Contextualising the bycatch 'problem' in the Olifants Estuary Small-Scale Gillnet Fishery using an Ecosystem Approach to Fisheries

By Wayne Stanley Rice

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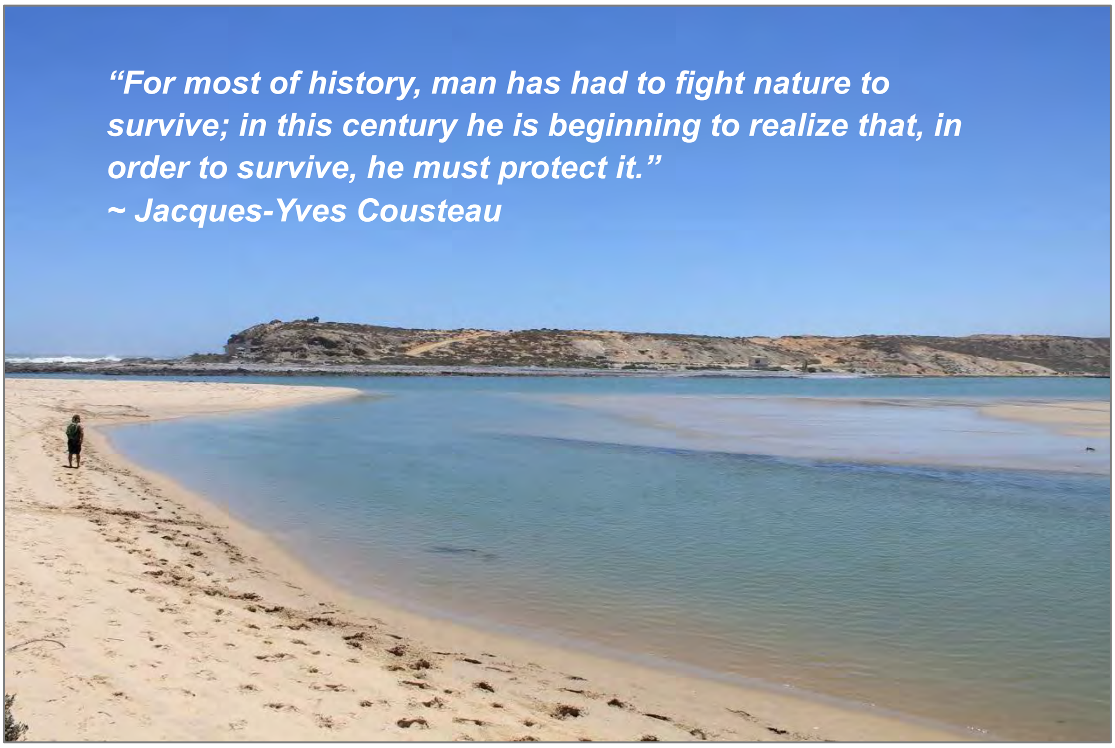
Supervised by Dr. Serge Raemaekers and Assoc. Prof. Merle Sowman

Department of Environmental and Geographical Sciences

University of Cape Town



Picture 2: At the mouth of the Olifants estuary. **Photography:** Nolene Rice.

Declaration

I, Wayne Stanley Rice know the meaning of plagiarism and declare that all the work in this dissertation is my own and has not been previously submitted in part or in whole for a degree or examination. All the sources referenced or quoted in contribution to this work or the works of others have been acknowledged and cited accordingly.

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Abstract

Conventional fisheries management approaches have been shown, in many instances, to have been ineffective in dealing with complex conservation concerns such as bycatch. Greater considerations for broader-scale and holistic approaches, as proposed by the *'Ecosystem Approach to Fisheries'* (EAF) and the '*balanced harvesting approach'*, are beginning to challenge some of the negative misconceptions around bycatch, especially in small-scale fisheries. The need for a more holistic approach to fisheries management, particularly in small-scale fisheries, in South Africa is highlighted by its commitment to an EAF and the recent *Small-Scale Fisheries Policy*, for which the *Marine living Resource Act* of 1998 provides the legal framework to implement. The case study of the Olifants estuary small-scale traditional gillnet fishing community, located on the west coast of South Africa, provides a particularly relevant example of a complex fishery requiring a holistic approach. Current regulations prohibit the harvesting or retention of any bycatch species. Fisheries management worldwide and in South Africa, generally view gillnet fisheries as destructive, due to the occurrence of bycatch and the fact that many of these bycatch species are considered overexploited, which has led to numerous attempts over the years to phase out the Olifants gillnet fishery.

The purpose of this study was to, firstly, use an EAF framework to contextualise the issue of bycatch in the Olifants gillnet fishery, and secondly, to identify the relative contributions of all fisheriy sectors to the four key selected linefish species caught as bycatch by the fishery. An extensive review and analysis of available secondary data, as well as primary data collected for this study, have estimated, with acknowledged limitations, the magnitude of the exploitation by all known fisheries of these species. Key information from small-scale fisher interviews and community-monitoring data highlight the capture rate of key linefish species by this fishery. This is echoed by recent landings for 2012 indicating the relative contribution of the national beache seine and gillnet fishery to the overall catch of (Elf [*Pomatomus saltatrix]* – 26.94%; Silver Kob [*Argyrosomus inodorus]* – 0.88%; White Stumpnose [*Rhabdosargus globiceps*] – 1.05% - excluding the recreational sector). A significant finding of this study is the substantial levels of cross-sectorial exploitation of Silver Kob and White Stumpnose, and to a somewhat lesser extent Elf and White Steenbras.

The greatest pattern of overlapping exploitation by multiple fisheries of these species is represented by *Silver Kob* in both historical (commercial line- and trawl-fishery peak landings of 1769 t in 1938 & 1303 t in 1926 respectively) as well as more recent catches (i.e. commercial line- and trawl-fishery of 214.7 t & 119.8 t respectively for 2012). Furthermore, its popularity endures within the recreational fishery sector (i.e. especially in the Southern Cape –percentage of respondents targeting [81.8%] and commonly catching [45.5%]; and in the Western Cape [targeting - 86.4%]). Existing as three separate established stocks the species is of both national, but perhaps more importantly, regional management concern, most notably in the Southern Cape region where it is heavily exploited by the commercial inshore trawl-, and line-fishery, and the recreational linefishery.

White Stumpnose provides a further example of overlapping exploitation, with significant and consistent catches being made in the commercial line-, and inshore trawl-fishery both historically (respective peak landings of 540 t in 1925 & 80-100 t in the 1930s – subject to identification issues) and more recently (commercial line- and trawl fishery 38.5 t & 49.5 t respectively in 2012). In addition, it is a favoured

recreational linefishery species, particularly in the Western Cape (86.4% targeting) and more specifically along the west coast (targeting and commonly catching 71.4% and 42.9% respectively). These exploitation patterns will have regional concerns due to the proposed existence of four separate stocks, most notably once again for the Southern Cape, and the Western Cape.

Elf is the most prominent bycatch species of the Olifants gillnet fishery, but has additionally formed a principle component of the national commercial linefishery both historically (peak of 90 t in 1928) and more recently (10.8 t in 2012) and its popularity as a recreational linefishery species persists especially in KwaZulu Natal (80-90% targeting and commonly catching rating). Elf's distribution range spans the entire South African coastline and is recognised to make large scale migrations to spawn, indicating that the species requires both regional and national management strategies across all fisheries.

White Steenbras represents an example of failed efforts to curb overfishing, most likely as a result of historical overharvesting (commercial line- and trawl-fishery peak landings of 123 t in 1929 & 270 t in 1938, respectively) and its continued recreational popularity (Southern and Eastern Cape targeting ratings of 54.6% and 51.3% respectively). Due to it being proposed as one well-mixed stock, regional fishing pressures (i.e. most notably in the Southern Cape) have most likely led to its current '*Endangered*' IUCN Red Listing.

The present study has estimated the levels of exploitation by the commercial line- and trawl-fishery, of these key linefish species, to be orders of magnitude greater than that of the national beach seine and gillnet fishery, in general, and more specifically the Olifants gillnet fishery. Consequently, the closure of the Olifants gillnet fishery would not necessarily address conservation concerns of these important linefish species. The fact that this fishery, known to capture juvenile linefish species, requires continuous monitoring is undisputed; however, in accordance with EAF thinking and practice it is essential that holistic considerations of the magnitude and extent of the cross-sectorial exploitation of species by all fisheries (in addition to other social-ecological components) be taken into account to address complex issues such as bycatch. Greater ecosystem considerations may lead to more sustainable management of these natural resources, which will better balance the need to provide for human wellbeing whilst avoiding adverse ecological consequences.

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"And once the storm is over, you won't remember how you made it through, how you managed to survive. You won't even be sure, whether the storm is really over. But one thing is certain. When you come out of the storm, you won't be the same person who walked in. That's what this storm's all about."

Haruki Murakami – *contempory Japanese writer*

Picture 3: Fishing boats at Olifantsdrif. **Photography:** Wayne Rice.

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List of Acronyms, Abbreviations and Units

ANC	African National Congress
AfrOBIS	African node of OBIS (see below)
BNP	Big Numbers Project
cm	Centimetres
CPUE	Catch Per Unit Effort
CT	Cape Town
DAFF	South African Department of Agriculture, Forestry and Fisheries (Fisheries Department formerly known as MCM – see below)
DEAT	South African Department of Environmental Affairs and Tourism (Presently known as DEA – Department of Environmental Affairs)
DWAF	South African Department of Water Affairs and Forestry (Presently known as DWA – Department of Water Affairs – after Forestry having moved to DAFF – see above)
EAF	Ecosystem Approach to Fisheries
EC	Eastern Cape Province
EEU	Environmental Evaluation Unit (housed at UCT)
FAO	Food and Agricultural Organisation of the United Nations
FIHB	Fishing Industry Handbook
hr	Hour
ICES	International Council for the Exploration of the Sea
IUCN	International Union for the Conservation of Nature
kg	Kilogram
km	Kilometre
KZN	KwaZulu Natal Province
KZNCAU	KwaZulu Natal Coastal Angling Union (Provincial Recreational Fishing Association)
MCM	South African Department of Marine and Coastal Management
MLRA	Marine Living Resources Act of 1998
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
OBIS	Oceanographic Biogeochemical Information System
OEMP	Olifants Estuary Management Plan
ORI	Oceanographic Research Institute

ORP	Olifants River Project
RASSPL	Rock and Surf Super Pro League (National Recreational Fishing Competitions)
RSA	Government of the Republic of South Africa
SA	South Africa
S.A.D.S.TI.A.	South African Deep Sea Trawling Industry Association
SAEON	South African Environmental Observation Network
SBPR	Spawner-Biomass-Per-Recruit
SC	Southern Cape (region)
S.E.C.I.F.A.	South East Coast Inshore Fishing Association
SFTG	Subsistence Fisheries Task Group
SS	Small-Scale
SSF	Small-scale fisheries
t	tons
TL	Total Length
UCT	University of Cape Town
WC	Western Cape Province
WCSAA	West Coast Shore-Angling Association (Regional Recreational Fishing Association)
WSSD	World Summit on Sustainable Development
ZAR	South African Rand

List of Fish Species Nomenclature

Note: The species in blue represent the focus of this study. All common names found in databases utilised for this study are included for convenience.

Scientific Name	Common Name/s
Argyrozona argyrozona	**Carpenter**
Argyrosomus inodorus	**Silver Kob** also referred to as **Kabeljou** and **Kabeljaauw**
Argyrosomus hololepidotus	**Kob**
Argyrosomus japonicus	**Dusky Kob**

Note: *Misidentification of Kob species was common until recently (see Griffiths and Heemstra, 1995) and the above three Kob species were often recorded as one Kob species in the past*

Austroglossus pectoralis	**Agulhas Sole**
Callorhinchus capensis	**St Joseph sharks**
Engraulis encrasicolus	**Anchovy**
Galeichthys ater	**Barbel**
Lichia amia	**Garrick** also referred to as **Leervis**
Lithognathus lithognathus	**White Steenbras** also referred to as **Steenbras**
Liza richardsonii	**Southern Mullet** also referred to as **harders**
Merluccius capensis	**Shallow-water cape hake**
Mugil cephalus	**Flathead Mullet** also referred to as **Springer**
Pomatomus saltatrix	**Elf** also referred to as **Shad**
Rhabdosargus globiceps	**White Stumpnose** also referred as **Stumpnose**
Sardinops sagax	**Sardine**
Seriola lalandi	**Yellowtail**

Chapter 1: Introduction

1.1 Introduction and Rationale

Human populations are often concentrated in coastal areas, for resource access reasons, and consequently coastal ecosystems are some of the most impacted and transformed (Burke et al., 2001; Harrison & Pearce, 2001). Coastal areas embody some of the most important environments for diverse interactions amongst human activity, socio-economic influence, and ecological diversity (Fabbri, 1998; Glaser et al., 2012; Glaser & Glaeser, 2014). An important example of an integral human interaction found within coastal ecosystems is that of wild capture fisheries. Wild capture fisheries represent a key contributor to food security and livelihoods, particularly in developing countries where small-scale fisheries are abundant (Béné & Heck, 2005; Béné et al., 2010; Hall et al., 2013; McClanahan et al., 2013). Small-scale fisheries contain most of the world fishers (FAO, 2005; BNP, 2009) and are the main source of food and livelihoods for millions of people and this is particularly true for developing nations (Béné & Heck, 2005; Sowman, 2006). In Africa, marine and inland fisheries are estimated to contribute towards the food security of 200 million Africans, in addition to the income of 10 million engaged in after catch commercial activities (Béné, 2003, 2004; Béné & Heck, 2005). With good governance practices these fisheries have been suggested by some to possess a greater capacity in meeting the growing human demand for animal protein sustainably, than that of terrestrial sources (Godfray et al., 2010; Pereira et al., 2010; Pelletier et al., 2011; FAO, 2012a). These fisheries nonetheless continue to be considered ineffectively regulated and inadequately quantitatively studied (Mahon, 1997; Pauly, 1997; Berkes et al., 2001; Castello et al., 2007, cited in Castello et al., 2011; Chuenpagdee & Pauly, 2008). A lack of knowledge on these dynamic, diverse, and complex social-ecological systems has led to their neglect, and ineffective monitoring and management. They are often overlooked by many fisheries managers as most fishing nation's major focus to date, including that of South Africa, has been commercial fisheries (McGoodwin, 1990; Kent, 1997; Berkes et al., 2001; Viswanathan et al., 2003; FAO, 2003a).

In the past two decades, however, the economic and socio-cultural value of this sector in realising sustainable development goals has been more widely acknowledged and received greater international, regional and national attention (McGoodwin, 1990, 2001; Kent, 1997; Berkes et al., 2001; FAO, 2002, 2003, 2005; Satia, 2002; Cockcroft et al., 2002; Béné & Heck, 2005; Andrew et al., 2007). This sector has proven difficult to define and the terms such as subsistence, traditional, artisanal and small-scale are often used interchangeably to describe this sector (McGoodwin, 1990, 2001; Satia & Hansen, 1994; Hauck, 2002). 'Subsistence' refers to fishers that rely on fish mainly for food but may trade surplus catches to meet their other basic needs (Sowman, 2006). 'Artisanal' in contrast, according to McGoodwin (1990), refers to fishers who possess skill, experience, and intuition in the art of fishing. 'Small-scale' is more commonly used to distinguish between intensive large-scale commercial fishing and the low technology and labour intensive smaller scale of fishing (see for e.g. Panayotou, 1982; Charles, 1991, 2001; Aguero, 1992). Small-scale is the term used more generally in the literature and incorporates all fishing including pre- and post-harvest activities from subsistence through traditional artisanal fishers all the way to formal sector fishing initiatives (Sowman, 2006) and is used as such in this study. Fishing activities, whether full or part-time are not identical across countries (Berkes et al., 2001;

McGoodwin, 2001; FAO, 2002b), and therefore small-scale fisheries will need to be socio-culturally and economically defined within each context (Sowman, 2006). Small-scale fisheries, encompassing all activities along the value chain, play an especially important role in food security and nutrition, poverty eradication, equitable development and sustainable resource utilisation (FAO, 2015).

According to Kolding & van Zwieten (2011), the current fisheries management discourse is supported by two fundamental narratives each with global impacts, namely: the fear of the negative impacts of *open access* regimes; and the condemnation of the consequences of catching *undersized* and *immature* fish. In addressing the first narrative, fears of open access regimes are in accordance with the rationale of Hardin's much referenced '*Tragedy of the Commons'* where he argued that, "freedom in a commons brings ruin to all' (Hardin, 1968: p1244). Open access continues to be considered unsustainable in essentially all the disciplines addressing resource management, whether economic, political, social, anthropological or ecological. With regards to the second narrative, fishing represents an inherently highly selective process, with fishers deliberately targeting specific species, within specific size classes of populations, during specific times of the year and in selected areas in order to maximize their short-term catch rates and profitability (Zhou et al., 2010). This is determined by market demand and increasing regulations derived from many single-species management models.

Some fishery scientists suggest that small-scale fisheries in developing countries employ wasteful and unselective fishing practices, ignore imposed gear regulations and legislation, and are subject to "*Malthusian overfishing*"[1] (Pauly, 1990, 1994; Amar et al., 1996; McClanahan et al., 2008), resulting in the need for management and regulation. However, many scholars would agree that the failure of conventional fisheries management approaches, such as top-down[2] and single-species approaches[3] (with insufficient consideration for human dimensions – see Fullon et al., 2011), in countless global fisheries, ought to be held responsible for a number of overfished populations as well as the indirect effects of fisheries on marine ecosystems (Berkes et al., 2001; Mullon et al., 2005; Worm et al., 2009; Branch et al., 2011; Ricard et al., 2012). It is argued that these management regimes have failed to achieve their principal goal of sustainability (Botsford et al., 1997; McConney & Charles, 2009; Sowman, 2011). The extent of the declines in global fish stocks, from industrial fisheries in particular, has been questioned by others however, who view these recent perspectives as 'alarmist' (Mace, 2004; Hilborn, 2007). The limitations of conventional fisheries management approaches thus far, while debatable, are frequently attributed to their primary focus being the maximizing of a single target species catch, which is undeniably motivated by economic and political factors, at the expense of other ecosystem components, ecosystem interactions and complex human dimensions (Pikitch et al., 2004; Vert-pre et al., 2013; Skern-Mauritzen et al., 2015). This lack of consideration of ecosystem approaches in fisheries management is thought to have contributed to world overfishing and stock depletion (Murawski, 2000). Nonetheless, the conventional single-species management approach still represents the dominant fisheries management concept (Morishita, 2008).

The principle practice of concentrating fishing mortality on a narrowly determined subclass of targets within the community is being progressively challenged by many advocating a more '*balanced harvesting*' approach (Conover & Munch, 2002; Bundy et al., 2005; Frid et al., 2006; Fenberg & Roy, 2008; Zhou et al., 2010; Rochet et al., 2011; Garcia et al., 2011, 2012, 2015; Law et al., 2012, 2014, 2015). In small-scale fisheries the capturing of juveniles is viewed as depleting the stocks and due to growing concern for discarded bycatch in single-species industrial fisheries (Kelleher, 2005; Lewison et al., 2009; FAO, 2011) and the protection of vulnerable or endangered species (Lewison et al., 2004), emphasis has been placed on selectivity as a management strategy. The selection of species and sizes by fishers is usually based on practical, economic, or regulatory reasons (Garcia et al., 2012). Although the concept of 'balanced harvesting' has recently been put forward, greater selectivity continues to be advocated as the panacea to prevent overfishing and to rebuild collapsed stocks (Bundy et al., 2005; Grafton et al., 2007; Zhou et al., 2010; Garcia et al., 2012; Law et al., 2012, 2015) and is highlighted in the 'FAO Code of Conduct framework' (Bianchi, 2008; FAO, 2011). Less selective harvesting patterns have been shown in principle to be ecosystem conserving (Kolding & van Zwieten, 2011), subject to the life history characteristics of the species of concern, although Garcia et al. (2012) suggest that balanced harvesting can be more selective than traditional management approaches.

Current fishing effort has led to concerns regarding the negative impacts on not only target species but also vulnerable non-target species and habitats (Chuenpendagee et al., 2003; Lewison et al., 2004; Stewart et al., 2010). The incidental catch of individuals of a species or population which are not the primary target of harvesting is termed *bycatch*. Bycatch can also comprise the incidental take of undesirable size or age classes of the target species, and therefore can be thought of as encompassing unharmed, released with injuries, or killed individuals (Lewison et al., 2004). Moreover, bycatch encompasses a wide spectrum of marine fauna, including fish, seabirds, marine mammals, turtles and benthic invertebrates (Davies et al., 2009) and relates to harvesting pressure (Barbraud et al., 2013). Globally bycatch is currently a contentious issue within fisheries, as the general perception of the role of bycatch is that it leads to the degrading of marine ecosystems, making it one of the most important global nature conservation issues at present (Hall et al., 2000; Lewison et al., 2004; Harrington et al., 2006), with serious food-security implications for up to one billion people who depend on fish as their principal source of protein (The World Bank, 2008).

However, bycatch in South African fisheries is regulated and in certain cases marketable (i.e. the inshore trawl fishery). Bycatch is often viewed in light of its wastage and its effects on biodiversity, to both top predators and prey (Hall et al., 2000). However, as opposed to the majority of commercial fishery catches, the bycatch of small-scale fisheries, particularly in Africa and Asia, is often kept by fishers, who view it as a food source, and therefore cannot be considered wastage (Alverson et al., 1994). Although some progress has been made in estimating the impact of harvesting bycatch species at the demographic, evolutionary and population level, limited research on the consequences of bycatch persists (Lewison et al., 2004). This is essential to effectively manage all sources of fishing mortality, including retained target catch, retained and discarded catch of non-targeted species, and unobservable mortalities (FAO, 1995, 2003a, 2011a; Hall et al., 2000; Gilman, 2011; Gilman et al., 2012), in order to prevent the degradation of living marine resources and minimise socio-economic impacts.

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[1] ***Malthusian overfishing*** is defined in this context in accordance with Pauly (1990) as the continued harvesting of fish beyond sustainable levels, and the partaking in destructive fishing practices to maintain catches.

[2] ***Top-down management approaches*** refer to state or institution enforced regulations or governance strategies which govern stakeholders (see Nielsen & Vedsmand, 1999)

[3] ***Single-species approaches*** employ operational objectives related to controlling the effects of fishing on target species (Jennings, 2006).

