pachymetopon aeneum	Blue hottentot	3035	1.89	0.993	3153000	2.56	1.031
	Pachymetopon grande	Bronze bream	82	0.05	0.027	149000	0.12	0.049
	Polyamblyodon germanum	German	8	<0.01	0.003	14000	0.01	0.005
	Polysteganus coeruleopunctatus	Blue skin	308	0.19	0.101	627000	0.51	0.205
	Polysteganus praeorbitalis	Scotsman	444	0.28	0.145	758000	0.62	0.248
	Porcostoma dentata	Dane	8	<0.01	<0.001	3000	<0.01	0.001

* Fish.angler^{-1}.hour^{-1}
** Kg.angler^{-1}.hour^{-1}
*** Species that were only identifiable to genus level in the field.

Appendix VI- Catalogue composition of 561 recreational boats checked along the KZN coast during 390 access-point surveys conducted between October 2008 and September 2009 (arranged in alphabetical order by family name). Note that released fish were not included in CPUE calculations.

Family	Species	Common Name	# Caught	# Kept	%	CPUE #*	g Kept	%	CPUE weight**
Ariidae	*Galeichthys trowi*	Natal seacatfish	17	9	0.19	0.005	18146	0.22	0.010
Balistidae	*Sufflamen fraenatus*	Bridle triggerfish	2	0	<0.01	<0.001	0	<0.01	<0.001
Carangidae	*Caranx ignobilis*	Giant kingfish	1	1	0.02	0.001	3000	0.04	0.002
	Caranx sem	Blacktip kingfish	5	4	0.08	0.002	14548	0.17	0.008
	Caranx sexfasciatus	Bigeye kingfish	2	0	<0.01	<0.001	0	<0.01	<0.001
	*Caranx spp.****	Unspecified kingfish	3	3	0.06	0.002	34000	0.40	0.019
	Lichia amia	Garrick	1	1	0.02	0.001	3000	0.04	0.002
	Scomberoides tol	Needlescaled queenfish	3	0	<0.01	<0.001	0	<0.01	<0.001
	Seriola lalandii	Giant yellowtail	15	15	0.31	0.008	166000	1.97	0.093
	Seriola rivoliana	Longfin yellowtail	3	2	0.04	0.001	2154	0.03	0.001
	Trachurus delgoa	Maasbanker	99	27	0.56	0.015	2003	0.02	0.001
Carcharhinidae	*Carcharhinus limbatus*	Blacktip shark	2	1	0.02	0.001	16668	0.20	0.009
	Rhizoprionodon acutus	Milkshark	1	0	<0.01	<0.001	0	<0.01	<0.001
Clupeidae	*Etrumeus teres*	East coast roundherring	204	202	4.20	0.113	14423	0.17	0.008
	Sardinops sagax	South African pilchard	6	6	0.12	0.003	656	0.01	<0.001
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	123	123	2.56	0.069	820319	9.75	0.457
Dinopercidae	*Dinoperca petersi*	Cavebass	76	76	1.58	0.042	119153	1.42	0.066
Elopidae	*Elops machnata*	Ladyfish	2	2	0.04	0.001	17764	0.21	0.010
Ephippidae	*Platax teira*	Longfin batfish	1	0	<0.01	<0.001	0	<0.01	<0.001
Haemulidae	*Plectorhinchus spp***.*	Unspecified rubberlip	5	5	0.10	0.003	5000	0.06	0.003
	Pomadasys kaakan	Javelin grunter	22	12	0.25	0.007	11325	0.13	0.006
	Pomadasys olivaceum	Pinky / Olive grunt	5	0	<0.01	<0.001	0	<0.01	<0.001
Istiophoridae	*Istiophorus platypterus*	Sailfish	1	1	0.02	0.001	32000	0.38	0.018
	Makaira mazara	Blue marlin	2	2	0.04	0.001	262000	3.11	0.146
Labridae	*Thalassoma spp.*	Unspecified wrasse	1	1	0.02	0.001	2000	0.02	0.001
Lethrinidae	*Lethrinus crocineus*	Yellowfin emperor	1	1	0.02	0.001	523	0.01	<0.001