The dependence of fishers on a resource already perceived to be degraded, has led to the increasing realisation within fisheries management and development policies of the need to sustain small-scale fisheries in developing countries (Allison, 2003). Small-scale fisheries are increasingly being referred to as *complex social-ecological systems,* comprising multiple components that interact on multiple spatial and temporal levels, and at multiple scales (Berkes et al. 2001, 2003; Kooiman et al., 2005; Castilla and Defeo, 2005; Ostrom, 2005; Garcia & Charles, 2008; McClanahan et al., 2009; Basurto et al., 2013; Kittinger et al., 2013). This comes as a result of attempts to better understand fishery systems by acknowledging their structure as comprising numerous interacting components, including: ecological, biophysical, economic, social and cultural components (Charles, 2001). The reliance on conventional scientific approaches (i.e. single-species/ single-sector) for the understanding of these complex social-ecological systems can therefore be limiting (Cilliers, 1998; Ravetz, 2004) and consideration of other knowledge systems and social science approaches is required (Sowman, 2011). The Ecosystem Approach to Fisheries (EAF) represents an integrated and holistic approach to fisheries management with the objective of balancing ecological and human well-being, and is epitomised by the avoidance of adverse ecological and socio-economic consequences in fisheries (FAO, 2003a). The current emphasis on EAF is evidence of progress toward recognising the holistic nature of fisheries systems and the complex linkages that characterise them (Garcia et al., 2003; FAO, 2003b). Nevertheless, operational fisheries management is still largely on a single-species basis, with the principal challenge facing nations worldwide being, how to incorporate more complex arrays of ecosystem considerations, including social dimensions, into fisheries management (Shannon et al., 2006a). EAF emphasises the need to confront human dimensions such as socio-economic and institutional issues in fisheries management and governance (Shannon et al., 2006b), however, the incorporation of such dimensions into practical management decisions and protocols remains poor (Paterson & Peterson, 2010).

The above mentioned notions strongly apply within the South African fisheries context. South Africa possesses some of the most productive coastal marine ecosystems in the world; most notably the Benguela current influenced west coast (Cochrane et al., 2009). The country's coastal resources provide food and livelihoods for tens of thousands of coastal dwellers, in addition to supporting a prosperous industrial sector, mainly in the south western region of the country (Sowman et al., 2014). The South African small-scale fishery sector is particularly complex due to its diverse bio-physical, socio-economic and cultural characteristics, accompanied by the variety of governance arrangements existing along its approximately 3 000 km coastline (Sowman, 2011). The diversity present is further emphasised from the west to the east coasts with regards to target species, gear, and the role fishing plays within the social and livelihood contexts of coastal communities. Notwithstanding the variety of fishing practices and economies represented among small-scale fishers in coastal settlements across South Africa, high levels of poverty and unemployment are prevalent, with limited opportunities for alternative livelihoods outside that of fishing (SFTG, 2000; Branch et al., 2002; Cardosa et al., 2005; Glavovic & Boonzaier, 2007). The goal of addressing inequity and encouraging broader participation in the fisheries sector is underlined in the *White Paper of 1997* and carried through to the *Marine Living Resource Act* (MLRA) of 1998 (RSA, 1998), which legally recognized subsistence fishers for the first time and required participation of resource users in decision-making (Sowman & Cardosa, 2010). The concept of equitable distribution of resources is represented as a key principle within the EAF guidelines (FAO, 2009), when referring to the need to preserve "*intergenerational equity*" which is mentioned in the context of improving human well-being and equity. The recognition of subsistence fishers in legislation was initially seen as a major step forward to incorporating previously marginalised fishers into the formal fisheries governance process. However, given the restrictions on subsistence fisheries in terms of the sale of catch, the need to identify a further category of small-scale fishers became apparent (Sowman, 2006). This was eventually achieved with the promulgation of the new Small-Scale Fisheries Policy in South Africa (DAFF, 2012a). Moreover, the need for a more holistic approach to fisheries management in South Africa is highlighted by its commitment to an EAF in the MLRA (Cochrane et al., 2009) which is also incorporated in the new *Small-Scale Fisheries Policy* (Sowman et al., 2014).

A particularly relevant example of a South African complex small-scale fishery, requiring a more holistic understanding, can be found at the Olifants Estuary. The Olifants Estuary encompasses a unique and productive coastal ecosystem located on the west coast of South Africa, approximately 350 km north of Cape Town and represents one of only four permanently open estuaries on the west coast (Whitfield, 2000). The estuary possesses significant conservation value in terms of its ecological, social and cultural heritage (OEMP, 2013), and was ranked 3rd in the country in terms of conservation importance by Turpie et al. (2002). The traditional gillnet fishing community present in the area continue to depend on the estuary for a significant component of their livelihoods (Sowman, 2009). Current regulations limit the number of permits, regulate mesh size, and net length and prohibit the harvesting or retention of any bycatch species. Fisheries management worldwide and in South Africa, generally view gillnet fisheries as destructive, due to the occurrence of bycatch and the fact that many of these bycatch species are considered overexploited (Hutchings & Lamberth, 2002a; Mann, 2013). This concern about bycatch has led to numerous attempts over the years to phase out the *Olifants Estuary Small-Scale Gillnet Fishery* (DEAT, 2005; Anchor Consulting, 2008). These efforts have thus far been unsuccessful due to opposition from fishers and support from researchers and non-governmental organisations, seeking recognition of the cultural and socio-economic needs and rights of this community in management decision-making (Sowman, 2009).

Despite much research on the status of the target species, Southern Mullet *(Lisa richardsonii),* and fisher livelihoods, research on bycatch, its uses, and the perceptions of bycatch amongst resource users has not be holistically investigated. A more holistic social-ecological systems understanding of bycatch is required to account for the diverse array of factors influencing this complex fishery system. While some preliminary data on bycatch has been analysed from the community-catch monitoring data, these data may be unreliable due to the fear of legal ramifications from fishers (Soutschka, 2014). Thus, a more holistic analysis of bycatch using an EAF framework is needed. An important aspect of an EAF would be to understand the relative contribution of the Olifants Estuary Gillnet Fishery to the overall exploitation of selected bycatch species occurring nationally, in comparison to other fishery sectors, and subject to life history characteristics and possible separate stocks. In addition, several human activities, taking place in estuaries and their catchment areas impact directly on estuarine biodiversity and resources, and are often in conflict with one another through such impacts (Lamberth & Turpie, 2003), and while beyond the scope of this study would also require consideration.

1.2 Aim and Objectives:

The overall aim of this study is to gain a more holistic understanding of the bycatch issue in the Olifants Estuary Small-Scale Gillnet Fishery using an *Ecosystem Approach to Fisheries* with a view to making management recommendations.

Furthermore the objectives of the study are:

1. To describe the *socio-ecological* characteristics of the Olifants estuary small-scale gillnet fishery with emphasis on bycatch;
2. To employ an *Ecosystem Approach to Fisheries* to better understand the bycatch issue in the Olifants gillnet fishery and in particular:
   a. review and analyse the existing data on the key selected linefish species caught by the Olifants gillnet fishery;
   b. identify other fisheries impacting on the selected linefish species and assess their relative catch contributions to the selected linefish species under consideration in this study;
3. To provide recommendations based on the findings of the study for addressing bycatch in the Olifants estuary small-scale gillnet fishery from a more holistic *Ecosystem Approach to Fisheries* perspective.

1.3 Limitations of the study

Several limitations were encountered in this study. The lack of data on certain sectors, most notably the recreational linefish sector, posed a problem. Within the time and budget available an attempt was made to address this by conducting a local roving creel survey in the Olifants estuary and surrounding area. However, this exercise produced limited data due to the lack of fishers encountered, and the subsequent launch of an online national recreational survey, which received support from national and provincial organisations as well as local communities, better informed the relative contribution of this sector to these selected species, although with its own limitations. Additional concerns existed with the use of secondary data as all datasets are subject to human error and bias, in addition to possible inaccuracy issues associated with reported figures, and these factors needed to be taken into consideration. The mistrust of fishers for the research was of a minor concern, with some recreational fishers encountered being somewhat evasive. This was avoided with small-scale fishers for the most part due to extensive previous work done within this community by the University of Cape Town (UCT), and the associated Environmental Evaluation Unit (EEU), however, certain fishers did at times seem wary of their answers particularly pertaining to the sensitive issue of levels of bycatch. A challenge in any fisheries research is the unpredictable nature of fishing and thus the availability of respondents, with fishing conditions always the determining factor. However, local small-scale fishers were found to be most accommodating and helpful. Conditions and seasonal factors coupled with the limited time frame of the study also prevented extensive participant observation opportunities. Further limitations, challenges and associated ethical concerns are addressed in Chapter 4.

1.4 Structure of the Dissertation

This dissertation comprises seven chapters. Chapter one provides an overview of the dissertation by providing a brief introduction and background to the study, in addition to introducing the case study site. Furthermore, it describes the research rationale, and aims and objectives of the study. Chapter two encompasses a review of relevant literature in order to establish the foundation for the research approach taken and to inform the discussion of the findings of this study. Chapter three presents a review of literature pertaining to South African small-scale fisheries, the case study site in particular, and the fisheries known to capture the selected linefish species of this study. Chapter four describes the research methods utilised for data collection and analysis as well as their limitations, challenges experienced and the associated ethical concerns of the study. Chapter five presents the findings of the study describing those pertaining to the Olifants estuary small-scale gillnet fishery as well as species specific findings from the relative contributions of other known species-related fisheries of concern. Chapter six provides a discussion of the findings, while Chapter seven concludes the study and suggests a way forward.

Chapter 2: Literature Review

In this chapter the relevant literature relating to the understanding of small-scale fisheries as complex social-ecological systems is presented and reviewed, in addition to introducing the use of EAF as a framework to accomplish this level of understanding. This provides the foundation for, and informs the research approach to, contextualising the issue of bycatch in small-scale fisheries and specifically in the Olifants estuary small-scale gillnet fishery.

2.1 Understanding small-scale fisheries as complex social-ecological systems

2.1.1 Complex Social-Ecological Systems

According to Berkes et al. (2003) natural and social systems are themselves complex, but many of our current natural resource and environmental problems involve greater complexity due to interactions between these systems (Norgaard, 1994; Berkes & Folke, 1998). Jasanoff et al. (1997) note that complexity provides significant challenges to disciplinary approaches as contributing factors are various and diverse, and are therefore difficult to understand or manage. Kooiman & Bavinck (2005) describe complexity as a function of the construction of relationships among parts of the system, and the system and its environment. The necessity to emphasise the integrated nature of the relationship of *humans-in-nature* is stressed by Berkes et al. (2003) when they refer to *social-ecological systems* and *social-ecological linkages*. Social-ecological systems are complex systems, comprising multiple contributing components that interact on multiple levels and at multiple scales. Garcia & Charles (2007) describe a fishery system as representing a *plexus of subsystems* and forming part of the broader natural and human systems, which are affected by the global environment, economy, and society within which it exists. The systemic nature of fisheries has been clearly underlined in the literature of the recent past (Rothschild, 1971; Allen & McGlade, 1986; Charles, 1995). The integration of the available understanding into operational management, however, has been "slow and patchy" (Garcia and Charles, 2007: p580).

Small-scale fisheries are increasingly being referred to as *complex social-ecological systems* (Berkes et al. 2001, 2003; Kooiman et al., 2005; Castilla & Defeo, 2005; Ostrom, 2005; Garcia & Charles, 2008; McClanahan et al., 2009; Basurto et al., 2013; Kittinger et al., 2013). This comes as a result of attempts to better understand fishery systems by acknowledging their structure as comprising numerous interacting components, including: ecological, biophysical, economic, social and cultural factors (Charles, 2001). The significant components characteristic of a typical fishery system include: the ecological system, consisting of fish, physical processes, and ecosystemic components and interactions; the social system, consisting of fishers, post-harvest fish workers, fisher households and communities, and markets; and the governance system, including institutional structures and arrangements such as policies, rules, management systems, stakeholders and rights holders, as well as rights allocation procedures (Sowman, 2011). However, the ability to understand such a complex and uncertain system is proving challenging (Parravicini et al., 2012). Undeniably, fishery system complexity and unpredictability has long plagued fishery managers (Walters, 1986). Crowder & Norse (2008) refer to our ability to understand an isolated population, but that populations behave differently within the contexts of their ecosystems.

The framework of understanding of fisheries as complex social-ecological systems is based on concepts and principles found in *general systems theory* (von Bertalanffy, 1968) and *complexity theory* (Kauffman, 1993; Cilliers, 1998). Fundamental to the understanding of complex systems is the recognition that interactions among the components cannot be understood through the isolated analysis of each of the individual component parts. The non-linear interactions among components, occurring across multiple temporal and spatial scales result in emergent properties, which contribute to the unpredictable nature of these systems and therefore the need for a more holistic and comprehensive approach (Cilliers, 1998; Berkes et al., 2001; Gunderson, 2003). The holistic understanding of small-scale fishery systems can therefore only occur by obtaining a thorough understanding of their historical, social, economic and political context (Sowman, 2011), in addition to their ecological context.

The Olifants estuary small-scale gillnet fishery can be viewed as a *complex social-ecological system*, with multiple components and actors (discussed in more detail throughout this study) interacting and affecting the system as a whole through feedback mechanisms. As these systems are constantly evolving, their past is largely responsible for their present behaviour (Cilliers, 1998). The reliance on conventional scientific approaches (e.g. single-species or single-sector) for the understanding of these complex social-ecological systems can therefore be limiting (Cilliers, 1998; Ravetz, 2004) and consideration of other knowledge systems and social science approaches is required (Sowman, 2011). A social-ecological systems understanding of the exploitation of marine resources within these complex systems is therefore required in order to holistically address contextually diverse problems such as bycatch, which are best described by Rittel & Webber (1973) as '*wicked problems*'.

2.1.2 The Need for a Social-Ecological Systems Understanding: Limitations of current conventional management approaches

The *control of effort or 'management belief'* discourse (Jul-Larsen et al., 2003), is based on the past theorical image among some ecologists that ecosystems are closed entities in equilibrium, or at least in a process of striving for equilibrium, with limited resources (Jul-Larsen et al., 2003). Within this understanding humans and their interventions (e.g. fishing) are generally not considered part of the natural pristine environments and are therefore regarded as an external disruption with significant effects, that affect the productivity of the system (Kolding & van Zwieten, 2011). While this discourse has a long history and largely dictated the abstract mathematical modelling framework, which was characteristic of certain components of recent fisheries science (Rose, 1997; Angelini & Moloney, 2007), much progress has been made to move away from this thinking. The biological foundation of fisheries resource management was extended to include *economic theory* (Gordon, 1954), referring to *common property* problems, i.e. open access. Gordon (1954) argued that any *common property* *resource* where competitive exploitation under diminishing returns (e.g. decreased catch per unit effort [CPUE][4]) is uncontrolled, would ultimately lead to poverty because the harvesting would end yielding no economic profit. This is captured by Gordon (1954: p135) when he states: "Wealth that is free for all is valued by none . . . the fish in the sea are valueless to the fisherman, because there is no assurance that they will be there for him tomorrow if they are left behind today." Hardin (1968) made use of the same rationale to develop the '*Tragedy of the Commons'* where he believed that, "freedom in a commons brings ruin to all' (Hardin, 1968: p1244), as mentioned previously. Fisheries in particular are considered one of the classic examples of the '*Tragedy of the Commons'* (Berkes, 1985; Benjamin, 2001). However, these management discourses have failed to capture the inherent complexity that exists within fishery systems. Experiences with community involvement in resource management, such as *community-based management* (Berkes, 1995; Sowman, 2003; Armitage, 2005), *adaptive co-management* (Carpenter and Gunderson, 2001; Olsson et al., 2004a, 2004b) and *adaptive governance* (Dietz et al., 2003, Folke et al., 2005) suggest that an alternative to the government-centred approach of the past is required (Jul-Larsen et al., 2003). Nonetheless, current conventional fisheries management approaches have in many instances failed to effectively deal with the complexities and uncertainties that are known to exist within fishery systems, and therefore, the use of a social-ecological systems approach is preferred as it facilitates better understanding and management of modern fishery problems (e.g. the issue of bycatch). The Ecosystem Approach to Fisheries (EAF) represents the formulation of such a social-ecological systems approach, specific to fishery systems management, and is discussed in the following section.

2.2 The Ecosystem Approach to Fisheries Management

2.2.1 The Need for an EAF: Ecosystemic effects of marine fisheries

Substantial declines in fish stocks from global industrial fisheries, although hotly contested, has been documented by numerous recent researchers (Mullon et al., 2005; Worm et al., 2009; Branch et al., 2011; Ricard et al., 2012). Yet, the exploitation of fish populations has been viewed in isolation within conventional fishery science and management approaches with regards to the physical, chemical and biological environment (Goñi, 1998). An applied appreciation of the niches that exploited fish populations fill and the biological interactions in stock assessment models has been slow in developing (ICES, 1988; Fernandes et al., 2013). The ecosystemic impacts of fishing can be divided into indirect and direct effects. Indirect effects include the impacts of destructive fishing methods, such as habitat destruction, and changes to species, community and ecosystem structure (Goñi, 1998). Direct effects include overfishing, and more specifically the mortality of target fish species, in addition to the mortality of bycatch species. Both impacts, discussed briefly below, are however inherently difficult to characterise due to their uncertain and complex nature, in addition to their responses to multiple unknown feedback mechanisms over large areas and over unknown temporal scales.

[4] ***Catch per unit of fishing effort*** (CPUE) is the total catch divided by the total amount of effort used to harvest the catch and can be represented by a variety of units (e.g. the number of hours spent fishing or number of boat days, among others).

2.2.1.1 Indirect effects: Habitat Destruction; Competition and Predation; and Changes to Community and Ecosystem structure

A major threat to the maintenance of environmental integrity is that of habitat destruction, which is caused almost exclusively by human activities, including fishing (Claudet & Fraschetti, 2010). The world's marine environments are being subjected to increasingly and often unregulated anthropocentric perturbations (Lotze et al., 2006; Boero & Bonsdorff, 2007; Halpern et al., 2007, 2008). Such perturbations can lead to the homogeneity of ecosystems due to reductions in the complexity of food-webs, diversity within community groups, biogenic habitat structure, and size of organisms (Airoldi & Beck, 2007; Airoldi et al., 2008; Dulvy et al., 2008). Habitat destruction is considered the most persistent threat to marine coastal ecosystem diversity, structure, and functioning (Lotze et al., 2006; Airoldi et al., 2008; Halpern et al., 2008). Habitat loss or fragmentation can also lead to the worsening of overfishing by reducing the possible fishable areas or by decreasing the productivity of marine environments (Newton et al., 2007). Human-induced stressors on marine environments include aquaculture, water degradation, destructive fishery activities, species invasion, urbanization and increased sedimentation (Claudet & Fraschetti, 2010).

Indirect ecosystemic effects of marine fisheries additionally include those mediated by biological interactions, such as competition and predation. Many fishery managers have become aware of the impacts of fishing, and especially overfishing, on the entire length of a food chain (see Pauly et al., 1998), through competition and predation (Sherman, 1991). The effects of environmental conditions climb upward through a system to meet the effects of fishing cascading down from the top, known as the *trophic cascade model* (Paine, 1980; Daan, 1989; McQueen, 1986). It is for this reason that it is problematic to separate natural and anthropocentric causes observed at different levels of an ecosystem. Furthermore, the evaluation of the impacts of fisheries on fish communities is challenging (Hilborn & Ludwig, 1993) in that the existence of control sites, i.e. where fishing has not occurred or had an impact, are essentially non-existent., although McLaren et al. (2015) are not in agreement with this statement and provide an example of an Australian no-take marine protected area (established in 1988), which could fulfil this role for experimentation of protection mechanisms for bycatch species. Therefore attributing current characteristics or patterns in fisheries to particular events is problematic (ICES, 1996). The selective removal of some species alters the physical support for communities (ICES, 1996). The replacement of dominant species, driven to low levels, by another species can result in cascading effects on other components of the ecosystem and ultimately lead to ecosystem regime shifts (Lees et al., 2006; Möllmann & Diekmann, 2012; Möllmann et al., 2015; Pershing et al., 2015). Two examples of extreme regime shifts exist in the Baltic Sea (Möllmann et al., 2009), and the Yellow Sea (Jin & Tang, 1996). In pelagic marine ecosystems, biomass flips in species abundance seem to be attributed to density independent environmental changes, in contrast to dominance flips in several continental shelf marine ecosystems which seem to be attributed to density-dependent predation, including the practice of fishing (Sherman, 1989). Examples of past changes in species composition of marine ecosystems abound (Goeden, 1982; Duran & Castilla, 1989; Quero & Cendrero, 1996). Changes observed differ in direction and intensity but suggest that marine communities respond to exploitation and/or habitat destruction through complex interactions and feedback mechanisms (Goñi, 1998; Auster et al., 2013). Increasingly studies are being undertaken to better understand community and ecosystem structures and the effects of exploitation thereof, and are providing greater evidentiary support for an EAF approach (Hartvig et al., 2011).

2.2.1.2 Direct effects: Overfishing and Bycatch

The concept of *overfishing* has been acknowledged internationally as early as 1890, was the subject of the *London Conference on Overfishing* in 1946 (Prattis, 1978; Goñi, 1998), and has developed into a dominant issue within most global fisheries. Harvesting has been shown to change the demographics of selected exploited fish stocks (Myers et al., 1995), and the evolution of heritable traits (Law, 2000; Walsh et al., 2006). Three primary effects of overexploitation of fishing can be observed through effects to population size; demographic structure; and genetic diversity. The initial observable effects of fishing are the declines in biomass of target species. Most common exploitation strategies involve increasing fishing effort up to the level of maximum sustainable yield (MSY)[5] or a slightly lower precautionary level in line with traditional bio-economic approaches (Schaefer, 1954; 1957). Species specific life history characteristics determine at what level fishing effort is at risk of exploiting the biological stock, which requires knowledge of the species population, often only obtained once stocks are seen to be becoming too low (Gislason, 1994). The species-specific life history and additional biological characteristics will be dealt with in greater detail within Chapter 5, and preceed the findings of each species.

Past fisheries management has shown that it is very difficult to reduce fishing effort before commercial extinction of the target stock occurs (Hilborn & Walters, 1992; Ludwig et al., 1993; Cook et al., 1997). Effects of fishing on population size are dependent on the characteristics of the target species including, life span, population growth, and fecundity (Goñi, 1998). Past theories have stipulated how species with short life spans, rapid population growth and high fecundity (i.e. *r-selected species*) can react quickly to fishing and may sustain high levels of mortality at young ages. On the contrary, species which assign more energy to individual growth, due to competitive fitness, than to reproduction (i.e. *k-selected species*) and exhibit low natural mortality, will support fairly low rates of fishing mortality and at older ages (Pianka, 1970; Gislason, 1994).

Whilst the vulnerability of species with *k-selected* life-history strategies, endemism within restricted ranges, and sporadic recruitment to fisheries overexploitation is well established; even species with high fecundity and broad distributions can be unsustainably exploited (Hall et al., 2000; Pauly et al., 2002; Gilman et al., 2011). Winemiller & Rose (1992) have proposed a contempory life history theory, which has been regarded by some to have replaced past r-k continuum theories. They define three strategies, namely: *opportunistic* (small, rapidly maturing, short-lived fishes), *periodic* (larger, highly-fecund fishes with long life spans), and *equilibrium* (fishes of intermediate size that often exhibit parental care and produce relatively few, large offspring).

[5] ***Maximum sustainable yield*** is the number (or mass) of a species that can be removed from the stock without impacting the long-term stability of the population.