	Lethrinus nebulosus	Blue emperor	432	432	8.98	0.241	304000	3.61	0.169
	*Lethrinus spp.****	Unspecified emperor	1	0	<0.01	<0.001	0	<0.01	<0.001
Lutjanidae	*Aprion virescens*	Green jobfish	5	5	0.10	0.003	12000	0.14	0.007
	Paracaesio xanthura	Protea bream	15	15	0.31	0.008	25008	0.30	0.014
	Pristipomoides filamentosus	Rosy jobfish	3	3	0.06	0.002	4000	0.05	0.002
Mullidae	*Parupeneus rubescens*	Blacksaddle goatfish	1	1	0.02	0.001	387	<0.01	<0.001
	*Parupeneus spp.****	Unspecified goatfish	11	11	0.23	0.006	9000	0.11	0.005
Muraenidae	*Gymnothorax spp.****	Unspecified eel	1	0	<0.01	<0.001	0	<0.01	<0.001
Pomatomidae	*Pomatomus saltatrix*	Elf	89	35	0.73	0.020	14777	0.18	0.008
Rachycentridae	*Rachycentron canadum*	Prodigal son	1	0	<0.01	<0.001	0	<0.01	<0.001
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	17	17	0.35	0.009	114000	1.35	0.064
	Argyrosomus thorpei	Squaretail kob	29	29	0.60	0.016	24000	0.29	0.013
	Atractoscion aequidens	Geelbek	13	13	0.27	0.007	68490	0.81	0.038
	Otolithes ruber	Snapper kob	5	2	0.04	0.001	1356	0.02	0.001
	Umbrina robinsoni	Tasselfish / Baardman	1	1	0.02	0.001	3000	0.04	0.002
Scombridae	*Acanthocybium solandri*	Wahoo	2	2	0.04	0.001	25855	0.31	0.014
	Auxis thazard	Bullet tuna/frigate	2	2	0.04	0.001	564	0.01	<0.001
	Euthynnus affinis	Eastern little tuna	202	183	3.80	0.102	413419	4.91	0.230
	Katsuwonus pelamis	Skipjack tuna	9	8	0.17	0.004	17566	0.21	0.010
	Sarda orientalis	Striped bonito	5	5	0.10	0.003	7000	0.08	0.004
	Scomber japonicus	Mackerel	258	256	5.32	0.143	30393	0.36	0.017
	Scomberomorus commerson	King mackerel	45	45	0.94	0.025	286528	3.40	0.160
	Scomberomorus plurilineatus	Queen mackerel	123	122	2.54	0.068	358989	4.27	0.200
	Thunnus albacares	Yellowfin tuna	358	356	7.40	0.198	1828594	21.73	1.019
Serranidae	*Cephalopholis sonnerati*	Tomato rockcod	6	2	0.04	0.001	1904	0.02	0.001
	Epinephelus albomarginatus	Captain fine rockcod	51	50	1.04	0.028	167519	1.99	0.093
	Epinephelus andersoni	Catface rockcod	161	151	3.14	0.084	363477	4.32	0.203
	Epinephelus flavocaeruleus	Yellowtail rockcod	1	1	0.02	0.001	6000	0.07	0.003
	Epinephelus marginatus	Yellowbelly rockcod	41	36	0.75	0.020	140488	1.67	0.078
	Epinephelus rivulatus	Halfmoon rockcod	95	93	1.93	0.052	50508	0.60	0.028
Sillaginidae	*Sillago sihama*	Silver sillago	3	0	<0.01	<0.001	0	<0.01	<0.001
Sparidae	*Boopsoidea inornata*	Fransmadam	6	6	0.12	0.003	3000	0.04	0.002
	Cheimerius nufar	Santer	198	168	3.49	0.094	165877	1.97	0.092
	Chrysoblephus anglicus	Englishman	211	211	4.38	0.118	362589	4.31	0.202
	Chrysoblephus cristiceps	Dageraad	3	3	0.06	0.002	5000	0.06	0.003
	Chrysoblephus lophus	False englishman	4	4	0.08	0.002	4000	0.05	0.002
	Chrysoblephus puniceus	Slinger	1647	1631	33.89	0.909	1190056	14.14	0.663
	Cymatoceps nasutus	Black musselcracker	34	33	0.69	0.018	429447	5.10	0.239
	Diplodus hottentotus	Zebra	3	2	0.04	0.001	2000	0.02	0.001

	Diplodus capensis	Blacktail	2	2	0.04	0.001	1568	0.02	0.001
	Pachymetopon aeneum	Blue hottentot	147	147	3.05	0.082	165212	1.96	0.092
	Pachymetopon grande	Bronze bream	34	34	0.71	0.019	52000	0.62	0.029
	Pagellus bellottii natalensis	Sand soldier	118	0	<0.01	<0.001	0	<0.01	<0.001
	Polyamblyodon germanum	German	10	10	0.21	0.006	12074	0.14	0.007
	Polysteganus coeruleopunctatus	Blue skin	46	46	0.96	0.026	47138	0.56	0.026
	Polysteganus praeorbitalis	Scotsman	108	108	2.24	0.060	131157	1.56	0.073
	Polysteganus undulosus	Seventy-four	2	0	<0.01	<0.001	0	<0.01	<0.001
	Porcostoma dentata	Dane	36	36	0.75	0.020	20467	0.24	0.011
	Rhabdosargus sarba	Natal stumpnose	2	0	<0.01	<0.001	0	<0.01	<0.001
Sphyraenidae	*Sphyraena jello*	Pickhandle barracuda	1	1	0.02	0.001	200	<0.01	<0.001
Synodontidae	*Saurida undosquamis*	Largescale lizardfish	1	0	<0.01	<0.001	0	<0.01	<0.001
Teraponidae	*Terapon jarbua*	Thornfish	4	0	<0.01	<0.001	0	<0.01	<0.001

* Fish.angler^{-1}.hour^{-1}
** Kg.angler^{-1}.hour^{-1}
*** Species that were only identifiable to genus level in the field.

Appendix VII- Catch composition of 234 charter boats checked along the KZN coast during 390 access-point surveys conducted between October 2008 and September 2009 (arranged in alphabetical order by family name). Note that released fish were not included in CPUE calculations.

Family	Species	Common Name	# Caught	# Kept	%	CPUE #	g Kept	%	CPUE weight
Ariidae	*Galeichthys trowi*	Natal seacatfish	10	10	0.16	0.007	18000	0.18	0.012
Carangidae	*Caranx spp.****	Unspecified kingfish	11	11	0.18	0.008	21000	0.22	0.014
	Seriola lalandii	Giant yellowtail	3	3	0.05	0.002	26000	0.27	0.018
	Seriola rivoliana	Longfin yellowtail	1	1	0.02	0.001	3000	0.03	0.002
Coryphaenidae	*Coryphaena hippurus*	Dolphinfish	15	15	0.24	0.010	99000	1.02	0.068
Dinopercidae	*Dinoperca petersi*	Cavebass	21	21	0.34	0.014	19174	0.20	0.013
Haemulidae	*Plectorhinchus chubbi*	Dusky rubberlip	6	6	0.10	0.004	8357	0.09	0.006
	*Plectorhinchus spp.****	Unspecified rubberlip	10	10	0.16	0.007	13000	0.13	0.009
	Pomadasys kaakan	Javelin grunter	8	8	0.13	0.006	6000	0.06	0.004
Istiophoridae	*Makaira indica*	Black marlin	1	1	0.02	0.001	103000	1.06	0.071
Labridae	*Bodianus bilunulatus*	Saddleback hogfish	6	6	0.10	0.004	7000	0.07	0.005
Lethrinidae	*Lethrinus crocineus*	Yellowfin emperor	6	6	0.10	0.004	3200	0.03	0.002
	Lethrinus nebulosus	Blue emperor	1041	1041	16.72	0.716	685009	7.04	0.471
Lutjanidae	*Aprion virescens*	Green jobfish	8	8	0.13	0.006	46000	0.47	0.032
	Paracaesio xanthura	Protea bream	64	64	1.03	0.044	102406	1.05	0.070
	Pristipomoides filamentosus	Rosy jobfish	96	96	1.54	0.066	194554	2.00	0.134
Mullidae	*Parupeneus cinnabarinus*	Redspot goatfish	1	1	0.02	0.001	362	<0.01	<0.001
	*Parupeneus spp.****	Unspecified goatfish	32	32	0.51	0.022	34000	0.35	0.023
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	1	1	0.02	0.001	9000	0.09	0.006
	Atractoscion aequidens	Geelbek	18	18	0.29	0.012	124000	1.27	0.085
	Umbrina robinsoni	Tasselfish / Baardman	3	3	0.05	0.002	11000	0.11	0.008
Scombridae	*Euthynnus affinis*	Eastern little tuna	139	139	2.23	0.096	255085	2.62	0.176
	Katsuwonus pelamis	Skipjack tuna	1	1	0.02	0.001	5417	0.06	0.004
	Scomber japonicus	Mackerel	30	5	0.08	0.003	498	0.01	<0.001
	Scomberomorus commerson	King mackerel	3	3	0.05	0.002	30771	0.32	0.021
	Scomberomorus plurilineatus	Queen mackerel	3	3	0.05	0.002	10815	0.11	0.007
	Thunnus albacores	Yellowfin tuna	815	815	13.09	0.561	4182000	42.96	2.878
Serranidae	*Cephalopholis sonnerati*	Tomato rockcod	2	2	0.03	0.001	2166	0.02	0.001
	Epinephelus albomarginatus	Captain fine rockcod	69	69	1.11	0.047	171800	1.76	0.118
	Epinephelus andersoni	Catface rockcod	78	78	1.25	0.054	157000	1.61	0.108
	Epinephelus marginatus	Yellowbelly rockcod	34	34	0.55	0.023	155761	1.60	0.107
	Epinephelus rivulatus	Halfmoon rockcod	126	125	2.01	0.086	91635	0.94	0.063
	*Epinephelus spp.****	Unspecified rockcod	1	1	0.02	0.001	1000	0.01	0.001
Sparidae	*Boopsoidea inornata*	Fransmadam	31	31	0.50	0.021	38437	0.39	0.026
	Cheimerius nufar	Santer	155	155	2.49	0.107	107123	1.10	0.074
	Chrysoblephus anglicus	Englishman	501	501	8.05	0.345	774977	7.96	0.533
	Chrysoblephus cristiceps	Dageraad	18	18	0.29	0.012	49000	0.50	0.034
	Chrysoblephus lophus	False englishman	7	7	0.11	0.005	7000	0.07	0.005
	Chrysoblephus puniceus	Slinger	2142	2142	34.40	1.474	1076030	11.05	0.741
	Cymatoceps nasutus	Black musselcracker	33	33	0.53	0.023	316000	3.25	0.217
	Diplodus hottentotus	Zebra	2	2	0.03	0.001	2000	0.02	0.001
	Pachymetopon aeneum	Blue hottentot	284	284	4.56	0.195	408661	4.20	0.281
	Pachymetopon grande	Bronze bream	5	5	0.08	0.003	6970	0.07	0.005
	Polyamblyodon germanum	German	9	9	0.14	0.006	8178	0.08	0.006
	Polyamblyodon gibbosum	Cristie	2	2	0.03	0.001	2131	0.02	0.001
	Polysteganus coeruleopunctatus	Blue skin	142	142	2.28	0.098	83648	0.86	0.058
	Polysteganus praeorbitalis	Scotsman	183	183	2.94	0.126	220157	2.26	0.152
	Porcostoma dentata	Dane	73	73	1.17	0.050	35305	0.36	0.024
Synodontidae	*Saurida undosquamis*	Largescale lizardfish	2	2	0.03	0.001	1135	0.01	0.001