Conventional fishery management approaches have targeted the removal of larger and older fish from populations. However, this causes alterations to the size and age structure of an exploited population (Ricker, 1963; Rosemberg & Brault, 1991; Bonhsack, 1992; Garcia et al., 2012; Canales et al., 2015). The reasons for this size fixation are both economic and biological. Economic factors include the marketability of species and sizes. The biological reasons can be divided into: the *propagation theory*, i.e. fish should be given at least one opportunity to reproduce before they are caught; and the *growth theory*, i.e. fish should not be caught before they have achieved their growth potential (Sissenwine & Shepherd, 1987; Cushing, 1976; Petersen, 1894). Propagation theory assumes that because fish may escape when young that they will contribute to future catches when mature (Fulton, 1890; Holt, 1895). However, under the *growth-overfishing* concept, old large mature individuals will be targeted for harvest, even though a healthy biomass of mature individuals, or the *spawning stock biomass*, would be required to safeguard the future of the stock against the risk of *recruitment overfishing*, or reducing its fecundity (Larkin, 1978; King & McFarlane, 2003). The reduction in numbers of larger fish and of their reproductive potentials leads to decreases in *stock spawning potential*[6] (see Wallace & Fletcher, 2001). Species with low fecundity and high age of first maturity will be affected by the highest number of reductions in spawning potential for a given level of effort (Brander, 1981; Gislason, 1994; Walker, 1996). An additional concern of this target strategy is the effects on genetic diversity, which needs to be considered when assessing levels of exploitation (Goñi, 1998). Fishing potentially alters the genetic structure of exploited populations (Bonhsack, 1992; ICES, 1996; Kuparinen & Hutchings, 2012; Pukk et al., 2013). Consequently, the impoverishment of the genetic makeup of a population has been postulated to lead to reductions in their homeostatic properties (May, 1994; Swain, 2011; Kuparinen & Hutchings, 2012; Pukk et al., 2013).

Hall et al. (2000) refer to the subdivision of fisheries catch into two main components: *target catch* and *non-target catch*, the latter including the *incidental catch* of other species which may be retained because of their economic value. According to McCaughran (1992) non-target or *bycatch* can be defined as that portion of the target catch returned to the sea as a result of economic, legal or personal considerations, as well as retained non-targeted species. In addition, Davies et al. (2009) identify bycatch as the catch that is either unused or unmanaged. Various common fishing practices are highly unselective and therefore bycatch has been shown to be occurring extensively (Alverson et al., 1994; Goñi, 1998; Lewison et al., 2011; Wilson et al., 2014). The rates and types of bycatch are technique specific (Lewison et al., 2011) and subject to contextual factors in particular fisheries. Guidelines on minimum mesh size regulations, for the purposes of promoting immature individuals escapement, have been shown to have limited effectiveness especially in the towing of trawlers (Sangster et al., 1996; Suronen et al., 1996). In addition, the levels of mortality of escaping fish also seem to be very species and size dependent (ICES, 1995). It is also important to specify at this point that the term bycatch includes not only non-target or incidentally caught fish species, as it is used throughout this thesis, but additional organisms, and although beyond the scope of this thesis research into bycatch species of turtle (Wallace et al., 2010; Martin & Crawford, 2015), sea bird (Anderson, O.R. et al., 2011; Žydelis et al., 2013; Regular et al., 2013), shark (Bonfil, 1994; Molina & Cooke, 2012), and marine mammals (Lewison et al., 2014; Werner et al., 2015) is quite extensive.

[6] ***Stock spawning potential*** refers to the principle that enough fish have to survive to spawn and replenish the stock at a sustainable level.

Growing interest in marine resource wastage has led to several studies in order to grasp the extent of bycatch/discards in major world fisheries (Hall et al., 2000; Perez & Wahrlich, 2005; Kelleher, 2005; Davies et al., 2009; Huang, 2011; Lewison et al., 2011). The main contributing factors to discarding include: regulations (e.g. prohibited species or minimum sizes); market economics; and the undifferentiating nature of current fishing methods. Estimations on world discard rate have varied with Saila (1983) providing an estimation of 10% of global catch, or 6.7 million metric tons. Alverson et al. (1994) assessed the discards of global commercial fisheries at the time at approximately 27 million metric tons, which relates to a discard rate of 20% and one-third of the then world landings of 80 million tons reported by the FAO (FAO, 1997). More recently, Kelleher (2005) investigated discards from 1992 to 2001, estimating an average of 7.3 million tons of fish discarded annually, representing 8% of the world catch. Significant reductions in discard levels, shown by recent research, are in part due to increased retention as a result of the development of food and non-food markets for previously discarded species and sizes (e.g. known as "joint products" in the South African demersal hake trawl, discussed in Chapter 3.6; see also S.A.D.S.T.I.A., 2010), but also from increased gear selectivity reducing catch rates of unwanted catch (Kelleher, 2005; FAO, 2012a). However, discards have long been known to be habitually underreported (NPFMC, 1992; Alverson et al., 1994) and therefore mortality of target and bycatch species is severely underestimated, due to high levels of barotrauma and post-release mortality (Yergey et al., 2012; Kerwath et al., 2013; Benoît et al., 2013; Raby et al., 2014). This gives rise to the increased risk of overexploitation and stock depletion; the effects of bycatch and discard mortality being dependent on the characteristics of the impacted species (Alverson et al., 1994). However, as opposed to the majority of commercial fisheries catches, the bycatch of small-scale fisheries in Africa and Asia is often kept by fishermen, as is acknowledged by the fishers in the Olifants gillnet fishery, and therefore cannot be considered wastage (Alverson et al., 1994), but providing a source of much needed nourishment and livelihoods. Discard is therefore not an issue of paramount concern in the Olifants gillnet fishery.

2.2.2 Introduction to EAF: The principles and process

The ecosystem approach to fisheries (EAF) broadens fisheries perspectives to go beyond the conventional focus of "fish and fleets" and places the fishery within the context of three main categories, namely: biotic; abiotic; and human as indicated by Figure 1 below (FAO, 2009). In essence, EAF adopts a holistic s*ocial-ecological systems approach* to understanding the multitude of components interacting within and influencing the system, with regards to fisheries. The concept of an '*ecosystems approach'*, as first expressed in the

UN Convention on Biological Diversity in 1992, can be viewed as a response to the acknowledgement of the need for a greater *systems-orientated* and integrated approach to natural resource management (Sowman, 2011) and a need to move away from single-species fisheries management (Johannes, 1982; Garcia et al., 2003; Pikitch et al., 2004; Link, 2002; Francis et al., 2007). The primary issues of concern for an EAF are the impact of fisheries on the environment, and the impact of the environment on fisheries (Garcia & Cochrane, 2005). According to Garcia & Cochrane (2005) ecosystem impacts of fisheries relate, among others, to target stocks (e.g. abundance, productivity, size and species composition), non-target species (e.g. endangered species, bycatch, and discards), and critical habitats, all discussed previously. Conventional fisheries management approaches up to now have often been unsuccessful, as the principal focus is on maximizing the catch of a single target species, often motivated by economic and political factors, at the expense of other ecosystem components and interactions including: the habitat; and the predators, and prey of the target species (Pikitch et al., 2004; Vert-pre et al., 2013; Skern-Mauritzen et al., 2015).

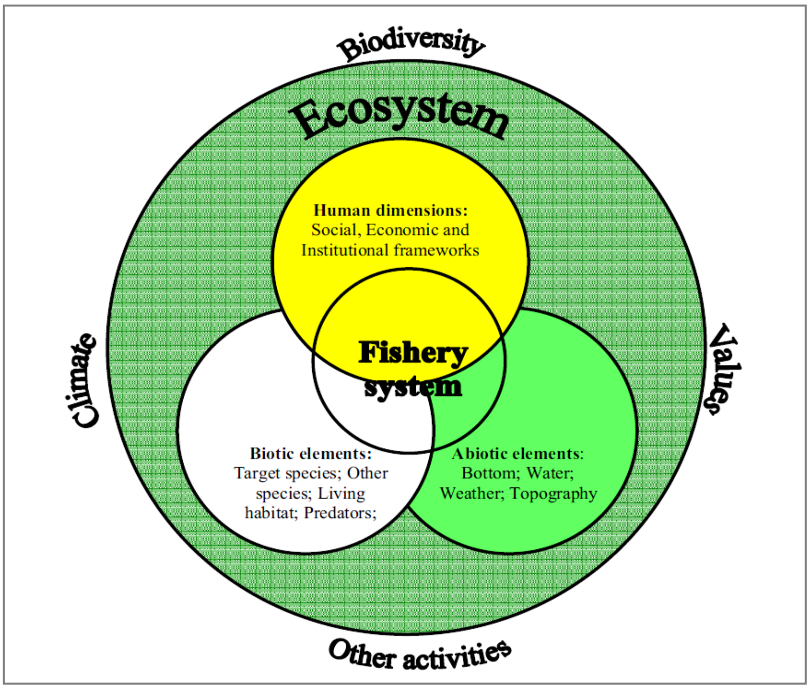

Figure 1: A simplified schematic view of the EAF context. **Source: FAO (2009).**

EAF essentially sets out to reverse management approaches in order to start with the ecosystem rather than the target species. EAF is a process, and refers to: the identification of issues needing to be managed; the formulation of policy; the development of an EAF management plan; the implementation of the designed EAF plan; and its subsequent monitoring and evaluation (FAO, 2009). The need for more ecosystemic consideration in fisheries management was supported by the *Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem,* signed by 47 countries (including South Africa) in 2001 (Cochrane & Doulman, 2005) and further emphasised at *The World Summit on Sustainable Development* (WSSD) in 2002, with several countries, including South Africa, committing to the application of EAF by 2010 (Cochrane et al., 2009). The current emphasis on an EAF is evidence of progress toward recognising the holistic nature of fisheries systems and the complex linkages that characterise them (Garcia et al., 2003; FAO, 2003b), with EAF proposing a framework within which human and nonhuman actors can be taken into consideration for improved fisheries management (Shannon et al., 2010). Nonetheless, operational fisheries management is still largely on a single-species basis, with the principal challenge facing nations worldwide being, how to incorporate more complex arrays of ecosystem considerations, including social or human dimensions, into fisheries management (Shannon et al., 2006a).

The pathway taken to undertake an EAF can vary extensively and the process may be initiated at any point in the EAF planning, development and implementation process (see Figure 2 below). In certain instances EAF may represent a reactive approach in order to deal with a problem issue, rather than comprising a future-orientated long-term planning process that begins with the policy formulation stage (FAO, 2009). In a reactive approach, the development of a locally appropriate solution, through an inclusive and participatory process, may lead to the greater understanding of wider issues present and stimulate a more holistic and comprehensive approach to and rethinking of fisheries management and the application of an EAF within the fishery, when compared to conventional fishery management approaches (FAO, 2009). With regards to the issue of bycatch, path D4 (see FAO, 2009: p14) would represent such a pathway taken in order to address a "crisis" (i.e. bycatch). Whether the issue of bycatch is identified as a crisis or not within the fishery of concern, it can be corrected and thereafter potentially leads to a revision of policy and management within the fishery and elsewhere that incorporates EAF principles (FAO, 2009). Therefore, path D4 may offer a somewhat more practical and more easily implementable solution to addressing fisheries management issues such as bycatch.

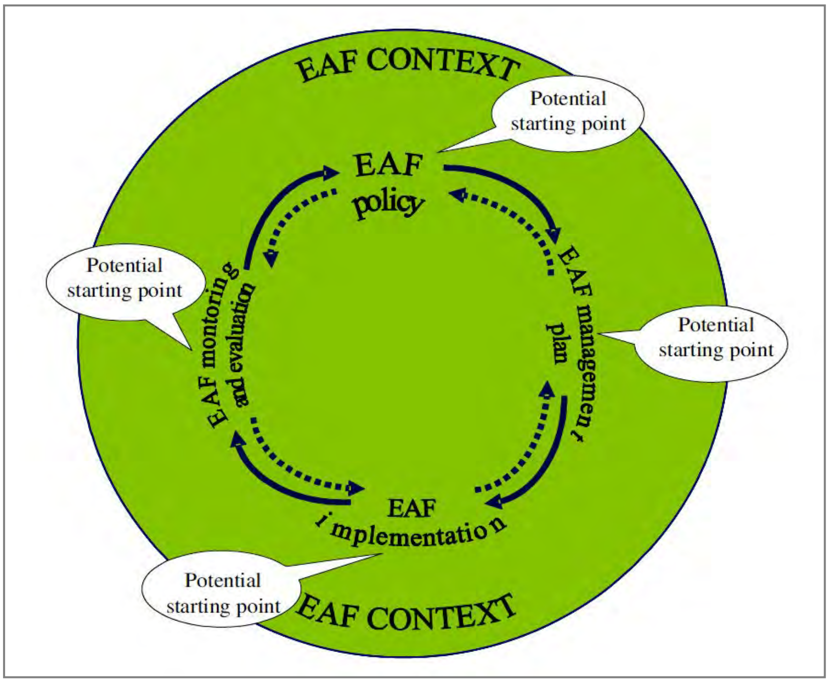

Figure 2: A simplified schematic view of the EAF process and its starting points. **Source: FAO (2009).**

The overall objective of an EAF is to sustain healthy marine ecosystems and the fisheries they support by: avoiding degradation of ecosystems (as detected by indicators of environmental quality and system status); minimising the risk of irreversible alterations to natural species assemblages and ecosystem processes; deriving and sustaining long-term socio-economic benefits whilst avoiding ecosystemic compromise; and producing knowledge of ecosystem processes necessary to understand the probable consequences of anthropocentric activities (Pikitch et al., 2004). These measures should ensure that total biomass removed by all fisheries in an ecosystem does not surpass a total amount of system productivity, after accounting for the requirements of other ecosystem components (e.g. non-target species, protected species, habitat considerations, and various trophic interactions); as maintaining ecosystem characteristics within certain limits may help to preserve ecosystem resilience and avoid irreversible alterations (Pikitch et al., 2004). EAF must therefore seek to define all marine habitats utilized by humans in the context of vulnerability to anthropogenic impacts (i.e. fishing-induced and other human impacts), identify the potential irreversibility of those impacts, and clarify critical habitats for vital population processes of species (Pikitch et al., 2004). The EAF promotes a holistic social-ecological systems approach to fisheries management; however, the implementation of such a holistic approach remains challenging and is discussed in the subsequent section.

2.2.3 The implementation of an EAF

Ward et al. (2002) in attempting to define EAF, refer to the approach as an extension of conventional fisheries management which more clearly recognises the interdependence between ecosystem and human well-being, in addition to the need to maintain ecosystem productivity for present and future generations. EAF therefore intends to improve, but not completely replace, existing management frameworks, and their implementation, in addition to reinforcing their ecological relevance, with the ultimate objective of contributing significantly to achieving sustainable use (Garcia, 2003). The complexity of attempting to implement EAF (expanding on Figures 1 and 2 above) as an extension of conventional fisheries management, into a more ecosystemically inclusive and holistic process, is depicted by Garcia et al. (2003) in Figure 3 below. Special note should be made of the inclusion of 'other species' (i.e. non-target or bycatch species) under biotic factors in Figure 3.

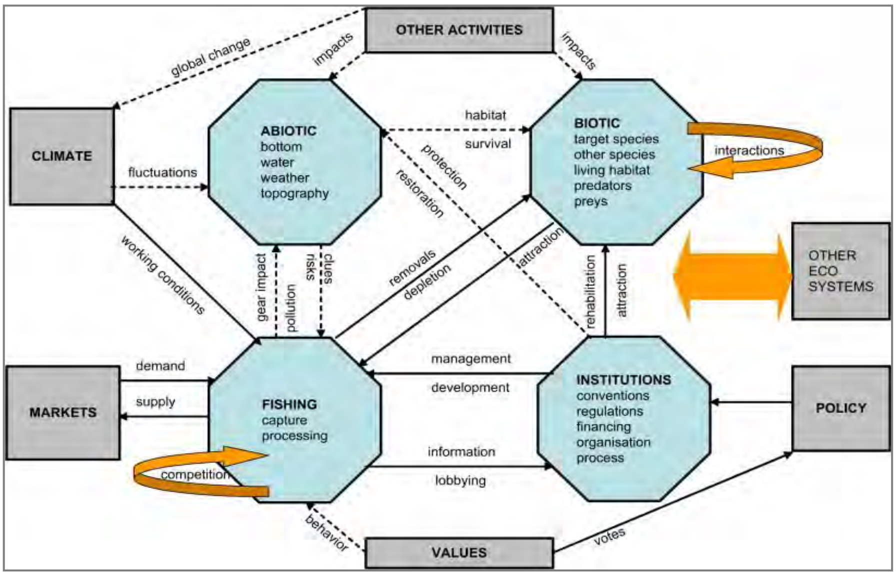

Figure 3: Ecosystem components and interactions addressed by EAF. Elements and interactions represented by solid black lines depict the conventional fishery management approach. Elements and interactions represented by dotted lines are elements of EAF. **Source: Garcia et al. (2003).**

The implementation of EAF is recommended through the use of existing institutional structures, including staff, laws and legislation, and control and compliance mechanisms (Garcia & Cochrane, 2005). Therefore it is possible to evolve the management system without incurring excessive costs, but adopting an EAF assumes political will and co-operation from industry in order to implement changes (Garcia & Cochrane, 2005). The socio-economic status of the fishers and fishing-related industry, and the lack of alternative livelihoods will be one of the biggest challenges in the process (Cochrane, 2000). The implementation of EAF in addition will require national, regional, and local levels to present interconnected policies, strategies, and plans at each institutional level (Garcia & Cochrane, 2005). The inherently higher levels of uncertainty in EAF will also require the governance system to adapt as and when information improves, especially with regards to resource allocation (Cochrane et al., 1998). The implementation of an EAF, presumes an even greater emphasis on the *precautionary approach* (FAO, 1996) due to increased uncertainty compared with *target resource-oriented management* (FAO, 2003b). With regards to the *precautionary principle* (Garcia, 1994) the FAO Technical guidelines (FAO, 1996) relating to capture fisheries and species introductions, suggest that where threats of serious irreversible damage exist a lack of full scientific certainty shall not warrant the postponing of cost-effective measures to prevent environmental degradation and should result in conservative management action being taken until greater knowledge of ecosystem structures and functions is obtained. Under an EAF, this principle is much broader than just environmental degradation, and applies to any undesirable outcome (i.e. ecological, social or economic) and should also be applied in all stages of the management process. The applicability of the precautionary approach to the Olifants gillnet fishery likewise relies on proceeding to attempt to address management issues like bycatch by attempting to overcome significant data gaps and the consolidation of available data from various sources on all relevant fisheries known to capture the four species of this study, as is the objective of this study. Greater emphasis on this point will be made within the discussion in Chapter 6.

It is important to note throughout, that the implementation of EAF is a *human pursuit* taking place within the context of differing societal goals and aspirations, as well as in the presence of varied human forces all needing to be understood and considered (FAO, 2009). These include, but are not limited to: policies, legal frameworks, social structures, cultural values, economic principles, and institutional processes (FAO, 2009). The EAF guidelines also refer to the maintaining of ecosystem integrity, which refers to the maintenance: of biodiversity at all levels (from community through to species and genetic levels); and of the ecological processes supporting biodiversity and resource productivity (FAO, 2009). Furthermore, the guidelines promote the importance of the understanding of species interdependence, which echoes previous comments made here, as well as the statements contained within the *1995 United Nations Fish Stock Agreement*, with significant implications for the management of bycatch.

According to the FAO (FAO, 2009), significant challenges for EAF implementation that exist include: mismatches between expectations and resources, problems reconciling conflicting objectives of multiple stakeholders, insufficient or ineffective stakeholder participation (due to reasons such as mistrust, unwillingness, or a lack of user-rights), cost and lack of adequate capacity, insufficient education and problem awareness, equity issues and the threat of poverty; aligning ecosystem boundaries with jurisdictions, and illegal stakeholder behaviour, including illegal fishing or misreporting..

Regardless of EAF being clearly defined in broadly human-ecological terms (FAO, 2003b); to date there remains a lack of understanding of what the human dimensions of EAF entail (Shannon et al., 2010). In South Africa specifically, the broad-spectrum of problems based on human dimensions in fisheries (Perry et al., 2010) are intensified by its specific history (see Chapter 3.1 below; see also van Sittert and Hauck, 2006). South Africa's commitment to the various international agreements identified above illustrates a willingness to change. While substantial progress has been made towards adopting an EAF in South Africa (Shannon et al., 2004, 2006a & b; Nel et al., 2007; Cochrane et al., 2009, Paterson & Peterson, 2010; Paterson et al., 2010), the main focus remains on improving the understanding of ecosystemic interactions within a particular fishery and determining the ecosystem effects of fisheries (Shannon et al., 2004; Branch & Clark, 2006). Even though there is general recognition for the need to confront human dimensions such as socio-economic and institutional issues in fisheries management and governance (Shannon et al., 2006b), incorporating such dimensions into practical management decisions and protocols remains poor (Paterson & Peterson, 2010). A key principle highlighted within the EAF guidelines (FAO, 2009) refers to the need to preserve "intergenerational equity" which is mentioned in the context of improving human well-being and equity, for present and future generations. Further to the point it should be noted that the implementation of an EAF can be derailed when the social and economic implications of management decisions are not given adequate consideration. The challenge of applying technical measures within the theoretical framework in place for an EAF, in the context of South Africa as a developing nation, has suggested priority should be placed on non-target species of conservation concern (Shannon et al., 2010).

According to Shannon et al. (2010), the two core challenges facing South Africa, in terms of achieving an EAF, are the balancing of conflicting objectives across a diverse range of stakeholders, and the development of mechanisms for incorporating broader scale ecosystem information into existing fisheries management frameworks, which were originally designed to meet single-species management objectives. A focus of South Africa has been multi-disciplinary marine science since the launch of the Benguela Ecology Programme in the early 1980s (Moloney et al., 2004), and remains highly pertinent in the current environment of EAF (Shannon et al., 2004). The policy requirements and practicalities of implementing an EAF in South Africa are highlighted by Cochrane et al. (2004), however, despite strong scientific progress in diverse fields, gaps (including the understanding of bycatch) persist and bridging these will be essential for the progression of an EAF in South Africa.

Chapter 3: Providing context for the study of the Olifants Estuary Small-Scale Gillnet Fishery and other Species-Related Fisheries

This chapter seeks to elaborate on introductions made within Chapter 1 of small-scale fisheries, and more specifically relating to South Africa (i.e. pertaining to its historical, cultural and socio-economic background), and thereafter the case study of the Olifants estuary small-scale gillnet fishery, in order to address the goal of contextualising bycatch in this fishery. Furthermore, in order to adopt an EAF approach to bycatch, consideration of other fisheries known to catch the selected species (the term species-related fisheries has been used interchangeably here), in addition to the introduction of social-ecological drivers (although beyond the scope of this study) is required, and therefore the relevant fisheries are introduced thereafter.

3.1 Providing context: A brief outline of South African Small-Scale Fisheries

Historical evidence suggests that indigenous people have been gathering intertidal resources along the coasts for many thousands of years (Parkington et al., 1988; Thackeray, 1988; Lasiak, 1993; Jeradino & Yates, 1996). In fact, marine resources, including fish, seals and certain invertebrates, have been harvested by coastal dwellers along the west coast of South Africa for at least the past 50,000 years (Parkington et al., 1988; Thackeray, 1988). Whilst these subsistence harvesting patterns have continued along the east coast of South Africa (Clark et al., 2002), colonial exclusion from the 17th century onward, the development of the fishing industry in the 20th century, and the introduction of the racially discriminating apartheid legislation, resulted in the systematic exclusion of apartheid defined *Coloured* and *Black* fishers from legal access to fisheries resources (Hauck, 2002; Sunde, 2004). This led to the creation of an informal sector of designated '*black poachers'*, i.e. the apartheid classification which included *African*, *Indian*, and *Coloured* populations in their definition of 'black' (Penn, 1987; van Sittert, 2003). Subsistence and small-scale fishers were forced to continue harvesting resources either operating illegally or under limited recreational fishing regulations (Sowman, 2006). In the context of these complex governance provisions, the high levels of poverty and the absence of a legitimate rights allocation system (Turner & Meer, 2001), overexploitation of these natural resources took place in certain locations (Hockey et al., 1988; Lasiak, 1991, 1993; Fielding et al., 1994; Cockcroft, 2002).

Increasing fishers' rights to access coastal marine resources and addressing previous injustices have been a goal of the new democratic government (Hatchard & Slinn, 1995). The South African ruling political party, the African National Congress (ANC) stated, with regards to fisheries, that the promise of the new government was, "the upliftment of impoverished coastal communities through improved access to marine resources'' (ANC, 1994: p104). Steps taken to this end included the promulgation of *The Constitution Act 108 of 1996* (RSA, 1996), and numerous other policies and legislation relevant to natural resource management, and fisheries and coastal policies in particular, which have emphasised equitable access to natural resources, access to information, as well as public participation in decision-making and management (Hauck and Sowman, 2001; Sowman et al., 2014). For example, the goal of addressing inequity and encouraging broader participation in the fisheries sector is underlined in the *White Paper of 1997* and carried through to the *MLRA of 1998* (RSA, 1998a), which legally recognized subsistence fishers for the first time (Sowman and Cardosa, 2010), as mentioned previously in Chapter 1. The MLRA specifically states in its objectives, a need for the protection of the needs of poor people who are dependent on marine resources as a source of food or for a modest income (Sowman & Cardosa, 2010). The new category of legally recognized subsistence fishers was originally viewed as a positive step, however, given the government's historic focus on the commercial sector it was poorly prepared to deal with this new sector, which led to the appointment of the Subsistence Fisheries Task Group (SFTG) in 1999 (SFTG, 2000) to assist in an advisory capacity on its future management (Sowman, 2006). A crucial task of the SFTG was to consider the formation of *small-scale commercial fishing sector* as an alternative to *subsistence food harvesting*, where deemed appropriate (Harris et al., 2002). The MLRA provided a modern democratic replacement for the old *Sea Fisheries Act of 1988* (RSA, 1988), which was viewed as outdated (De Young, 2006).

The small-scale fishery sector in South Africa is complex due to its diverse bio-physical, socio-economic and cultural characteristics, accompanied by the variety of governance arrangements existing along its approximately 3 000 km coastline (Sowman, 2011). This diversity is further emphasised from the west to the east coasts with regards to target species, gear, and the role fishing plays within the social and livelihood contexts of coastal communities. Along the west coast small-scale fishing is predominantly boat-based and the fishing activities are labour-intensive (e.g. marine and estuarine seine- and gillnetting; hand-line, and west coast rock lobster fisheries; and the harvesting of kelp, seaweed, and inter- and sub-tidal resources). In contrast, numerous communities along the East Coast harvest marine resources (mainly inter- and sub-tidal resources, e.g. oysters, mussels and limpets) as one of several livelihood options (Sunde et al., 2013) and small-scale fishing activity is exclusively shore-based (Sowman et al., 2013). According to Hara et al. (2008) the most commonly harvested resources, while regionally dependent, include commercial species such as linefish, rock lobster and abalone. Notwithstanding the variety of fishing practices and economies represented among small-scale fishers in coastal settlements across South Africa, high levels of poverty and unemployment are consistent throughout, with limited opportunities for alternative livelihoods outside that of fishing (SFTG, 2000; Branch et al., 2002; Cardosa et al., 2005; Glavovic & Boonzaier, 2007). Household surveys conducted in 20 coastal fishing communities in 1999 – 2000 discovered that there were high levels of food insecurity in all coastal regions of South Africa (SFTG, 2001). Small-scale fishing communities often suffer poor infrastructure and living conditions, and fishing in this sector is considered a low status occupation (Sowman, 2006). However, small-scale fisheries provide for local, national, regional and international markets (e.g. lobster and abalone) and generate important sources of income to support local and national economies (FAO, 2015). According to Glavovic & Boonzaaier (2007), small-scale fisheries still play an important role in meeting food needs in coastal communities and are an integral part of their cultural tradition. South Africa's fishing industry has been largely export-oriented since the early 20th century, and post-apartheid emphasis is still placed on global markets (Crosoer et al., 2006).

The recent *Small-Scale Fisheries Policy* (DAFF, 2012a), promulgated in June 2012, which stemmed from a five year policy development process, indicates an important paradigm shift in the governance of small-scale fisheries in South Africa (Sowman et al., 2014). The introduction to the policy, clearly states the aim of the policy, which is "to provide redress and recognition to the rights of the small-scale fisher communities in South Africa… in order to fulfil the constitutional promise of substantive equality" (DAFF, 2012a; Section 1:10) and the need to adhere to other international agreements, which includes those pertaining to the implementation of an EAF (Sowman et al., 2014). The rollout of this new policy is imminent; however, numerous challenges exist for the implementation of such a revolutionary and paradigm shifting policy (see Sowman et al., 2014). The policy represents a shift away from a *resource-centred* toward a more *people-centred* approach, calls for a *community-orientated* approach to rights allocation and management, and considers marine resources as a source of poverty alleviation (Sowman et al., 2014). The Olifants estuary small-scale gillnet fishery provides an example of one such small-scale fishery in South Africa, which will be affected by the implementation of this policy, and is introduced in the following section.

3.2 Case Study: The Olifants Estuary Small-Scale Gillnet Fishery

3.2.1 Historical, Cultural, Socio-Economic and Management Background

The Olifants Estuary encompasses a unique and productive ecosystem located on the west coast of South Africa approximately 350 km north of Cape Town (see Figure 4 below). The Olifants Estuary represents one of only four permanently open estuaries on the west coast of South Africa (Whitfield, 2000), and is one of the most important estuaries in the country with great conservation value in terms of its ecological, social and cultural heritage (OEMP, 2013). According to Turpie et al. (2002) the conservation importance of the Olifants Estuary, as calculated on the basis of weighted size, habitat, zonal type rarity, and biodiversity importance scores, was ranked 3rd in South Africa. When accounting for goods and services provided by the estuary it has been ranked in the top 5 in South Africa (Turpie et al., 2004; Turpie & Clark, 2007). The estuary and its surrounding land have formed the basis of the local culture and livelihoods for several centuries (OEMP, 2013), with the Olifants fishing communities possessing a long history of fishing in the estuary (Sowman, 2003). Fishing for Southern Mullet, locally referred to as *harders*, in the estuary, by small-scale fishers using rowing boats and gillnets, remains the primary source of livelihoods in the community. These communities consist of descendants of families historically evicted from fertile agricultural land near Lutzville in 1925, due to the discriminatory policies and laws of the apartheid regime (Hauck & Sowman, 2001; Sowman, 2009). This relocation to the lower reaches of the Olifants River brought about a shift in their subsistence activities from that of primarily farming to fishing (Sowman et al., 1997).

The Olifants fishing community can be classified as poor, with a mean monthly income per fisher family ranging from ZAR378–570 (Carvalho et al., 2009). Approximately 60% of the fisher households rely on fishing for 25-50% of their summer income, whereas for the remaining 40%, fishing comprises 75% of their household income (Sowman et al., 1997). A substantial portion of their catch is consumed, with greater than 50% of households eating fish every day (Anchor, 2008). While the local fishing communities largely subsist from the *harder* resource, they are known to sell their catches to farmers from the surrounding areas, particularly in the summer months when catches are good. In addition, excess catches are commonly salted and dried (referred to locally as *bokkoms;* see Picture 4) and used as a source of food during the winter months (Sowman, 2009). There is a core group of fishers who would consider fishing their sole livelihood source, with many additional fishers seeking limited alternative employment opportunities often seasonal, such as grape picking, or ad hoc, e.g. local road maintenance, in order to supplement their livelihoods (Sowman, 2009). According to Lamberth et al. (1997), the Olifants Estuary annual tonnage of Southern Mullet, comprises 1–2 % of the national catch by the inshore beach-seine and gillnet fisheries. Based on estimated catches of the Olifants estuary small-scale

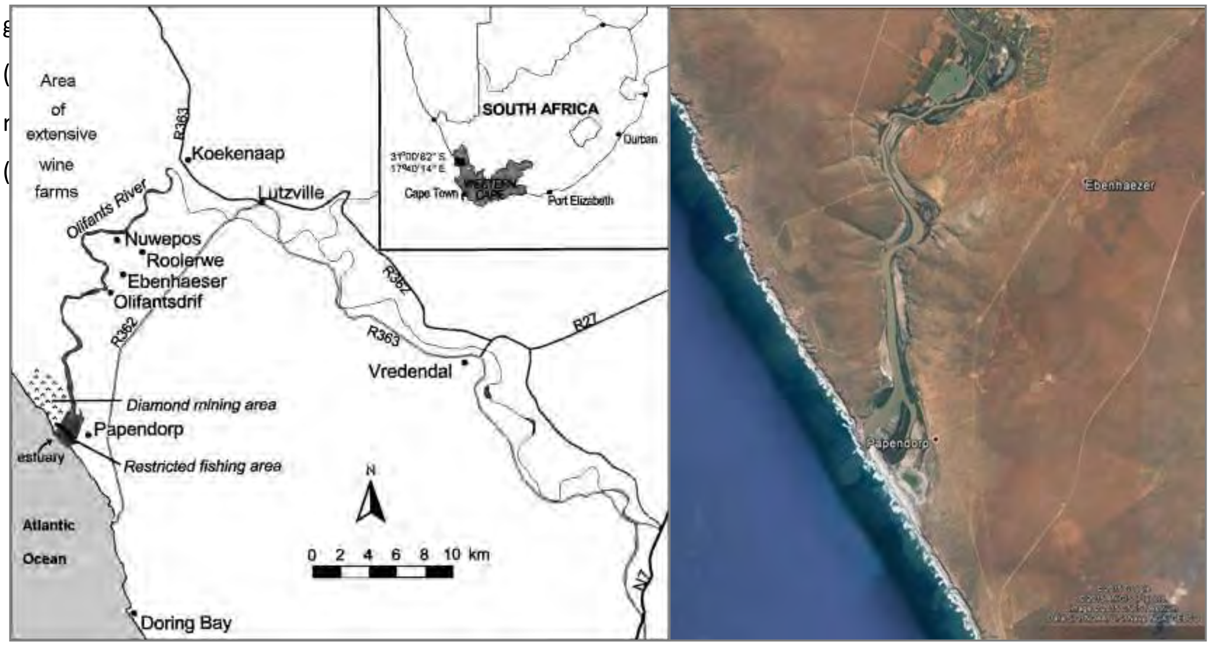

Figure 4: a) Map indicating the location of the Olifants small-scale gillnet fishery (and key fishing villages mentioned in the text) in the Western Cape, South Africa and b) a Google Earth image of the estuary. **Source: a) Carvalho et al. (2009) and b) Google Earth.**

Picture 4: The process of making 'Bokkom', in Olifantsdrif. **Photography:** Nolene Rice.

Fisheries management worldwide and in South Africa generally view gillnet fisheries as destructive, due to the occurrence of non-target species or bycatch, as gillnets are not target specific (Hutchings & Lamberth, 2002a). Furthermore, these bycatch species encompass nationally important linefish (or angling) species which are believed to be susceptible to high fishing pressure, and in addition make use of estuaries as nursery grounds. Conservation and fisheries scientists have thus proposed a closure of gillnet fishing in all West Coast estuaries, including the Olifants Estuary, for the purpose of maintaining their ecological integrity and in order to provide a refuge for numerous linefish species (Hutchings & Lamberth, 2002a; Hutchings et al., 2008). This has led to disputes between the fishing community, and fishery scientists and management authorities, and suggests that an alternative approach to management of these resources is necessary. A new approach to fisheries management, with a strong focus on resource user participation, has being advocated in the aforementioned recently released South African Small-Scale Fishing Policy (DAFF, 2012a), and is in line with an EAF.

3.2.2 The use of a Social-Ecological Lens to better understand the issue of bycatch in the Olifants Estuary Small-Scale Gillnet Fishery

Social-ecological systems thinking is concerned with making the connection between human systems (i.e. social systems) and natural systems (i.e. ecological systems) and represent this in a two-way feedback relationship (Berkes et al., 2014). Having an understanding of these linkages across the natural and social system is vital to any conservation effort, as without a holistic overview of the system it is impossible to attempt to account for, or manage any of the components which make up the system. Berkes et al. (2014), note that there is no single manner in which to attempt a social-ecological systems analysis of a particular system, but that "common ingredients" of such an approach include: firstly, a fundamental focus on the integrated nature of social-ecological systems, with natural, human, and governance sub-systems; and secondly, the need to consider multiple scales and levels, as well as the resilience attributes of the system. When attempting to apply a social-ecological system analysis of bycatch within the Olifants estuary small-scale gillnet fishery, these "common ingredients" become apparent. The most obvious components of the system that interact at a local scale, without even attempting to account for national, regional or global scale components, shed light on its complexity. At a glance the key components in need of consideration when considering the issue of bycatch in the Olifants estuary small-scale gillnet fishery at a local scale, include: the effects of all local fishing effort (i.e. ecological and social considerations of all relevant fishery sectors) and its management (i.e. governance considerations including monitoring and evaluation); the ecological anthropocentric effects of surrounding land and water usage (i.e. additional biophysical considerations including water abstraction and chemical run-off from agriculture); and the human well-being (socio-economic, historical, socio-political and socio-cultural considerations) of the local population (i.e. especially relating to livelihoods). If we are to expand the scope of the social-ecological systems analysis, consideration would also need to be given to those socio-ecological and governance components of the system existing at a provincial and national scale. At this scale the complexity of this fishery system becomes all the more evident. In order to better understand the bycatch issue in the Olifants estuary, it is necessary to investigate other species-related national fisheries that also impact on the linefish species of concern occurring in this fishery, and ascertain their relative contributions to the exploitation of these species. An introduction to these other species-related fisheries therefore follows.

3.3 Other South African Net Fisheries

The beach-seine and gill-net fisheries are South Africa's oldest commercial fisheries (Thompson, 1913; Thom, 1952). Fishing operations using beach-seine and gillnets on the Berg Estuary and in St Helena Bay, for example started shortly after the Dutch established a permanent trading station at the Cape in the mid-17th century, however, it is assumed that region would probably have been fished many years prior by the indigenous Khoikhoi (Morant et al., 2001; van Sittert, 1992). Commercial gillnet and beach-seine fishing is essentially confined to the Western Cape (Hutchings & Lamberth, 2002a), with the gillnet fishery restricted to Yzerfontein northwards while the beach-seine fishery is restricted to the west of Gordon's Bay (DEAT, 2005).

Gillnetting on the west coast is thought to be intensive (Lamberth et al., 1997) and not immune to conflict between net-fishers and other inshore fishery stakeholders, particularly recreational and commercial linefishers (Hutchings & Lamberth, 2002a). According to Hutchings & Lamberth (2002b) gillnet fishing in the St Helena Bay area and the Berg River[7] was largely restricted to summer, due to weather conditions, catch rates and the availability of permit-holders, many of whom were involved in other fishing sectors (e.g. small pelagic fishery and linefishery). In contrast, gillnet fishing in Saldanha Bay, the Langebaan Lagoon and the Olifants River estuary takes place throughout the year. Netting in the other regions of the country is thought to be relatively limited and this is largely as a result of management attempts to reduce participation in the fishery, especially of part-time fishermen, in the late 1970s (De Villiers, 1987). Catches on the west coast, and the Southern and Eastern Cape coasts are dominated by *harders*, which provide 70% or more of the total catch by mass, whereas on the KwaZulu-Natal coast the catches are dominated by Sardine (*Sardinops sagax*) (88%), although this species is highly seasonal, and Flathead Mullet (*Mugil cephalus*) which represents the most consistent catch in the region (Lamberth et al., 1997). St Joseph sharks (*Callorhinchus capensis)* have been shown to contribute up to 25% of the catch on the west coast, whereas yellowtail (*Seriola lalandi)* (17%) and White Steenbras (*Lithognathus lithognathus)* (3%) are important off the Southern Cape (Lamberth et al., 1997). Elf (*Pomatomus saltatrix)* provide 1% of catches in all four regions, with two species of Kob present in the catch, *Argyrosomus inodorus* (Silver Kob) off the west coast and the Southern Cape, and *Argyrosomus japonicus* (dusky Kob) off the Eastern Cape and KwaZulu-Natal coasts (Griffiths & Heemstra, 1995). The proportion of other bycatch species has been shown to increase from west to east and as such the risk of overexploitation of non-targeted species is suggested to increase from west to east (Lamberth et al., 1997).

Beach-seining represents a contentious issue in the Cape, with conflicts between anglers and net fishermen occurring since 1883 (Gilchrist & Williams, 1910; Yeats et al., 1966) and complaints about the catching of immature and spawning fish recorded as early as 1898 (Gilchrist, 1899). As is the case at present, many regulations were implemented in an attempt to decrease conflict between net fishermen and other fishing sectors (De Villiers, 1987; Lamberth et al., 1994; Kyle, 1995). According to Hutchings & Lamberth (2002a) beach-seine operators in certain areas on the west and south-west coasts suggest that intentional targeting of aggregations of valuable, overexploited species such as White Steenbras and Silver Kob (Bennett, 1993a; Griffiths, 1997d) does occur. Such concerns led to the restricting of beach-seine permits solely to the capture of harders and st joseph sharks, with the exception of False Bay where species such as yellowtail and White Steenbras are claimed as traditional and legitimate targets by seine fishermen (Wiley, 1985; Lamberth et al., 1994). According to Hutchings & Lamberth (2002b) beach-seine operators appear to operate opportunistically in most areas, i.e. during periods of higher fish abundance (see Bennett, 1989b) or more favourable weather conditions which concentrate harders shoals, or during periods when other fishing activities are not possible. The increased popularity of recreational shore- and boat-angling (Van der Elst, 1989, Bennett, 1991) has resulted in steadily increasing conflict between these stakeholder groups (Penney, 1991, Lamberth & Bennett, 1993).

[7] **The *Berg River gillnet fishery*** was closed in March 2003 (see Hutchings et al. 2008)

According to Bennett (1991) angling catches at the time in False Bay had declined noticeably in preceding years and groups opposed to beach-seining have blamed these declines on exploitation by the beach-seine fishery (Brouwer et al., 1997), emphasising particular concern for what are considered to be excessively large catches of adults and juveniles of angling species such as Elf, yellowtail and White Steenbras (Lamberth, et al. 1994).

3.4 The South African Linefishery

South African commercial and recreational fishers exploit more than 250 marine species, with fewer than 5% actively targeted and comprising 90% of the catch (DEAT, 2014). Linefishing in South Africa is defined as the capture of fish with hook and line, but excludes the use of longlines. The linefishery is the third most important fishery in South Africa in total tonnage landed and total economic value (Griffiths et al., 2010). The linefishery comprises commercial, recreational and subsistence sectors (DAFF, 2012b). Linefish are predominately shelf species, with most located in waters that are shallower than 150 m (Griffiths, 2000). The reported commercial linefish catch for the Cape region, for the period 1990-1997, was approximately 15 500 tons per annum, approximately 95% of the total South African linefish landings. In spite of a long history, the first comprehensive management framework for the South African linefishery was introduced only in 1985 (Penney et al., 1989). Owing to the large number of users, launch sites, species targeted and the operational range, the commercial fishery is managed in terms of a total applied effort, bag limits for species, closed areas, limitations of the gear used and restraints on the trade of collapsed and over-exploited species. The commercial fishery currently consists of an approved total applied effort of 455 vessels and 3 450 crew (DAFF, 2013).

Commercial linefishing is a low-earning, labor-intensive industry, and is important from a human livelihood point of view (DAFF, 2012b). Although records for the commercial linefish sector are maintained, landings by the open-access recreational linefishery are not reported, even though the total catch from this sector has been suggested to be double that reported by the commercial sector (DEAT, 2014). Recent stock assessments and the analysis of historical data point to many linefish, including the perceived *resilient* species (e.g. Silver Kob), being severely overexploited (Griffiths, 1997a & b, 1999). In fact, uncontrolled exploitation of these stocks has had significant adverse effects, with at least 18 of the most frequently targeted linefish species classified as collapsed (including Silver Kob and White Steenbras), 4 as over-exploited (including Elf), 6 as optimally exploited, and only 2 as under-exploited (DEAT, 2014). Many regulations have failed to provide appropriate resource protection, as evidenced in research surveys, because they did not limit catches (Attwood & Bennett, 1995; Brouwer et al., 1997; Griffiths, 1997a; Sauer et al., 1997). To address the failure of past regulations in managing South Africa's linefish resource, a Linefish Management Protocol (LMP) was developed for the linefishery (Griffiths et al., 1999). The LMP brought about drastic reductions in commercial linefish effort and stringent bag limits for recreational fishers, however, the status of most linefish species since 1999 has shown little improvement and the opportunity costs of the degrading of this resource are considered enormous (DEAT, 2014). New linefish policies, based on the LMP, were gazetted in May 2005 to help to rebuild linefish stocks (DEAT, 2014).

3.4.1 The South African Recreational Linefishery

Recreational angling methods include hand line fishing, pole fishing (without a reel) or the standard fishing by rod, line and reel. Globally the increasing importance of recreational fishing in many coastal areas and less developed nations has recently been noted (Cowx, 2002; Coleman et al., 2004). Recreational angling is widely practiced (Pitcher & Hollingworth, 2002) and recent studies have drawn greater attention to the magnitude of the landings by recreational fisheries (McPhee et al., 2002, Coleman et al., 2004, Cooke & Cowx, 2004). Marine recreational fisheries have been increasingly recognized as substantial in many countries in terms of the numbers of participants, the total catch they take, and their economic and social impacts (Kirkegaard & Gartside, 1998). It has been estimated that the total recreational catch worldwide is in the order of 2 million t, and represents an important animal protein source for many in developing countries, such as South Africa where small-scale fishers who are unsuccessful in obtaining small-scale commercial permits may operate under recreational licences (Coates, 1995).

Recreational fishing can be defined as fishing where the primary objective is for enjoyment and “not primarily to secure survival and generate resources to meet essential, nutritional needs” (FAO, 2012b: p2). However, recreational fisheries can involve both subsistence fishing, where the catch is consumed (which is sometimes the case in developing nations), and leisure fishing, where the fish are returned live to the water (Cowx, 1999; Arlinghaus, 2004). Definitions of recreational fishing may vary depending on the origin and cultural perception of the activity (Aas, 2002), with the abundance of definitions available for recreational fishing often leading to confusion for fisheries managers. Fishing with rod and line is a highly popular recreational activity along the entire coast of South Africa (Brouwer et al., 1997; Sauer et al., 1997; Pradervand et al.; 2003) and the most popular form of marine usage (Pradevand & Baird, 2002). Shore-angling is primarily recreational, and an increase in effort as well as a corresponding marked decline in catches of some species in South Africa has been noted (Van der Elst & de Freitas, 1988; Bennett, 1992). Active management of the shore-angling fishery has been ongoing since the 1970s, in an effort to promote sustainable utilisation of linefish resources (Brouwer et al., 1997). A comprehensive array of national management regulations designed to limit catch and effort were introduced in 1985, and subsequently revised in 1992. However, a lack of detailed knowledge of angler attitudes towards such regulations, in addition to social norms and limited enforcement, resulted in limited success (Brouwer et al., 1997; Sauer et al., 1997). Past stock assessments reveal that South African recreational fishers have been directly responsible for the depletion of several species, including representatives of the families Sparidae (Bennett, 1993a), Coricinidae (Bennett, 1988) and Sciaenidae (Griffiths, 1997a).