* Fish.angler^{-1}.hour^{-1}
** Kg.angler^{-1}.hour^{-1}
*** Species that were only identifiable to genus level in the field.

Appendix VIII- Commercial, charter and recreational skiboat fishing questionnaire.

Questionnaire no.__________________________________ Interviewer____

Section A: (to be completed by interviewer)

Zone:__________Date____________ Boat Reg No:______________BoatName______________________Weather_______

Boat type:_Skiboat / Inflat / Jetski / FishingSki REC / CHAR / COMM Bait: Pilchards_______ Squid__________

Other___________________ Number of crew (including skipper)___________ Estimated Age Range and Crew Codes:

< 15 ( ) 16-30 ( ) 31-45 ( ) 46-60 ( ) > 60 ( )

Section B (Catch and effort- Skipper interview)

Skipper code______ Age____ Where did you launch from?____________Where did you fish?________________________

What time did you start fishing?__________What time did you stop fishing?____

How many times have you gone boat fishing in the last 7 days?_______, month?_______ and in the last 12 months? _______

Is your vessel night rated? Y / N, If Y, What percentage of your outings do you fish at night? ____________________________

Which fishing/skiboat club do you belong to?_________________________________Years boat fishing?_________________

Section c: (Attitude to management)

Which of the following regulations, in your opinion, are effective in managing our fish stocks? (Y/N)

Minimumsizelimits?______Baglimits______Closedseasons?______MarineReserves?_______BeachVehicleBan?__________

Ever kept undersize fish?__________More than your bag limit?____________Kept fish in a closed season?______________

Fished in a closed area?_____________Driven on the beach illegally?____

What type of fish were you targeting today? (include apportion targeting effort %)

Baitfish ____________ Gamefish ____________Reeffish _________ Billfish ____________ Sharks/rays________________

Name 3 species you were targeting today?

	Target 1	Target 2	Target 3	
Species:				Score________
Minimum size				9
Bag limit:				
Closed season:				

Have you ever been checked by a fisheries inspector/EKZNW? Y / N If Y, how often in the last 12 months?_______________

Do you think that EKZNW does a good job managing the skiboat fishery in KZN? Y / N, Why?__________________________

Where/How did you find out about the fishing regulations?____

Section D (Economics)

What is your occupation?__________________ Employed_______Unemployed_______Retired_______Scholar__________

Where do you live?____Nationality____________________________________

Are you on a day?_______ , overnight/ wknd?_______or longer trip/holiday (i.e. staying away from home)?_______________

If on a overnight/ wknd or longer trip/holiday, where are you staying?____

How far did you travel to come fishing today (Kilometers one way)?____

How much did you spend on bait for this fishing outing?____

What is the estimated value of your skiboat fishing equipment? (i.e. what would they sell for?)

Tackle (Rods & Reels etc.)________________ Rig(boat, motors, trailer, GPS, Fish finders, etc.)________________________

Why do you fish (rank)? Recreation______Competition______Livelihood______Other_________________________________

Do you ever take charters? Y / N How many times have you charted in the last 12 months?____________________________

RECREATIONALS

What do you normally do with your catch (rank)? Eat_____GiveAway_____Release______Sell______Other______________

Do you have a recreational fishing permit? Y / N In possession? Y / N / UNSURE / Bought at: P.O. / EKZNW / OTHER

License Types?____

CHARTERS

Is your vessel licensed to take charters (SAMSA)? Y / N On average, how many fisherman do you take?______________

What do you charge per person?___________________________ What do you do with fish caught on a charter trip (rank)?

Sell__________Release______________Keep (food)______________Clients__________Other_____________________

Do you have a recreational fishing permit? Y / N In possession? Y / N / UNSURE / Bought at: P.O. / EKZNW / OTHER

License Types?____

COMMERCIALS

How many crew members do you employ? _______How much do you pay your crew per person per month? _____________

Have you registered any of your crew members on the "crew list"?____

Section E (General)

Have you ever caught a tagged fish? Y / N, If Y, did you report the tag to? ORI / EKZNW / Other_______________________

Did you receive feedback from ORI?____

Compared to 10 years ago, do you fish more or less often today? More / Less / Same / <10, why?_____________________

Appendix IX- All registered skiboat launch sites found along the KZN coast and their associated NMLS area codes (listed from north to south).

Launch site	Area code	Launch site	Area code
Kosi-Bay	3569	Bluff Yacht Club	3961a
Sodwana Bay	3644	Bobbies Angling Club	3961b
Cape Vidal	3709	Fynnlands Angling Club	3961c
St Lucia	3741	Rod and Reel Club	3961d
Mapelane	3743	Pompano Angling Club	3961e
Richards Bay Mereensee	3799	Chain Rocks	3988
Richards Bay	3800	Warner Beach	3991
Navel island	3801	Umkomaas	4006
Umlalazi	3829	Scottburgh	4016
Mtunzini(ramp)	3836	Rocky Bay	4024
Amatikulu	3857	Pennington	4030
Tugela	3875	Sezela	4033
Zinkwazi	3883	Ifafa	4039
Umvoti	3900	Mtwalume	4042
Umhlali	3909	Hibberdene	4051
Christmas Bay	3910	Phumula/Injambili	4064
Salmon Bay	3919	Umzimkulu River	4077
Westbrook	3927	Shelly Beach	4085
Umdloti	3935	Ramsgate	4098
Umhlanga	3944	Glenmore Beach	4114
Vetch's Pier	3960	Port Edward	4121

Appendix X- Minimum legal size and daily bag limits of *Argyrosomus spp*. (Note the slot limit of 110 cm for commercial and recreational boat-fishers).

Region	Commercial	Recreational	
	Offshore Boat	Shore & Estuary	Offshore Boat
Orange River to Cape Agulhas	50 cm (min. size) No bag limit	50 cm (min. size) 5 pppd (bag)	50 cm (min. size) 5 pppd (bag)
Cape Agulhas to Mtamvuna River	50 cm (min. size) No bag limit Only 1 > 110 cm pppd	60 cm (min. size) 1 pppd (bag)	50 cm (min. size) 5 pppd (bag) Only 1 > 110 cm pppd
KwaZulu-Natal	40 cm (size) No bag limit Only 1 > 110 cm pppd	60cm (size) 1 pppd (bag)	40 cm size 5 pppd (bag) Only 1 > 110 cm pppd

Note: pppd = per person per day