Pradervand & Baird (2002) noted that the importance of shore-based angling in South African estuaries has long been under-recognized, although several studies have concentrated on light tackle angling from small boats in estuaries and coastal embayments such as Swartkops, Durban Harbour, St Lucia and Kosi Bay (Marais & Baird, 1980; Guastella, 1994; James et al., 2001; Mann et al., 2002). Linefishing in estuaries is either a boat- or shore-based activity, with shore angling the more popular due to it being inexpensive and accessible. Linefishing in estuaries is primarily recreational although there are a small number of subsistence fishers who fish in the area between Port Elizabeth and KwaZulu-Natal (Lamberth & Turpie, 2003). No commercial linefishing is permitted in estuaries or along the coast (i.e. from the shore). According to Lamberth & Turpie (2003), estuary-dependent species dominate recreational shore-anglers catches and comprise approximately

83% of the catch by number and mass. An example of the effects of high levels of fishing mortality, particularly in estuarine nursery habitats, is that of the collapse of the dusky Kob stock (Griffiths, 1997). Cowley et al. (2008), in an acoustic telemetry study found that 41% of tagged dusky Kob (all juveniles) were recaptured in the estuarine fishery in less than a year after being tagged.

Leibold & van Zyl (2008) provided an estimate (in 2007) of 2.5 million anglers (approximately 5% of the population; in accordance with Arlinghaus & Cooke, 2009) participating in sport and recreational angling in South Africa, creating a total economic impact of ZAR18.8 billion. It has been estimated that the total economic impact of sport and recreational angling (including Deep Sea Angling) is at least 80% larger than that of commercial fishing in South Africa (Leibold & van Zyl, 2008). Under these circumstances recreational fisheries compete with commercial fisheries in utilisation of the resource, and the provision of economic and social benefits (Sumaila, 1999). Arlinghaus et al. (2011) refer to the need for the recreational sector to aim to avoid irreversible, costly or slowly reversible changes to aquatic biodiversity, fish populations and aquatic ecosystems, as there is increasing scientific evidence that recreational fishing can indeed result in such impacts (Post et al., 2002; Cooke & Cowx, 2006; Lewin et al., 2006).

3.5 The South African Demersal Trawl Fishery

South Africa's offshore marine living resources are the most commercially valuable of its renewable marine resources and include the demersal, pelagic and squid fisheries (Cochrane et al., 1997). The demersal hake trawl fishery is the largest in the world based on hake (Botha, 1985) and the most important and valuable fishery in South Africa (FAO, 2001; Strydom et al., 2009). In the 1960s, the demersal trawl fishery contributed approximately 90% of South Africa's overall fish landings, but this contribution had declined to 60% during the 1990s due to a shift in focus to mixed-species fisheries and increased landings of bycatch from this fishery (DEAT, 2014). This fishery is made up of two sectors: an offshore, deep-sea sector and an inshore sector (Payne, 1989). Regionally the trawl fishery can be divided into a south coast inshore fishery, mainly operated out of Mossel Bay and Port Elizabeth (Attwood et al., 2011), and an offshore fishery, principally operated out of Cape Town and Saldhana Bay (Walmsley et al., 2007). South Africa's inshore trawl fishery began in 1898 as a mixed fishery, however, today ostensibly targets shallow-water cape hake (*Merluccius capensis*) and agulhas sole (*Austroglossus pectoralis*) between Cape Agulhas and the Great Kei River (Walmsley, 2004; Attwood et al., 2011). Trawl fisheries, due to non-selective gear, typically result in high mortality of non-target species (Philippart, 1998; Hall et al., 2000; Bianchi et al., 2000; Rogers, 2000; Walmsley et al., 2007; DEAT, 2014). A major concern therefore is its impact on the diverse populations of non-target species, predominantly Silver Kob and Carpenter (*Argyrozona argyrozona)*, especially on the shallow parts of the Agulhas Bank (Japp et al., 1994; Nel et al., 2007). These concerns arose as early as the 1930s (Marchand, 1933). The substantial bycatch of pre-recruit Silver Kob also has negative implications for other fishery sectors, most notably the recreational sector (Japp et al., 1994; Walmsley et al., 2006; Nel et al., 2007). The inshore trawl fishery represents the second highest level of bycatch of any South African fishery, after the east coast prawn trawl fishery (Fennessy & Groenewald, 1997), with at least 137 nominal bycatch species (Attwood et al., 2011). According to Attwood et al. (2011) approximately 98% of the bycatch by weight in this fishery is accounted for by 20 species. In addition, their analysis of observer gathered data concluded that bycatch constitutes approximately 42% of the catch across both hake- and sole-directed vessels in the inshore fishery (Attwood et al., 2011). Furthermore, several of these bycatch species, which are landed in sizeable amounts by the inshore trawl sector (and targeted by other fisheries) are characterized by overly exploited and depressed population sizes, and thereby generate both conservation concern and sector-based conflicts (Attwood et al., 2011). Possibly the most appropriate example of such a cross-sector conflict exists with Silver Kob as it is a key species in the linefishery and is listed as “heavily depleted” in the recent “Status of the South African Marine Fisheries Resources report” (DAFF, 2012b). As a reactive measure to over-exploitation concerns, the government reduced linefishing effort by declaring the fishery in a state of emergency in 2000 (DAFF, 2012b). However, Greenston & Attwood (2013) suggest that similar quantities of Silver Kob are caught in both the handline and trawl fisheries without equivalent restrictions on the latter. Moreover, the trawl fishery operates in part in the nursery grounds of several linefish species (Nel et al. 2007), and often catches juvenile fish, frequently below the legal size limit for the handline fishery (Attwood et al., 2011).

Chapter 4: Methods and Research Approach

In this chapter an overview of the methods and research approach taken for the purposes of contextualising bycatch in the Olifants estuary small-scale gillnet fishery is provided. Moreover, specific descriptions of data collection, both primary and secondary data, and the explanations of subsequent limitations, challenges incurred and ethical procedures followed, are noted.

4.1 An Overview

The methods were selected with the aim of designing a holistic overview of the status of the occurrence of bycatch in the Olifants estuary small-scale gillnet fishery and its relative contributions, in comparison to the recreational and commercial sectors, to the status of the key selected linefish species of this study and the social and ecological implications thereof. The overall research approach, data collection, and sampling methods utilised during the fieldwork process are described. Different methods were combined using a process of 'triangulation', commonly used in social science research to improve both the value and validity of results (Jick, 1979). Triangulation comprises the use of multiple strategies to answer the same set of questions, and is thus useful for investigating phenomena from different perspectives and "deepening and widening one's understanding" of them (Olsen, 2004: p1). This approach also proves useful in attempting to cross-check information from different sources, and as a result attempts to reduce the risk of drawing false conclusions from unreliable data (Jick, 1979). Furthermore, triangulation allows quantitative and qualitative research methods to be combined, thus enabling greater interdisciplinarity within the research (Olsen, 2004). Ethnographic techniques[8], including extensive interviews and participant observation, formed a key basis of the first phase of this study, i.e. attempting to gain a socio-ecological systems understanding of bycatch in the Olifants estuary small-scale gillnet fishery; however, the extensive use of secondary data sources accompanied this process in order to address this, as well as the remaining objectives. Further to this end, both qualitative and quantitative primary data collection and analysis methods were engaged, and included more specifically one-on-one semi-structured small-scale fisher interviews and informal focus group meetings, a snapshot recreational roving-creel survey within the area of the estuary, an online national recreational survey, and key informant email correspondences. A variety of sources of secondary data were consulted including published and unpublished literature and databases (see Table 2 below). The research process included a scoping study, intensive fieldwork, and feedback meetings, and an extensive review of available published and unpublished literature as well as the aforementioned secondary datasets.

[8]According To Emerson et al. (1995: p1), **Ethnography** comprises two core activities: "First-hand participation in some initially unfamiliar social world," and "the production of written accounts of that world," based on such participation. This definition has been adopted for this study.

4.2 Methods and Data:

4.2.1 Primary Data Collection

4.2.1.1 Local small-scale fisher interviews and informal focus groups

Individual semi-structured interviews were conducted with 25 local small-scale fishers, in the Olifantsdrif (16), Papendorp (2), Nuwepos (1), and Hopland districts (6), in order to better understand the relative contribution of this fishery to the status of the key bycatch species present in the Olifants estuary, in addition to areas of conservation and management concern. A large proportion of the interviews were conducted in Olifantsdrif as it represents a large percentage of the Olifants estuary small-scale gillnet fishing community, and has been shown to contribute the majority of the catch (see Figure 5 below). Moreover a 'snowball sampling' approach (i.e. producing a study sample based on referrals, see Biernacki & Waldorf, 1981) was adopted due to a longstanding working relationship with this fisher district. This proved a successful method of both identifying key participants and attempting to curb mistrust of researchers, who may be perceived as threatening to their primary source of livelihood. Interviews were conducted in an effort to: engage with the fishers, who are important stakeholders within this fishery system; and confirm and enhance the understanding of the contribution of this fishery to these species, obtained via established datasets, monitoring, and participant observation. In addition, to the semi-structured interviews described above it is worth noting that numerous points of interest came out of several informal discussions, and an informal focus group (held in September 2014 on a scoping visit), with fishers during fieldwork visits (See *Appendix 1* for sample interview).

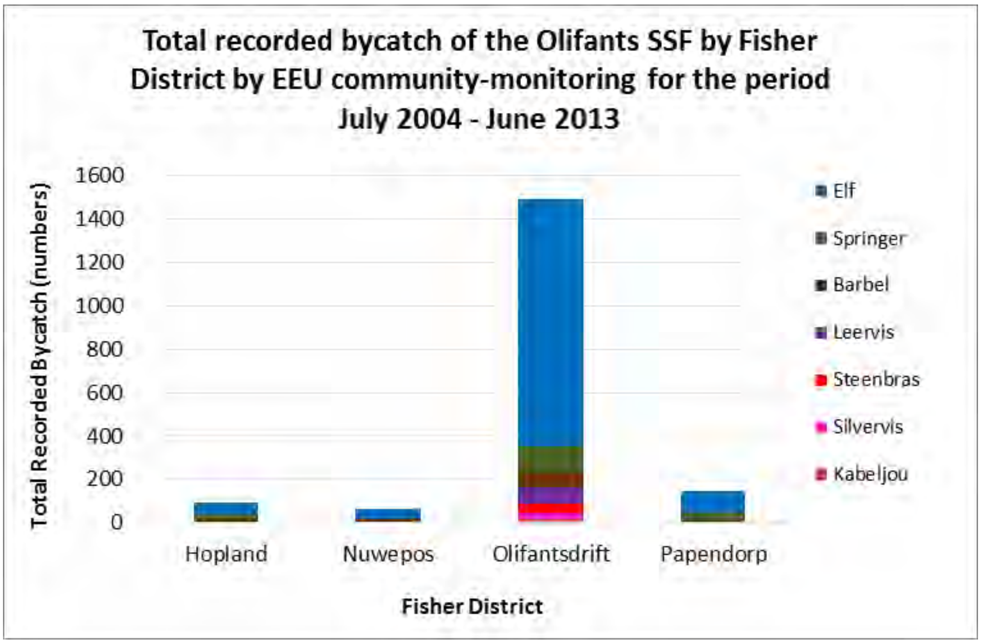

Figure 5: Total recorded bycatch by numbers for the four fisher districts involved in this study by EEU community-monitoring indicating the relative distribution of bycatch and fishing effort. **Source: EEU community-monitoring.** Note: this graph will be discussed further in Chapter 5.

Picture 5: Focus groups and semi-structured interviews were conducted with experienced Papendorp, Olifantsdrif, Hopland, and Nuwepos small-scale gillnet fishers. **Photography:** Wayne Rice and Nolene Rice.

4.2.1.2 Participant observation

Three local small-scale fishers were accompanied on four fishing trips, during the peak fishing month of December, to attempt to better understand the issue and prevalence of bycatch in the fishery, as well as the relative contribution of this fishery to the status of the selected key linefish species. Moreover, this allowed a very limited opportunity to conduct preliminary observations of possible retention rates of bycatch species as well as undersized individuals. While limited in scope it did assist with the task of comparing results of official (and unofficial) monitoring data, in order to attempt to better ascertain the accuracy of monitoring data and therefore the status of these species within this fishery. Fishing trips included various locations along the river and in the estuary, including Baken, Stootwal, Hotnotskop Plaat, Langklip, Rooikrans, Pomp, and Dittmer (see Figure 14 in Chapter 5 for a map of fishing locations).

Picture 6: Pictures from participant observation fishing trips with experienced small-scale gillnet fishers at the Olifants estuary and upriver. **Photography:** Wayne Rice and Nolene Rice

4.2.1.3 Snapshot recreational holiday survey

A snapshot roving-roving creel survey (Robson, 1961), which has been shown to be an effective research tool in recreational fisheries (Malvestuto, 1996) was conducted over 16 days during a peak recreational fishing time of year (i.e. over the December/January holiday period) as a preliminary attempt to gain a better understanding of the relative contribution of this fishery to the status of the selected key linefish species. Limitations exist with this approach as it produces incomplete fishing trip analysis (Pollock et al., 1997); however, as the primary objective was the identification of species of conservation concern, and identifying overlaps in exploitation of the selected key linefish species, it proved a relatively successful preliminary assessment of this, a data-poor fishery. The survey was conducted in an effort to: engage the recreational fishers, who represent an additional and equally important stakeholder group within this fishery system; and confirm and enhance the understanding of the contribution of this fishery, to these species, obtained via established published and unpublished literature and datasets. A total of 21 recreational fishers were encountered during the survey period, of which 5 were first timers (all encountered at the mouth), which posed a problem as no valuable information could be gathered on target species, common catches, and changes in catch composition or reasons for such changes and it was for this reason that these interviews were omitted from the analysis (discussed further in Chapter 5.1.2) (See *Appendix 2* for sample interview).

4.2.1.4 Online National Recreational Survey

In addition to the snapshot survey conducted, after consultation with and assistance from various regional recreational fishing associations and local organisations (see Table 1 below), it was decided to distribute a short online survey to their members in an effort to obtain a more holistic perspective of the relative contribution of the recreational fishery, to the selected key linefish species, obtained via established literature and datasets, as well as to attempt to better engage a major stakeholder segment of this fishery. A total of 132 responses were received encompassing the west coast (14), the southern Cape (11), the rest of the Western Cape (19) (i.e. as a whole the Western Cape was represented by 44 respondents), Eastern Cape (39) and KwaZulu-Natal (49) (See *Appendix 3* for a sample of the survey).

Table 1: A list of points of contact made for distribution of the national online recreational fishing survey.

Point of Contact	Type of Association	Region
South African Shore-Angling Association	National	National
South African Consolidated Recreational Angling Association	National	National
South African Underwater Fishing Federation (Spearfishing)	National	National
West Coast Shore-Angling Association	Regional	West Coast
KwaZulu-Natal Coastal Angling Union	Regional	KZN
Zululand Shore-Angling Association	Regional	KZN
Eastern Province Shore-Angling Association	Regional	EC
http://www.fishing-sa.co.za and Facebook page	Website and Facebook page	N/A
Salt Fishing South Africa	Facebook Community	N/A
Eastern Cape Rock and Surf Fishing	Facebook Community	EC
Jikeleza Fishing…365!	Facebook Community	EC
Eastern Cape Lure Fishing	Facebook Community	EC
Salt Water Fishing South Africa	Facebook Community	N/A
Fishing the Eastern Cape	Facebook Community	EC
Sealine – South African Angling and Boating Community	Facebook Community	National
http://www.fishthesea.co.za	Website	N/A
Rock and Surf Super Pro League (RASSPL)	Competitive Fishing Organisation	National
Goodwood Angling Club	Local Club	WC
4Oceans Angling Club	Local Club	WC
Abbreviations: EC – Eastern Cape; KZN – KwaZulu-Natal; N/A – Not Applicable; and WC – Western Cape		

4.2.2 Secondary Data Collection

Available datasets for small-scale; commercial; and recreational fisheries were sought out and analysed, in addition to data contained in both published and unpublished literature, in order to better understand the relative contribution of each fishery sector to the status of the key bycatch species present in the Olifants Estuary. Table 2 below depicts and describes the secondary datasets that were made use of for this study. A brief description of each dataset follows. The EEU Olifants community-catch monitoring dataset is the product of an EEU and UCT funded initiative to implement community monitoring through the training of local community members in the recording of catches based on species, length, weight and location. The data was recorded between July 2004 and June 2013, however, due to periods of low funds significant gaps exist, most notably the complete lack of data for 2007, and between 2009 and 2011 (see Figure 8 in Chapter 5 for all recorded months). The Olifants River Project (ORP) is a Western Cape District Municipality funded program of monitoring by local Papendorp residents conducted at that location. The program existed between April 2014 and February 2015, and recorded the number of boats and catches (in numbers) of both harders and bycatch species, however, this was observed first hand to be inaccurate as not all bycatch was recorded in the month of December (ratified by participant observation). Jaymat community-catch monitoring represents the outsourced government monitoring efforts of the Department of Agriculture, Forestry and Fisheries (DAFF) and is ongoing, recording boat and crew particulars and catches based on species, length, and location. The Jaymat monitoring data is known to possess great limitations, due to the fact that monitors are known to work only between 8am and 2pm and therefore are absent for the majority of catches by fishers who tend to return in the early hours of the morning after fishing at night. The South African Environmental Observation Network (SAEON) Egagasini Node database comprises historical commercial catch return datasets from all recorded fisheries, which were transcribed (digitised manually) from printed books and scanned copies of catch-return data sheets, and represents data from as early as 1896. The Marine and Coastal Management (MCM) Linefish dataset represents recordings collected from the entire South African coastline by the fisheries department for the commercial linefishery and spans the years 1985 to 2005. The Oceanographic Research Institute (ORI) Cooperative Fish Tagging Project (ORI-CFTP) is an ongoing national project involving the large-scale participation of recreational fishermen in the tag-and-release of priority species, in order to attempt to obtain information on migration routes, growth rates, stock identity and population dynamics of important linefish and elasmobranch species. Data was obtained from the commencement of the project in 1984 until the end of 2014 for the nominated species. The Fishing Industry Handbook (FIHB, 2013), contains valuable information about the fishing industry including catches, imports and exports and vessel information, and was consulted for recent landings of the selected key linefish species. Recreational competition data was also consulted for the West Coast Shore-Angling Association (WCSAA) and the KwaZulu-Natal Coastal Angling Union (KZNCAU), as well as national competition data represented by the Rock and Surf Super Pro League (RASSPL).

Table 2: List and description of secondary datasets analysed for this study.

Dataset	Fishery Sector	Data Description	Time Period	Region
EEU Olifants community-catch monitoring dataset	SSF	NC; M; TL; and Loc	2004 - 2013	Olifants River
Olifants River Project: Community-Monitoring dataset (WCDM)	SSF	NC	Apr 2014 – Jan 2015	Papendorp: Olifants River
Jaymat community-catch monitoring dataset (DAFF)	SSF	NC; TL; and Loc	2014	Olifants River
SAEON Egagasini Node: Historical Catch Database	CF	NC; M	1896 - 1960	National
MCM – Linefish Dataset (AfrOBIS) via OBIS	CF/Rec	SD	1985 - 2005	National
ORI Tagging Data	Rec	SD	1984 - 2014	National
Fishing Industry Handbook (FIHB) 2013	All	TC in M	2001 - 2012	National
WCSAA – Competition Data	Rec	NC; TL; and M	Nov 2011 – Mar 2014	West Coast
KZNCAU – Competition Data	Rec	NC and M	2007 – 2014	KZN
RASSPL – Competition Data	Rec	NC; TL; M; SD	2013-2015	National
Abbreviations: Apr – April; CF – Commercial Fisheries; Jan – January; KZN – KwaZulu-Natal; Loc – Location of catch; Mar – March; M – Mass; NC – Numbers Caught; Nov – November; OBIS – Ocean Biogeographic Information system; Rec – Recreational Fisheries; SD – Spatial Distribution; SSF – Small-Scale Fisheries; TC – Total Catch; and TL – Total Length				

4.3 Ethical Considerations, Limitations, and Challenges

Ethical approval had been obtained from the Faculty of Science, at the UCT before commencing any fieldwork. Informed verbal consent was at all times obtained from participants of interviews and focus groups and anonymity assured in all cases. While some video clips were taken during a select few interviews, in addition to several photographs, for the purposes of documenting the research process, these were all done with the express verbal permission of participants. Mistrust of fishers for researchers was for the most part avoided due to extensive previous work done by the EEU and UCT within this community, however, certain fishers may have been unsure of how their answers would affect their future livelihoods and therefore their answers may have been influenced, particularly pertaining to the sensitive issue of levels of bycatch. Moreover, some fishers (both recreational and small-scale) may have sought to utilise their interactions with the study in order to promote their own agendas, i.e. the need to increase allowable catches, monitoring of recreational and non-permit holding river fishers, issues with recreational permits and or bag limits etc…Therefore results of interviews need to permit for the possibilities of such inaccuracies. Nonetheless, most fishers spoke freely and honestly especially in the case of the small-scale fisher interviews conducted whilst being accompanied by the fisher association president and upon hearing the objectives of the study. The maintenance of clear boundaries between different stakeholders was at all times attempted to be maintained in order to maintain hard-earned trust. Further to this end, the obligation to report illegal activities was brought into question as the retention of bycatch was witnessed, as was the retention of undersized individuals, although the latter was very infrequently observed. Additional concerns exist with the use of secondary data as all datasets are subject to human error and bias, in addition to possible inaccuracy issues associated with reported figures, specifically the often challenged reliability of community-based small-scale fishery monitoring data (with respect to bycatch and undersize levels), and recreational catches (especially pertaining to levels of undersized individuals) and these factors need to be taken into consideration. As far as possible appropriate measures were taken to address such issues including: collecting, assessing and analysing data from a variety of sources; and comparing various sources of secondary data with each other as well as with that obtained through primary data collection. Furthermore, data analysis and interpretation will be influenced by life history, and possible population and stock status, i.e. the possibility of different stocks, and their levels of exploitation, for each of the key bycatch species of this study. Various methods were utilised in an attempt to most effectively analyse the data, and best and most accurately represent the results obtained. A summary of the approach to data collection can be found in Table 3 below.

Table 3: Summary of the research approach and data sources.

Key Bycatch Species	Fishery	Data sources		
Elf/Shad White Stumpnose White Steenbras Kabeljou (Silver Kob)	Olifants Gillnet Fishery	1. EEU – community-catch monitoring data (compare 2 and 3) 2. Olifants River Project community-catch monitoring data (compare 1 and 3) 3. DAFF – Jaymat community-catch monitoring data (compare 1 and 2) 4. Participant observation* (fishing trips; compare with 1-3) 5. Fisher interviews* 6. Focus groups* 7. Published and unpublished literature	Relative Contribution to Total Species Catch	Life History and Stock Considerations
	Other Net Fisheries	1. DAFF annual reports 2. FIHB 2013 3. Published and unpublished literature		
	Olifants Recreational Fishery	1. Snapshot Olifants Recreational holiday survey* 2. Published and unpublished literature		
	Other Recreational Fishers	1. Correspondence with Recreational Shore Angling Clubs, and Provincial and National Associations* 2. ORI tagging data 3. Online Recreational Survey* 4. RASSPL competition catch data 5. KZNCAU competition catch data 6. WCSAA competition catch data		
	Commercial Traditional Linefisheries	1. SAEON Historical database 2. DAFF annual reports 3. FIHB 2013 4. AfrOBIS (MCM - Linefish database) through OBIS 5. Published and unpublished literature		
	Commercial Inshore Trawl	1. SAEON Historical database 2. FIHB 2013 3. Published and unpublished literature		

* Primary data collection

Chapter 5: Results

This chapter presents the results obtained from the various primary and secondary data sources on the selected linefish species that occur in Olifants estuary small-scale gillnet fishery catches. The chapter seeks to present the findings of this study in order to contextualise bycatch in the Olifants estuary small-scale gillnet fishery, in relation to other fishery sectors that also impact these species, in addition to highlighting the catches of these selected species by the local recreational linefishery. The chapter is subdivided to firstly focus specifically on the Olifants estuary fishery as a whole, and secondly to focus on each of the four selected linefish species, which are caught as bycatch in the Olifants gillnet fishery. The species specific subsections seek to address the objective of assessing the relative contributions of the fisheries known to catch these linefish species and therefore inform a more holistic understanding of the exploitation of these species in line with an Ecosystem Approach to Fisheries (EAF).

5.1. The Olifants Estuary Fishery

5.1.1 The Olifants Estuary Small-Scale Gillnet Fishery

5.1.1.1 An Overview

Data obtained for utilisation within this analysis came from secondary datasets and 24 small-scale fisher semi-structured interviews and informal discussions, as well as participant observation (described Chapter 4). The level of fishing experience of small-scale fishers interviewed ranged from 6 to 75 years and is represented in Figure 6 below. The Olifants estuary small-scale gillnet fishery currently comprises 44 permit holders, who are each able to take an additional fisher on their boat with them making a total of 88 legal fishers. Moreover, a limited number of non-permit holders also fish in the river; these include: approximately 33 interim relief marine permit holders, who mainly fish at sea but may fish on the river from time to time, and 15-20 non-permit holders. From fisher interviews it was suggested that there are a core group of fishers (approximately 12-15 fishers) that fish on the river on a regular basis for food and as a main source of livelihood while the others fish as required mainly when there is no fishing at sea (pers. comm. fishers). However the exact extent of fishing in the estuary remains unclear. The bulk of the fishers came from Olifantsdrif and as such the fishers of this area are known to make the proportionately larger total catches (see Figure 5 in Chapter 4). The species caught in the greatest magnitude, as confirmed by community-monitoring data and small-scale fisher interviews is the target species of *harder*, referred to as the "*income species*" by the fishers, with Elf, being the most common bycatch species (see Figures 6-11 below). Elf is known to swim with harders, and appear in greater quantities when harders enter the estuary during the summer months, although high harder and Elf catches are known to occur up until approximately the month of May (established from fisher focus group, September 2014). Other bycatch species caught relatively frequently, confirmed by community-monitoring and small-scale fisher interviews (see Figures 6-11 below), include *Barbel* (*Galeichthys ater*) and another Mugillidae species commonly known as *Springer (Mugil cephalus* – Flathead Mullet), as well as important linefish species such as Silver Kob (known locally as kabeljou and refered to as such in figures), White Steenbras (refered to as Steenbras in figures throughout), White Stumpnose (refered to as Stumpnose in figures throughout), and Garrick (*Lichia amia* - known locally as Leervis and refered to as such in figures). Hypothetically favoured catch species of the small-scale fishery, i.e. if no legal ramifications existed, are referred to as *Favoured Species* in Figure 6 below. Barbel and Springer are not thought to be overly exploited (and don't represent important linefish species) and were therefore not the focus of this study, but have been included in certain figures throughout this section for comparison purposes.

Concerns about the status of bycatch species of this estuary gillnet fishery to the linefishery sector in general (and in particular the recreational linefishery) have led to their conservation priority. Therefore the key species selected for this study are Elf, Silver Kob, White Steenbras, and White Stumpnose; however, Leervis (Garrick) is included in numerous graphs and tables, yet not comprehensively described due to the limited scope of this study. The catch levels of these linefish species in the Olifants estuary are known to be relatively small, sporadic, seasonal and/or inconsistent, and dependent on the season, and climatic conditions (including the wind, river flow, and state of the sea – Carvalho et al., 2009). This is the case especially for Silver Kob, Garrick, White Stumpnose, and White Steenbras, based on small-scale fisher interviews and community-monitoring data, although this data is subject to acknowledged limitations (see Figures 7-11 below). In recent months (i.e. February to April 2015), there have been periods of higher bycatch which have been acknowledged by the local fishers in interviews. The retention of bycatch species by fishers at the Olifants estuary was acknowledged by all interviewees, mostly for self-consumption, but a few fishers did admit to selling bycatch from time to time when a buyer was available. The perceived changes in catches of the species mentioned above as well as the impact of different fisheries on these species, as identified by the small-scale fisher interviews, are depicted in Figure 6 below. The Jaymat and the Olifants River Project (ORP) datasets (described previously in Chapter 4) were also combined, as these were focused on different regions of the river and therefore assumed to not overlap spatially (see Figure 10 below). Jaymat monitoring is focused on the Olifantsdrif/Ebenhaeser region (i.e. upstream; see Figure 4 in Chapter 3 for locations) whereas the ORP data is focused on the Papendorp region (located near the mouth; see Figure 4 in Chapter 3 for locations for this study). A comparison can be made of the results of the combination of Jaymat and ORP data (see Figure 10 below) with EEU community-monitoring data, for the only full year of EEU data recording (i.e. 2005) represented by Figure 11 below. However, the 9 year discrepancy of these two groups of data makes comparison problematic. With the exception of the months of February and November (with one daily recording of 2115 Elf in the Jaymat data skewing the results for this month, see Figure 10) monthly bycatch levels represented in these two graphs are fairly similar and Elf continues to be represented as the dominant bycatch species with limited and sporadic catches of other bycatch species. Ultimately the greatest concern for fishery scientists is the capture of undersized important linefish. Gillnets are thought to be very size-selective, however, the size distribution of catches has been shown to be relatively broad (see Table 4 and Figures 12 and 13 below) except for Garrick/ Leervis (see Figure 13), although the use of minimum, or maximum total length as an indicator can be problematic as it could represent one unusual recording in the data. This is perhaps due to the stretching and indiscriminate mending of fishing nets, leading to a decrease in size-specific targeting and a broad array of capture sizes. Current minimum legal recreational size limits for each species is indicated alongside total length data from the Olifants gillnet fishery in Figures 12 and 13 below, for comparison purposes.

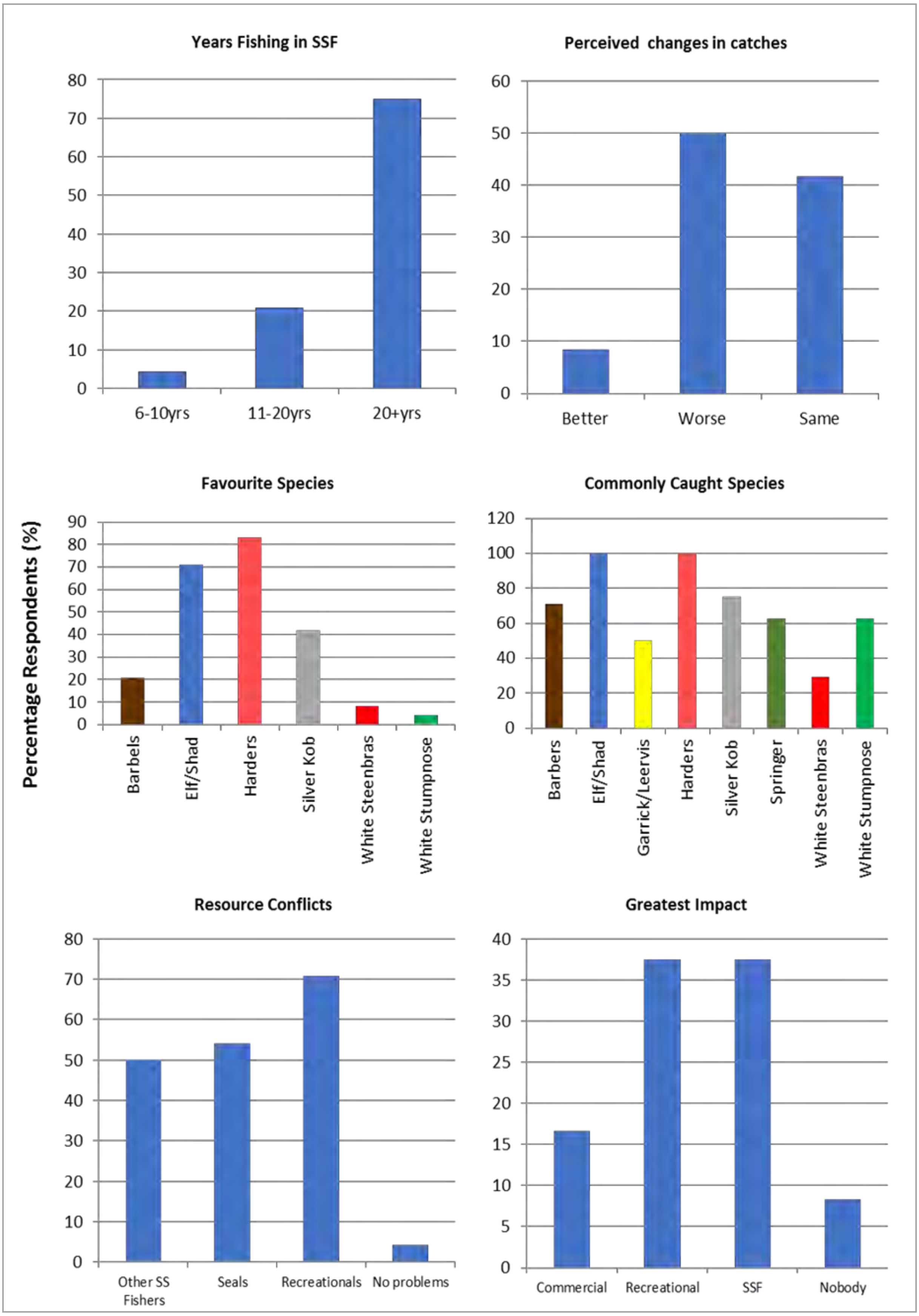

Figure 6: Key results of the Olifants estuary small-scale gillnet fisher semi-structured interviews.

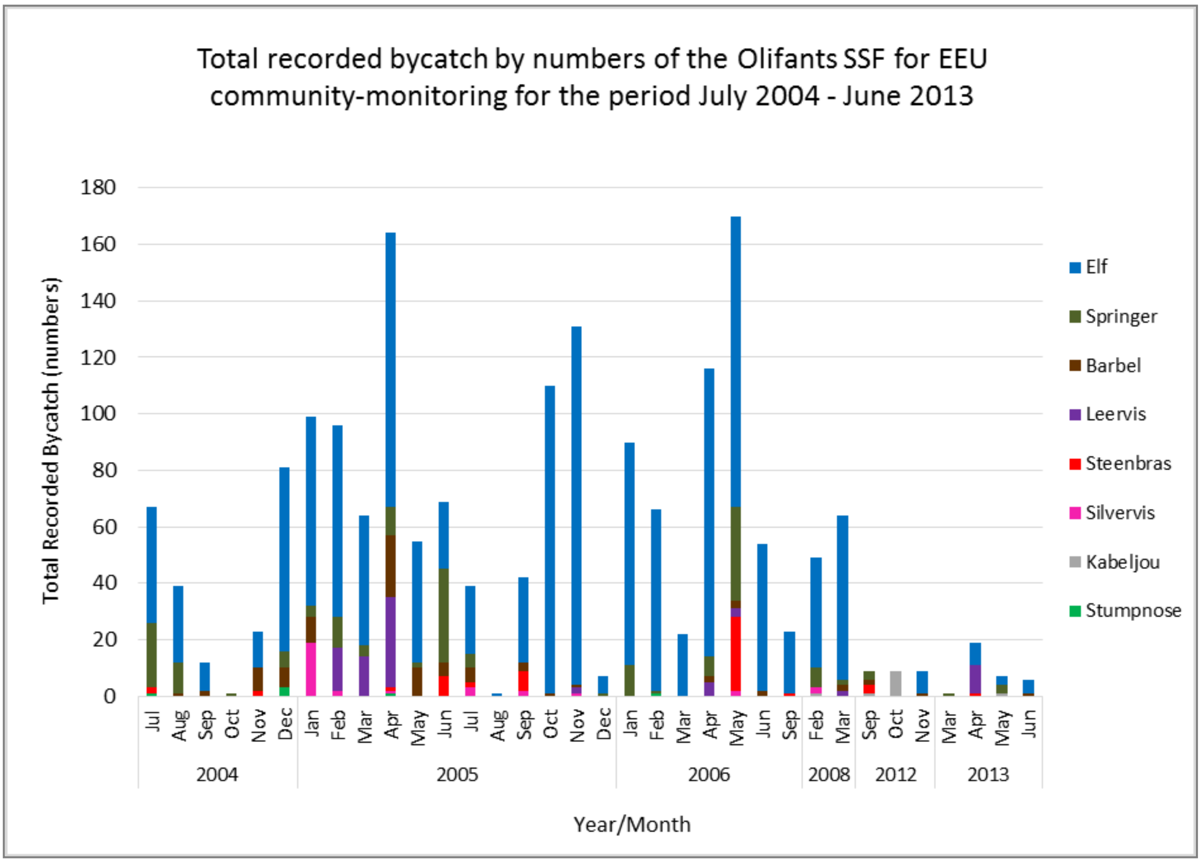

Figure 7: Total recorded bycatch by numbers by EEU community monitors in the Olifants estuary small-scale gillnet fishery for the period July 2004 to June 2013. **Source: EEU community-monitoring database.**

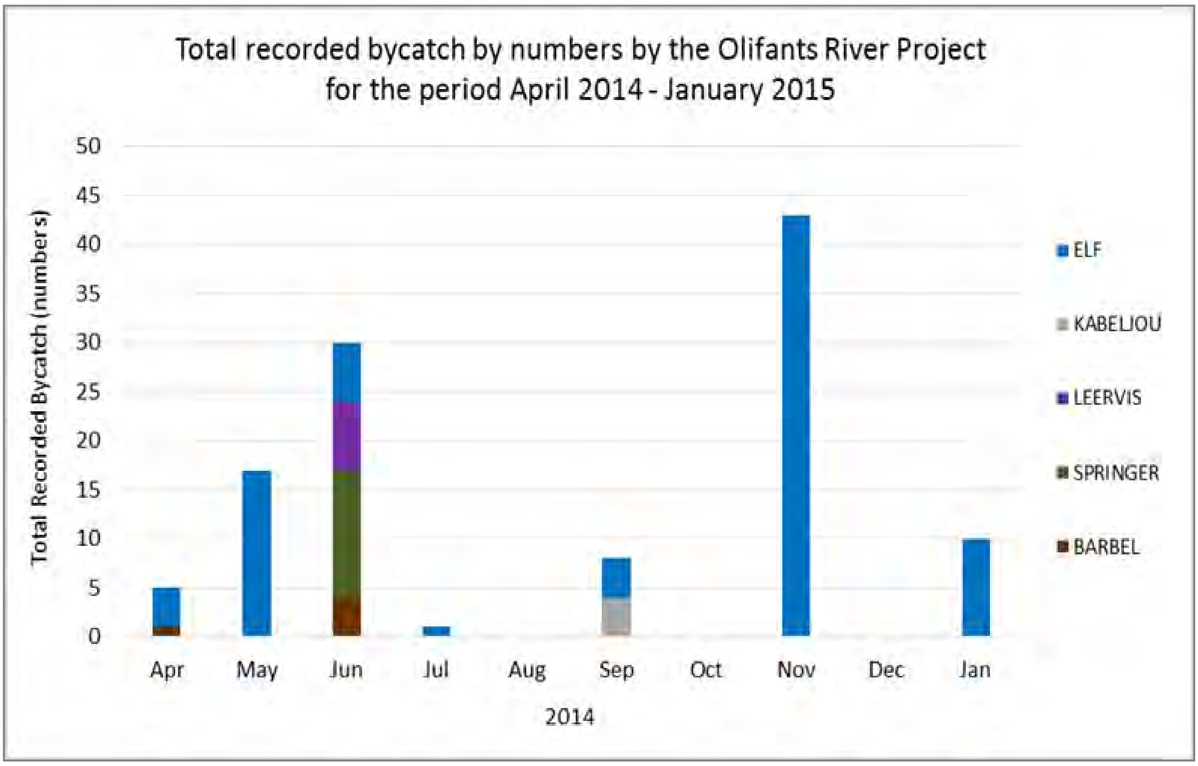

Figure 8: Total recorded bycatch by numbers for the Olifants River Project community-catch monitors in the Olifants estuary small-scale gillnet fishery for the period April 2014 to January 2015. **Source: Olifants River Project community-monitoring database.**

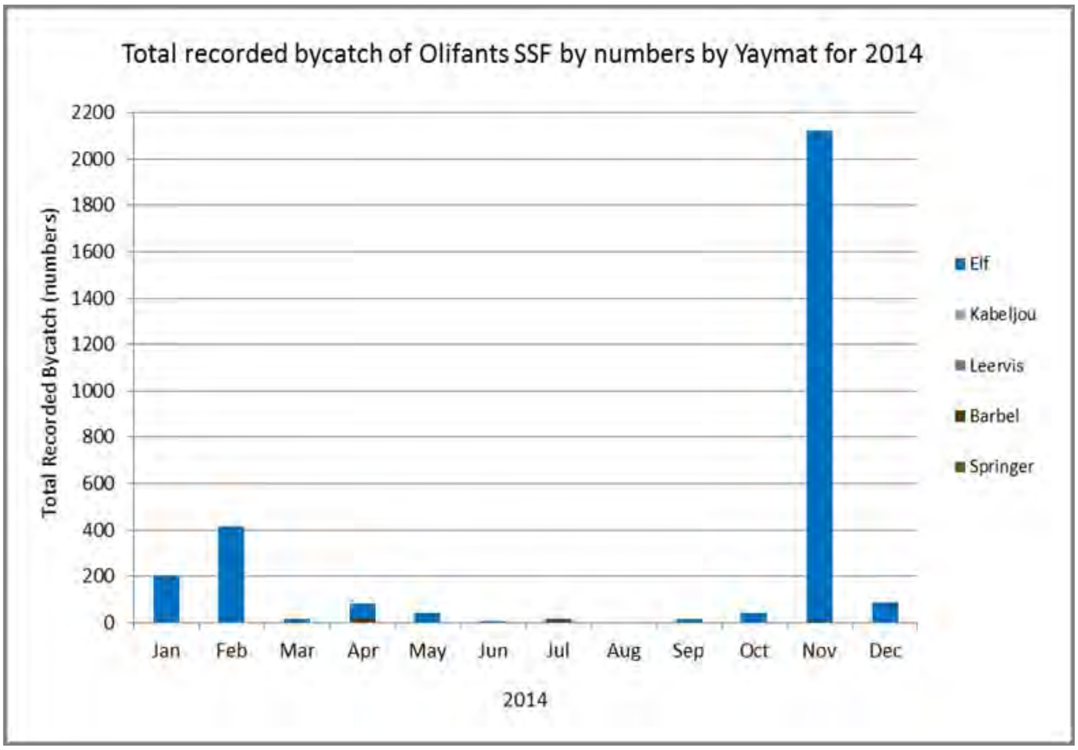

Figure 9: Total recorded bycatch by numbers for the Olifants estuary small-scale gillnet fishery recorded by Jaymat for 2014. **Source: Jaymat community-monitoring database.**

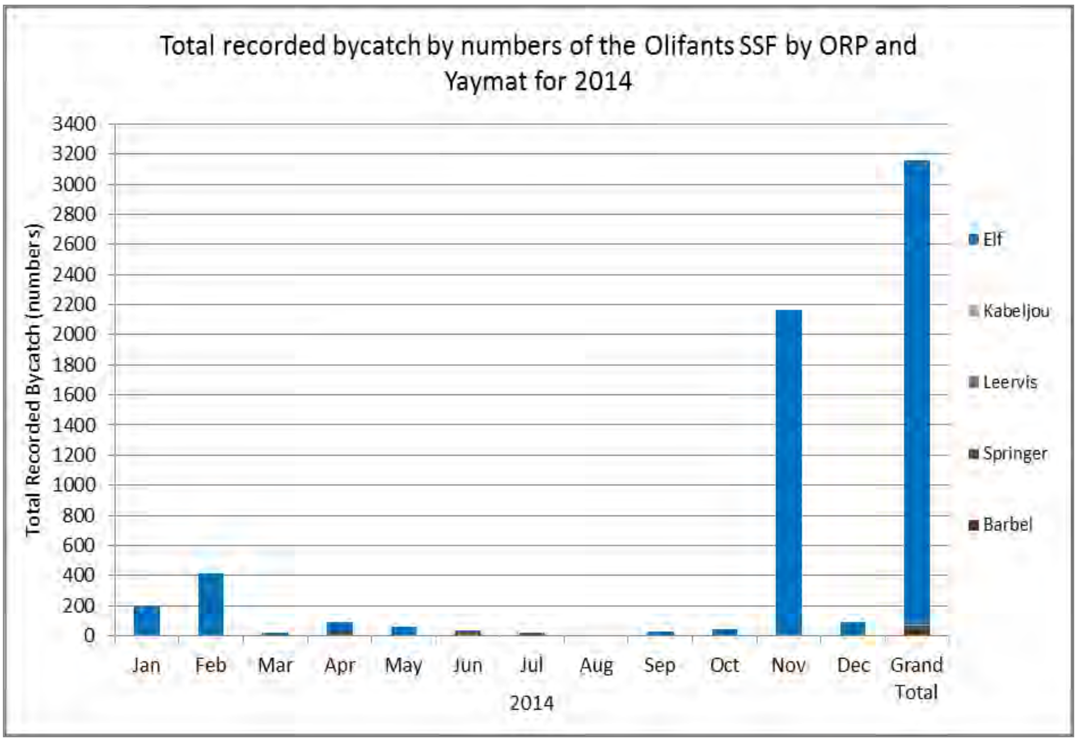

Figure 10: Total combined recorded bycatch by numbers for the Olifants estuary small-scale gillnet fishery as recorded by the Olifants River Project and Jaymat for 2014. **Source: Olifants River Project and Jaymat community-monitoring database.**

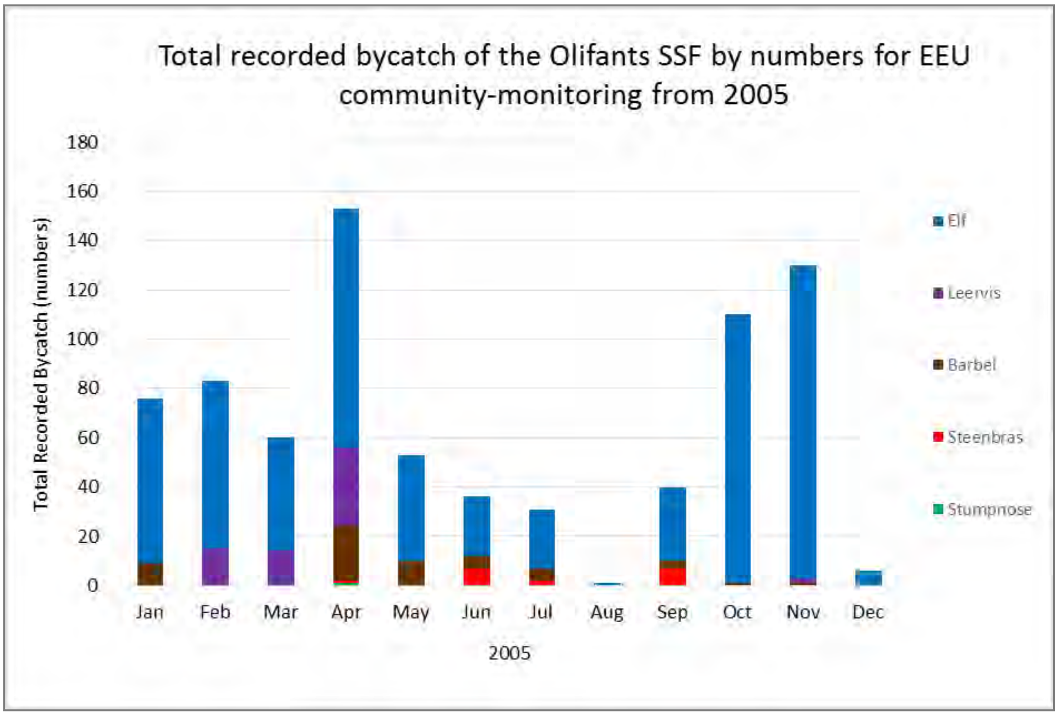

Figure 11: Total recorded bycatch by numbers for the Olifants estuary small-scale gillnet fishery recorded by EEU community-monitoring for 2005. **Source: EEU community-monitoring database.**

Table 4: Average, maximum, and minimum size caught (in cm) in Olifants estuary small-scale gillnet fishery according EEU community-monitoring database. Minimum recreational size limits are also provided (**based on DAFF 2014/2015 Marine Recreational Activity Information Brochure**).

Species	Average of Total Length (cm)	Max of Total Length (cm)	Min of Total Length (cm)	Minimum size Recreational (cm)
Elf	21.4	54.6	15.5	30
Kabeljou/Silver Kob*	37.6	80	31	40 - 60*
Steenbras	21.4	38.5	15.5	60
Stumpnose	19.3	22.4	16.4	25
Leervis/Garrick†	27.3	28.0	26.5	70

***Kob caught from: a boat at sea Cape Agulhas to Umtamvuna River = 50cm and KZN province = 40cm; caught in estuaries and from shore East of Cape Agulhas only = 60cm and West of Cape Agulhas only = 50cm.**

† Leervis Total Lengths calculated from Jaymat community-monitoring database.

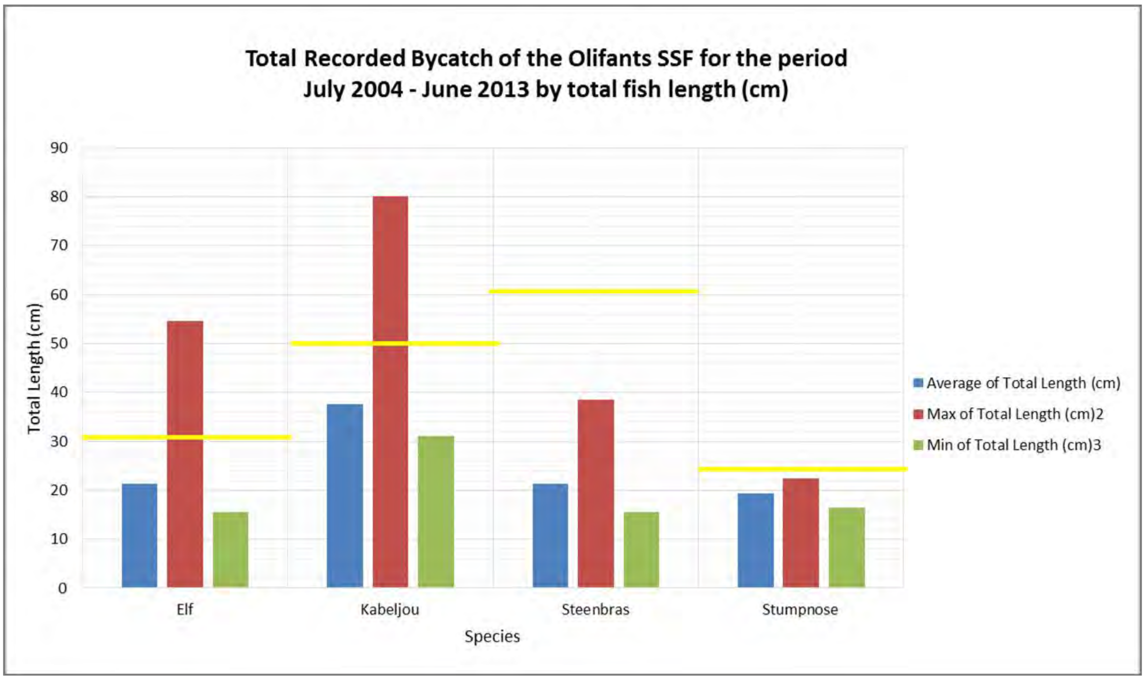

Figure 12: Total recorded average, maximum, and minimum total lengths (in cm) for key selected linefish species caught in the Olifants estuary small-scale gillnet fishery. Note: The yellow lines indicate minimum allowable size for recreational fishers based on DAFF 2014/2015 Marine Recreational Activity Information Brochure. Refer to Table 4 for regionally specifc recreational Kabeljou regulations. **Source: EEU community monitoring database.**

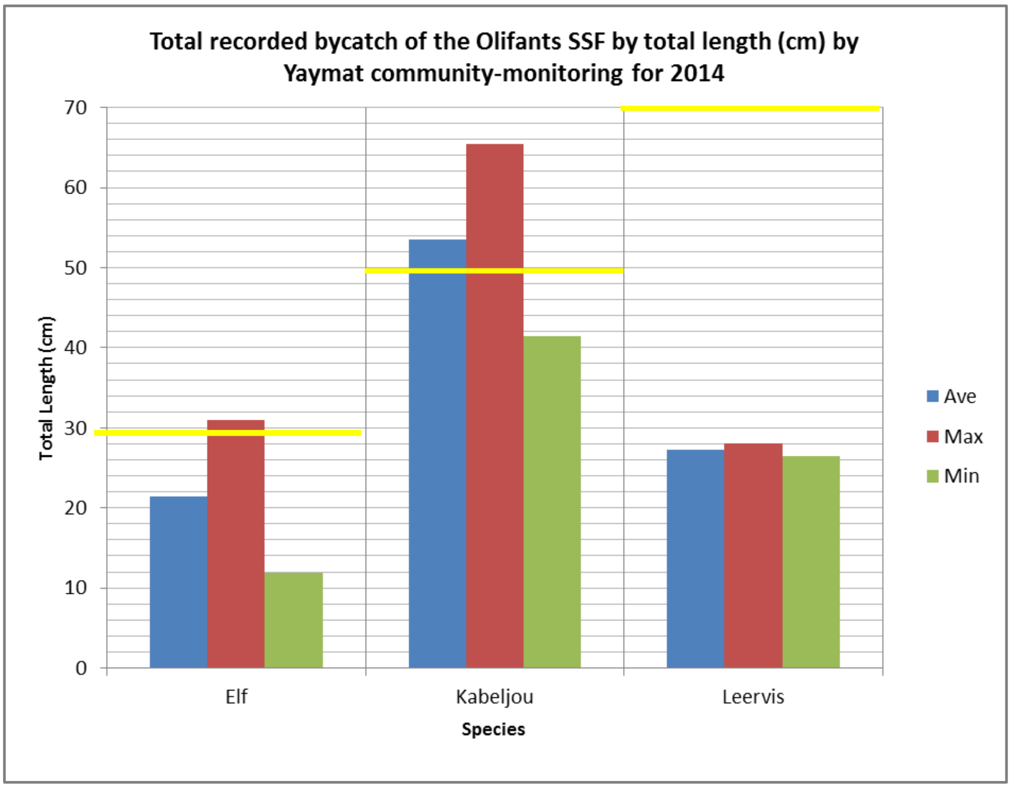

Figure 13: Total recorded average (Ave), maximum (Max), and minimum (Min) total lengths (in cm) for key selected linefish species caught in the Olifants estuary small-scale gillnet fishery for 2014. Note: The yellow lines indicate minimum allowable size for recreational fishers based on DAFF 2014/2015 Marine Recreational Activity Information Brochure. Refer to Table 4 for regionally specifc recreational Kabeljou regulations. **Source: Jaymat community-monitoring database.**

5.1.1.2 Location of catches

The Mouth to Baken area has been designated a no-take zone in line with a local nature conservation ordinance (see Figure 14 below for region of concern; see also Anchor, 2010; discussed further in the next chapter). Fishers have supported closure of this area and this has been reinforced during negotiations amongst members of the Olifants Estuary Management Forum (Jackson et al., 2013). Recorded bycatch was grouped into four zonal areas based on incorporating and making the most effective use of the available EEU community-monitoring data, and subject to data recording limitations, i.e. a small but significant portion of data was recorded as a single catch for multiple overlapping locations and therefore could not be included. The zonal areas selected are represented by Table 5 below. Zone 1 includes the closed fishing area as well as the highly productive Stootwal area, further upstream. The greatest percentage of total catches (by number) is known to occur in this zone (see Figure 15 below). This was supported by participant observation during fishing trips; and from fisher focus group held in September 2014. Most fishing ocurrs at night when fishers are known to catch greater numbers of Southern Mullet and at times Elf (fisher focus group, September 2014) coinciding with the Elf diel vertical movements to the surface at night as proposed by Wiedenmann and Essington (2006) and Hedger et al. (2010). The percentage of incidental Silver Kob and White Steenbras catches, also appear to be greater in zone 1 (see Figure 15 below). Interestingly, Leervis (Garrick) catches are higher in zone 2, whilst White Stumpnose catches are higher in zone 3. The available data from the gillnet fishery, despite its acknowledged limitations, with some preliminary analysis indicates a significant decreasing trend (as would be expected for marine species) for almost all bycatch species in the catch contribution, the further one moves upstream (see Figure 15 below). This decreasing trend is observed when total number of fish recorded for each zone by percentage is produced (see *Grand Total* in Figure 15). Reasonably productive fishing grounds are also located around Hotnotskop and the "Plaat" (plaat – meaning sand bank, see Figure 14 below), as identified by small-scale fisher interviews and the available community-monitoring data; a location which itself provides the scene for a cross-sector resource conflict between recreational, especially but not limited to shore-based, and small-scale fishers (see *Resource Conflicts* in Figure 6 above).

Table 5: Zonal demarcation of Olifants estuary small-scale gillnet fishery for data analysis purposes.

Zone	Landmarks
Zone 1	Punt - Stootwal
Zone 2	Stootwal - Hotnotskop
Zone 3	Hotnotskop - Langklip
Zone 4	Langklip - Upstream

Figure 14: Fishing locations in the Olifants estuary small-scale gillnet fishery. Note: Mapped using Google Earth.

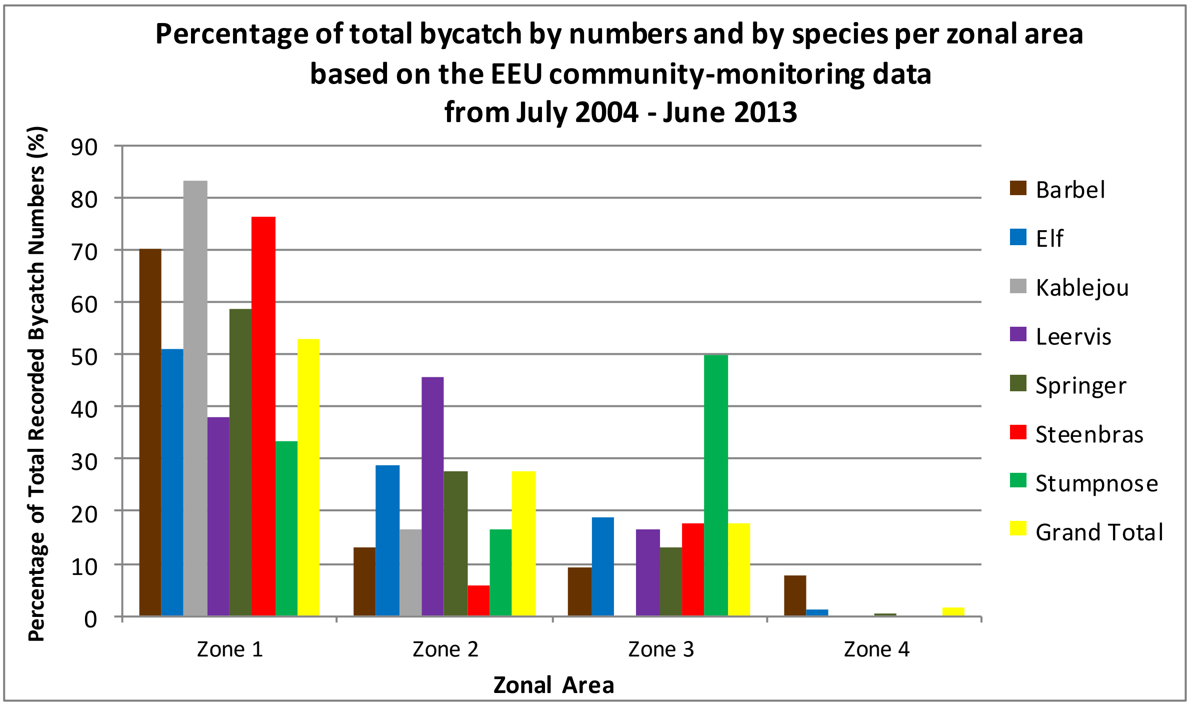

Figure 15: Percentage of total bycatch by numbers and by species per zonal area for the Olifants estuary small-scale gillnet fishery for the period July 2004 to June 2013. **Source: EEU community-monitoring database.**

5.1.2 The Olifants Estuary Recreational Fishery

With regards to the recreational fishing sector present in the area, a roving creel survey was conducted at various times of the day in four areas between Doringbaai and the Olifants Estuary as well as upstream on the Olifants River. As mentioned previously (Chapter 4), a total of 21 recreational shore-based fishers were encountered, with 5 fishers at Hotnotskop (on the river – see Figure 14 above), 3 fishers along the stretch of coast between the nearby towns of Strandfontein and Doringbaai (south of the Olifants Estuary), one spearfishermen from Strandfontein, and the majority (12) of the fishers in the vicinity of the Olifants estuary mouth. Therefore, the majority of the interviewees were encountered at the estuarine mouth, which has been identified as a sensitive area for certain estuarine-dependent species and thus poses a conservation concern. A summary of key findings coming out of this survey are found in Figure 16 below. When asked whether catch-and-release was practiced almost half the respondents said yes, though most were referring to undersized individuals, who all said they would release. The levels of truth of such responses are however unsubstantiated. The west coast region as a whole was rated by 81% of recreational fishers to have poor to average catches and 56% referred to the Oliftants/Strandfontein area as being poor for fishing. Kabeljou (Silver Kob), Hottentot (*Pachymetopon blochii*), White Steenbras, and Galjoen (*Dichistius capensis*) were identified consistently as the target species of this fishery, with Hottentot and White Stumpnose being considered the most commonly caught. The respondents considered fishing to have deteriorated in general (81%), many specifically highlighting the drastic declines in Silver Kob, and especially Galjoen catches in the area. None of the interviewees considered the recreational sector as having the greatest impact on fish stocks in the area, with 75% stating commercial, and 25% stating small-scale fishers as having the greatest impact. The perceptions of the recreational fishers interviewed of the performance of the fisheries management process was represented by an average of 57%. When asked about the levels of illegal recreational fishing 62.5% indicated that illegal fishing is a major problem in this fishery. The response to the question on the need for greater conservation efforts was split 50/50 and only 37.5% stated that they would be willing to pay more to support such conservation efforts. Numerous recreational fishers complained about the costs associated with buying required permits and highlighted this point in answer to this question. Of the 21 fishers interviewed only one admitted to not having a permit. The key finding of the local recreational fishery is that very little information and limited understanding exists of this fishery and its possible impacts.

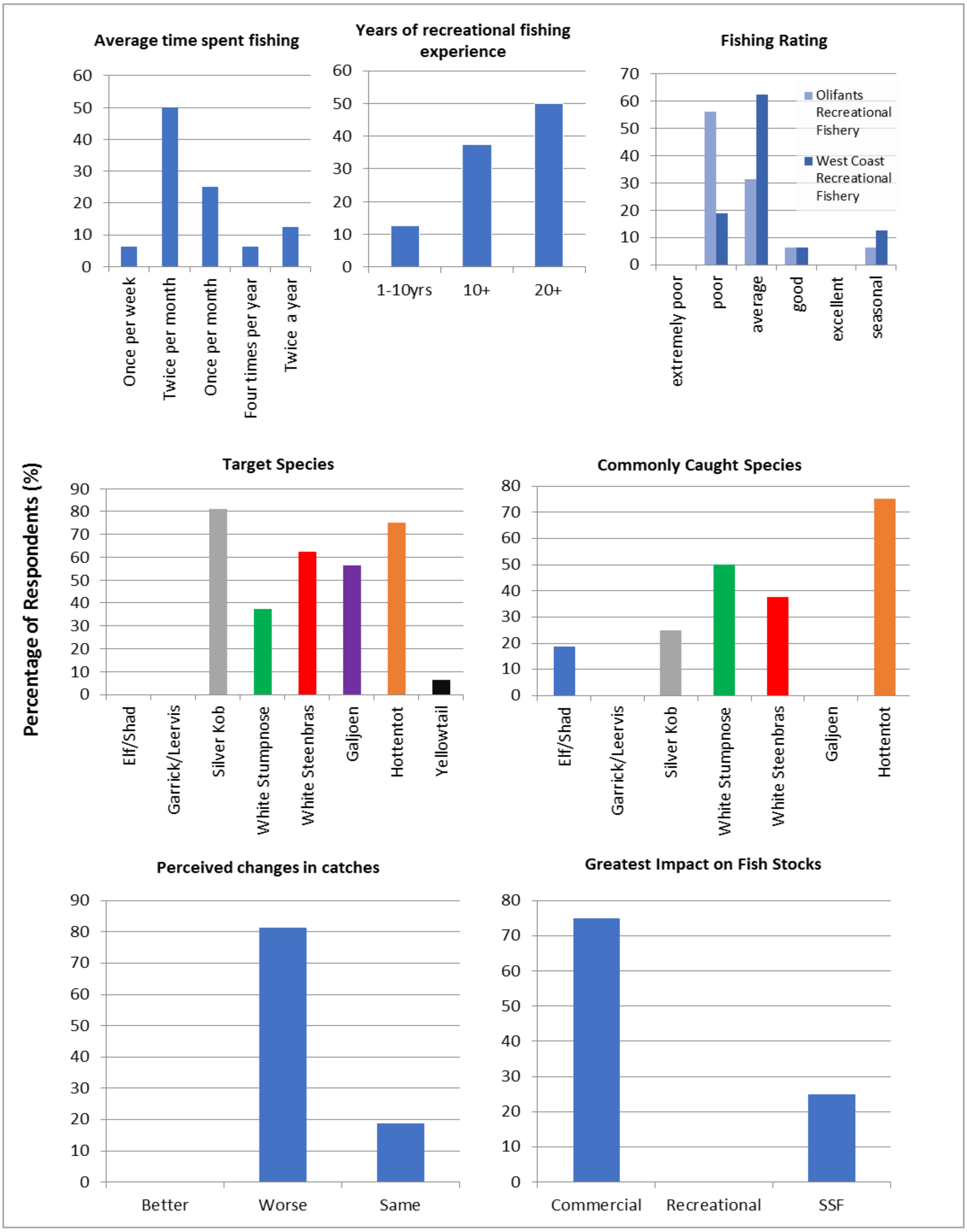

Figure 16: Key results of the Olifants estuary recreational fisher roving creel survey.

5.2 Key bycatch species and the relative contributions of fisheries

The subsequent sections will serve to contextualise the occurrence, and relative contributions of all fisheries known to capture these species and presents both historical and more recent data on landings in order to inform a more holistic understanding of the specific linefish species. Each section will commence with an overview of the life history and additional biological characteristics of each species.

5.2.1 Elf

An overview of the species:

Pomatomus saltatrix is a cosmopolitan epipelagic marine fish found in temperate and subtropical oceanic and coastal waters, and is commonly known as *bluefish* in North America and Europe, *tailor* in Australia, and *Elf* or *shad* in South Africa (Juanes & Conover, 1995; Munch & Conover, 2000; Ward et al., 2003; Hedger et al., 2010; Maggs et al., 2012). In South Africa Elf is abundant along the entire south-eastern seaboard (Van der Elst, 1976), where it is known to be capable of reaching a maximum length of 1000 cm (total length) and a mass of 10.3 kg (Van der Elst, 1993). Adults inhabit sandy and rocky substrata from the shore up to a depth of 100m (Van der Elst, 1975), and are common in KwaZulu-Natal waters in winter and spring (van der Elst 1975; Govender, 1995), however they are caught year-round (Maggs et al., 2012). They are found in Cape waters during summer and autumn, with some believed to be resident as they are apparently caught year-round in the Western Cape (Lamberth et al., 1995a) and have been shown to exhibit possible residency behaviour within Langebaan Lagoon (Hedger et al., 2010). Elf are characterised by a seasonal eastward along shore migration culminating in spawning off the KwaZulu-Natal coast in the late austral spring (Van der Elst, 1976), with the migration of juvenile Elf believed to precede that of adults (Govender & Radebe, 2000). The Agulhas current then carries larvae southward and inshore (Beckley & Connell, 1996), where juveniles can be located, in summer, in shallow coastal waters and estuaries along the south coast (Smale, 1984; Smale & Kok, 1983). These sites provide productive feeding grounds and decreased probability of offshore advection (Hutchings et al., 2002). Moreover, juveniles are also known to be found along the west coast (Clark, 1997; Hutchings & Lamberth, 2002a), which due to the great distance from KwaZulu-Natal has led to the suggestion that spawning may take place either on the Agulhas Bank or locally on the west coast resulting in these west coast nursery sites (Hedger et al., 2010). According to Hedger et al., (2010), this could be due to the presence of a stock separation of this species into an eastern and a western stock, or a mixed evolutionary strategy within the South African Elf population, represented by both a resident and a migratory component within the same stock. The mobility of the species along the coastline remains uncertain, however, after reviewing the data prepared by the ORI Tagging program for this species, specifically for this study, (for a 20 year period, i.e. 1st of January 1984 – 31st December 2014) (Dunlop & Mann, 2015) several tagged-released-and-recaptured individuals occurring substantial distances apart were identified (e.g. up to 1600kms). Most notably, several recordings were made of individuals moving between the Western Cape and the northern KwaZulu-Natal coast, which possibly affirms the migratory nature of the species (Dunlop & Mann, 2015). It is only with greater long-term studies, involving technology like acoustic telemetry, that we may gain a better understanding of their movements, and the existence of potential different stocks, and therefore the extent to which they are spatially exploited. Elf is a piscivorous species, and visual predator, and as such more active during daylight hours (Hedger et al., 2010), with gut-content analyses supporting this (Buckel & Conover, 1997; Buckel et al., 1999). Wiedenmann & Essington (2006) have hypothesized that Elf descend to the near-bottom during the day to feed, and ascended to the surface at night. A similar pattern was found by Hedger et al. (2010), however, more research is necessary in order to establish a relationship between diel change in depth and the vertical distribution of prey species, which has important implications for Elf's vulnerability to fishing mortality especially gillnetting which occurs predominantly at night.

Elf represents an important recreational and commercial species in many parts of the world (Beckley & Connell, 1996; Juanes et al., 1996; Lenanton et al., 1996; Ward et al., 2003). In South Africa, it has been considered the most important linefish species caught in the recreational shore-fishery (Joubert, 1981; Brouwer et al., 1997) and to a lesser extent in the recreational skiboat fishery (Sauer et al., 1997). The spatial distribution of Elf in commercial linefishery catches is represented in Figure 17 below. Commercial exploitation of Elf is prohibited in KwaZulu-Natal, however, it is permitted in the Eastern and Western Cape (Maggs et al., 2012). According to the Linefish Management Protocol developed for the South African Linefishery (Griffiths et al., 1999), a stock is considered to be overexploited if it falls below the target reference point of 40% of pristine (spawner-biomass-per-recruit [$SBPR_{(F=0)}$] with zero fishing mortality) and thus is in need of management intervention (Maggs et al., 2012). The $SBPR_{(F=0)}$ of Elf was estimated by Govender (1997) to be at 34% of unfished levels (Govender, 1997, cited in Govender & Radebe, 2000) and this level is believed to have remained unimproved over the past 15 years (Maggs et al., 2012). A selection of key sources of published data on Elf that were consulted for this study can be found in *Appendix 4.*

Figure 17: Spatial distribution of Elf caught by the commercial linefishery along the South African coastline. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped using Google Earth.

The following sections will address the occurrence and relative contributions of Elf to the landings of all fisheries known to capture this species and presents both historical and more recent data.

Historical Commercial Fishery Findings

The extent of the possible implications of past landings on potential future landings for Elf is particularly strongly emphasised by the historical South African Commercial Linefishery landings between the years of 1922 and 1931 (see Figure 18 below). Recorded Elf catches were extensive in the years of 1925, 1926, 1928, 1929 and 1931, represented by a maximum of approximately 90 t in 1928. The average annual landing for this 10 year period, even with some leaner years, is approximately 42.7 t. This level of harvesting is especially noteworthy considering that recent national landings for the period of 2001 to 2012 indicate an average annual landing of 8.16 t with a maximum of 35 t in 2005 (see Table 6, and Figure 19 below). The current decreased landings of Elf could be the result of a variety of factors including depleted stock, changing market value and bycatch regulations or gear modifications among many, and only further long term catch data will provide a more accurate picture of its status in this fishery. The occurrence of Elf in the trawl fishery historically is only represented by a once-off total annual recording of 1.88 t in 1921 (SAEON database), which is still greater than the average annual landing of this fishery of 0.8 t estimated by Attwood et al. (2011) for the period 2003-2006. However, greater knowledge of historical catches would be necessary to confirm any causal relationship.

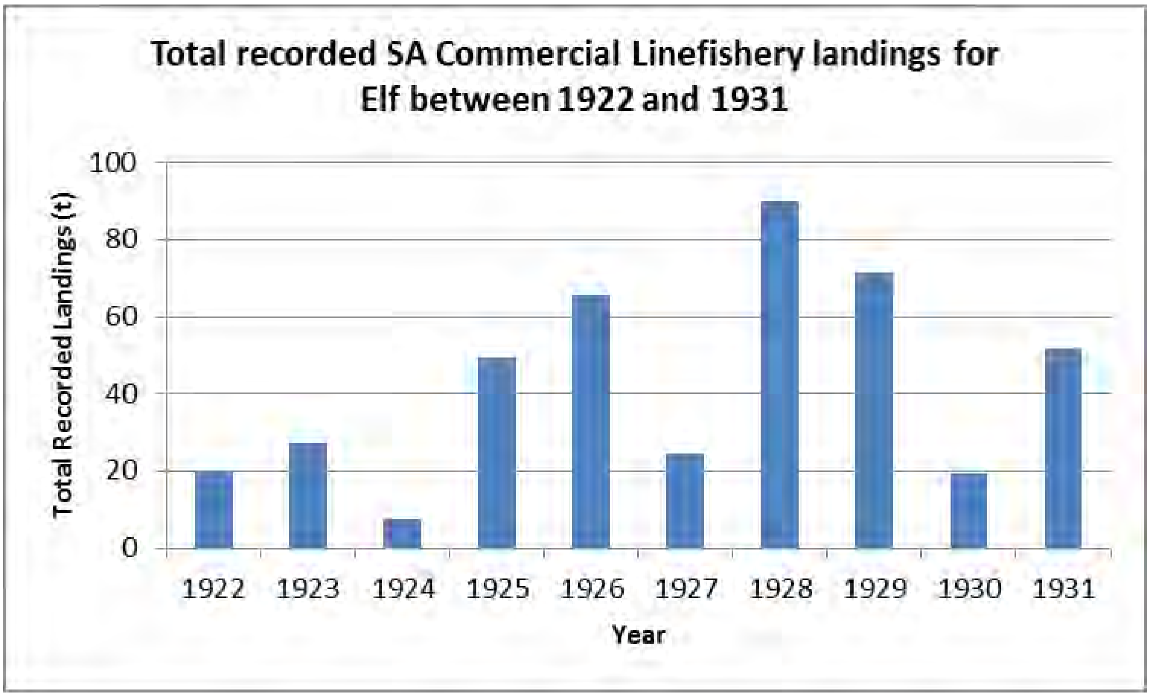

Figure 18: Total recorded South African Commercial Linefishery landings for Elf in tons between 1922 and 1931.
Source: SAEON database.

Recent Landings: an overview

Recent figures for the total annual landings o Elf by fishery sector for the year 2012 are represented in Table 6 below. Upon initial inspection possible concerns over the exploitation pattern of this species are the 4 t of beach seine and gillnet catches, which are often undersized individuals, and the extent of the impact of the commercial linefishery at almost 11 t. In addition, the unknown but theorised substantial impact of the open-access recreational linefishery needs to be considered in any attempt to estimate the overall or relative sector levels of exploitation of this species.

Table 6: Total recorded national landings of Elf for 2012 in tons by fishery sector. **Source: FIHB (2013).**

Fishery	Total Landings (t)
Commercial Linefishery	**10.79**
Inshore Trawl	**0.07**
Beach seine and gillnet	**4.00**
Grand Total	**14.85**

The South African Commercial Linefishery

Currently, Elf may be caught and sold by the traditional boat-based fishery in all provinces except KwaZulu-Natal with the only reprieve from commercial exploitation in the Eastern and Western Cape ocurring during the two-month closed season between 1 October and 30 November (Maggs et al., 2012; Mann, 2013). However, as Elf migrate to KwaZulu-Natal during this period, this closed season is considered largely ineffective, as is the no bag limit for commercial exploitation during summer, i.e. the high prevalence months for the Eastern and Western Cape (Mann, 2013). An additional concern is that Elf are mostly used as bait in the boat fishery and is consequently seldom reported in the retained catch (Maggs et al., 2012). Commercial linefish catches of Elf, as recorded by the Marine and Coastal Management (MCM) Linefish dataset between the years 1985 and 2005, can be represented by Figure 20 below, which exhibit the recordings made by the Commercial Linefishery sector along the entire South African coastline. The South African Commercial Linefishery has shown highly variable recorded landings of Elf in the years 2001 – 2012, with as little as 3 t in 2001 and as much as 35 t in 2005 (see Figure 19 below), but as mentioned previously landings have been much depreciated by comparison to historical values. However, the aforementioned average annual landing of 8.16 t for the period 2001 to 2012 (see Figure 19), as well as more specifically the 2012 landing of approximately 11 t (FIHB, 2013), are still indicative of a substantial catch, especially when compared to the 2012 beach-seine and gillnet landing of 4 t (FIHB, 2013), which interestingly represents merely 0.003 % of the catch of the main target species of Mullet by this fishery (FIHB, 2013).

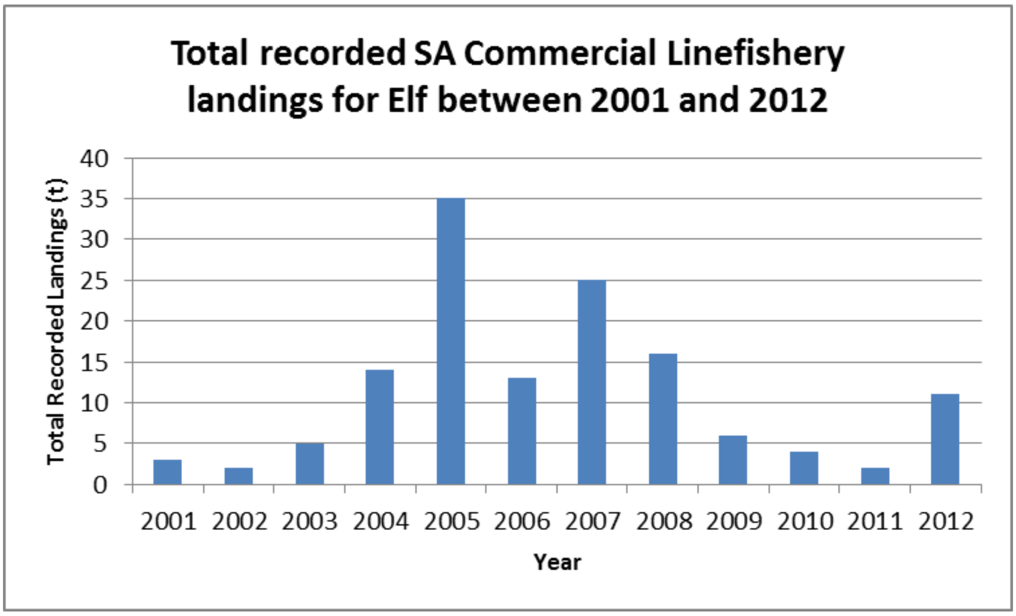

Figure 19: Total recorded South African Commercial Linefishery landings of Elf in tons between 2001 and 2012. **Source: FIHB (2013).**

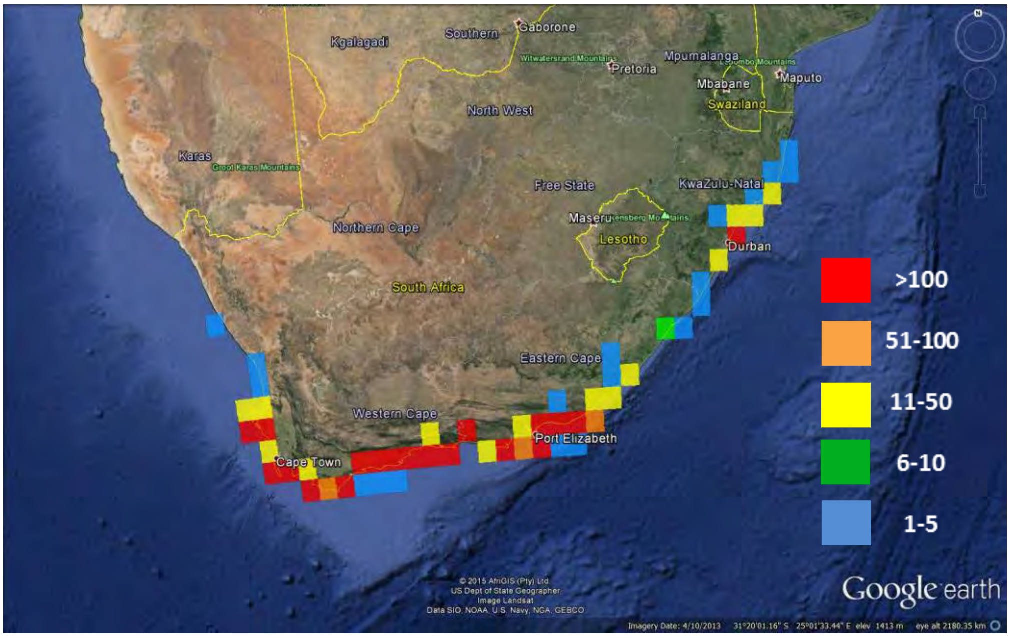

Figure 20: Occurrence of Elf (by numbers of recordings) in commercial linefishery catches along the South African coastline between 1985 and 2005. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped using Google Earth.

The South African Commercial Inshore Trawl

Consistent with its historical catch records, Elf is not known to occur in great quantities within the South African Commercial Inshore Trawl sector relative to the Commercial Linefishery, with Attwood et al. (2011) estimating an annual average landing of 0.8 t for the 2003-2006 period. However, these figures are still significant and should be monitored to account for the overall landings of the species by all sectors and the implications thereof for sustainable use in line with an EAF. Although not part of the inshore trawl it is interesting to note that Elf is also known to occur as bycatch in the KwaZulu-Natal prawn trawl but no data are available (Mann, 2013).

The South African Recreational Fishery

Elf has long been known to represent a highly popular recreational angling species (Joubert, 1981; Brouwer et al., 1997). Brouwer et al. (1997) provided a breakdown of anglers targeting this species of 12% for the south coast, 14% for the eastern coast and 29% for the KwaZulu-Natal coast. Results from the online recreational survey conducted for this study revealed that this regional pattern endures, with KwaZulu-Natal receiving 80-90% respondent score and the Southern, Eastern and Western Cape between 40-65% for targeting and commonly catching Elf (see Figure 21 below). Furthermore, Smale and Buxton (1985) refer to Elf as a *'principal'* species to ski-boat anglers in the Eastern Cape. In a study conducted on the KZN paddle-ski fishery, Mann et al. (2012) established a frequency of 3 and 17 Elf per 100 fish caught on the north and south coasts of KwaZulu-Natal respectively. Mann et al. (2002) reported an estimated total weight of 1.2 t of Elf caught by recreational anglers in the St Lucia system from 1986-1999. In addition, Mann et al. (2003) when assessing the catch composition of 760 shore-fishers in the Eastern Cape (between April 1997 and January 1998) revealed an 18.2% and 14.4% total catch by number and mass of Elf respectively. Moreover, Hutchings et al. (2008) showcased the significant contribution of Elf to recreational fishers in the Berg River Estuary where 1784 Elf were recorded making up 55.6% of the total catch and representing a size range of 10-45 cm total length.

Dicken et al. (2012) when analysing data captured at *Angling Week*, in the Eastern Cape, between 1999 and 2010, reported a total weight of 0.157 t, however this relatively low number is influenced by the fact that competitive fishers usually target species of greater mass such as sharks and skates (i.e. elasmobranchs) and not teleosts, as this is how points are allocated to catches. This is echoed in competition data between 2011 and 2013 gathered by the West Coast Shore-Angling Association (WCSAA), where in competition Elf is shown to be very sporadically caught (a recording of 0.0097 t and 0.00985 t for competitions in March 2012 and January 2013 respectively – WCSSA dataset). This finding is further supported by the competition data from all Rock and Shore Super Pro League (RASSPL) events in 2013 and 2014, where the highest recorded catches for Elf are 0.067 t in the Eastern Cape (see Figure 22 below). Moreover, the minimum total length of Elf caught (in cm) at RASSPL competitions (see Figure 23 below), especially in the Eastern Cape (EC) with a 2014 recording of 23 cm, does allude to the potential of the recreational sector to land undersized individuals (i.e. less than 30 cm – although this may be skewed by one individual). In contrast, data from the KwaZulu-Natal Coastal Angling Union (KZNCAU) for competition catches obtained at 9 postal and 7 common venue competitions per year for the period 2007 to 2014 indicate relatively substantial catches of Elf in both numbers (average of 1091 individuals and peak recording of 2295 in 2007) and mass (average of 1.45 t and peak recording of 4585 t in 2007), although a decline in both total numbers and mass has been recorded since 2008 (see Figure 24 below).

Competition data provides interesting insights into the relative biomass of species, and its frequency in catches, however, as most competitive fishing events involve catch-and-release (as was the case for this data) these figures do not necessarily contribute to overall landings of the species. An additional point of interest is that Elf is also present in recreational spearfishing catches, although these levels are thought to be negligible. Nonetheless, the figures do attest to the potential catches that could be occurring by recreational fishers all along the South African coastline, yet it is only through more rigorous monitoring of the open-access and essentially unknown recreational fishing sector that the contributions of this sector to the overall exploitation of Elf and various other target species will be confirmed.

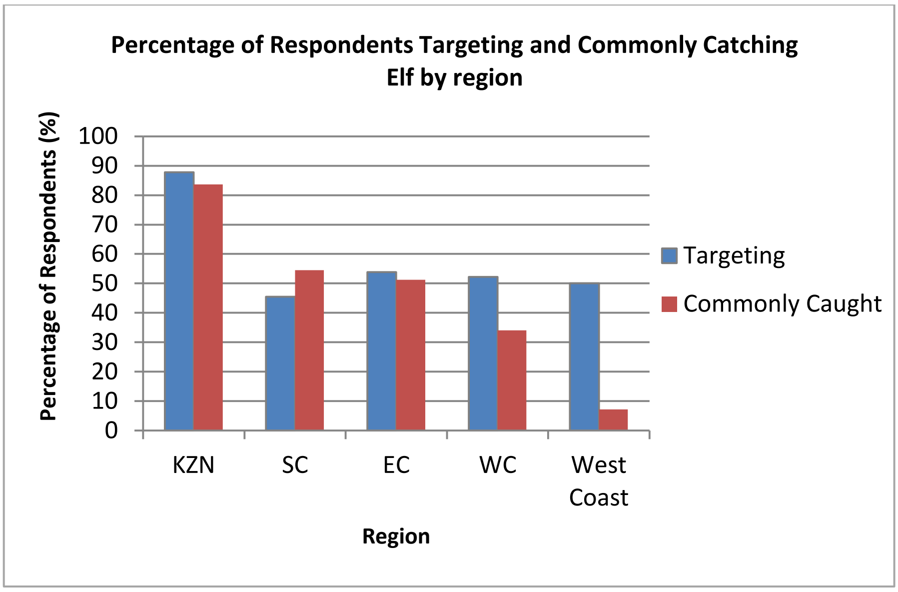

Figure 21: Percentage of respondents from the online national recreational survey targeting and commonly catching Elf by region. Note: WC (Western Cape) represents the entire WC provincial area and therefore incorporates the three regional distinctions made in the survey of the Southern Cape (SC), the West Coast, and The rest of the Western Cape. KZN – KwaZulu-Natal; EC- Eastern Cape.

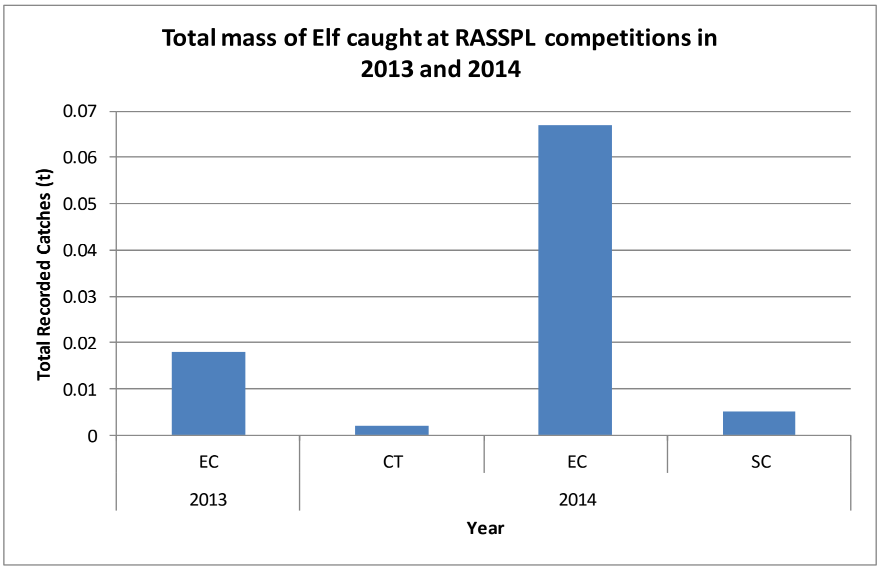

Figure 22: Total recorded Elf catches in tons at RASSPL competitions by region and year for 2013 and 2014. Note: EC – Eastern Cape; SC – Southern Cape; and CT - Cape Town. **Source: RASSPL.**

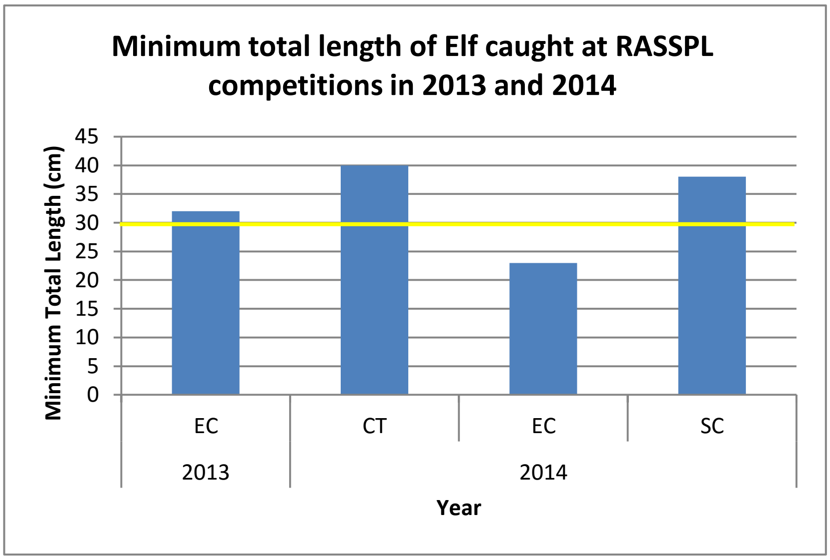

Figure 23: Minimum total length in cm of Elf caught at RASSPL competitions in 2013 and 2014. Note: The yellow line indicates the minimum allowable recreational size of Elf (according to the DAFF Marine Recreational Use Brochure 2014/2015). EC – Eastern Cape; SC – Southern Cape; and CT - Cape Town. **Source: RASSPL.**

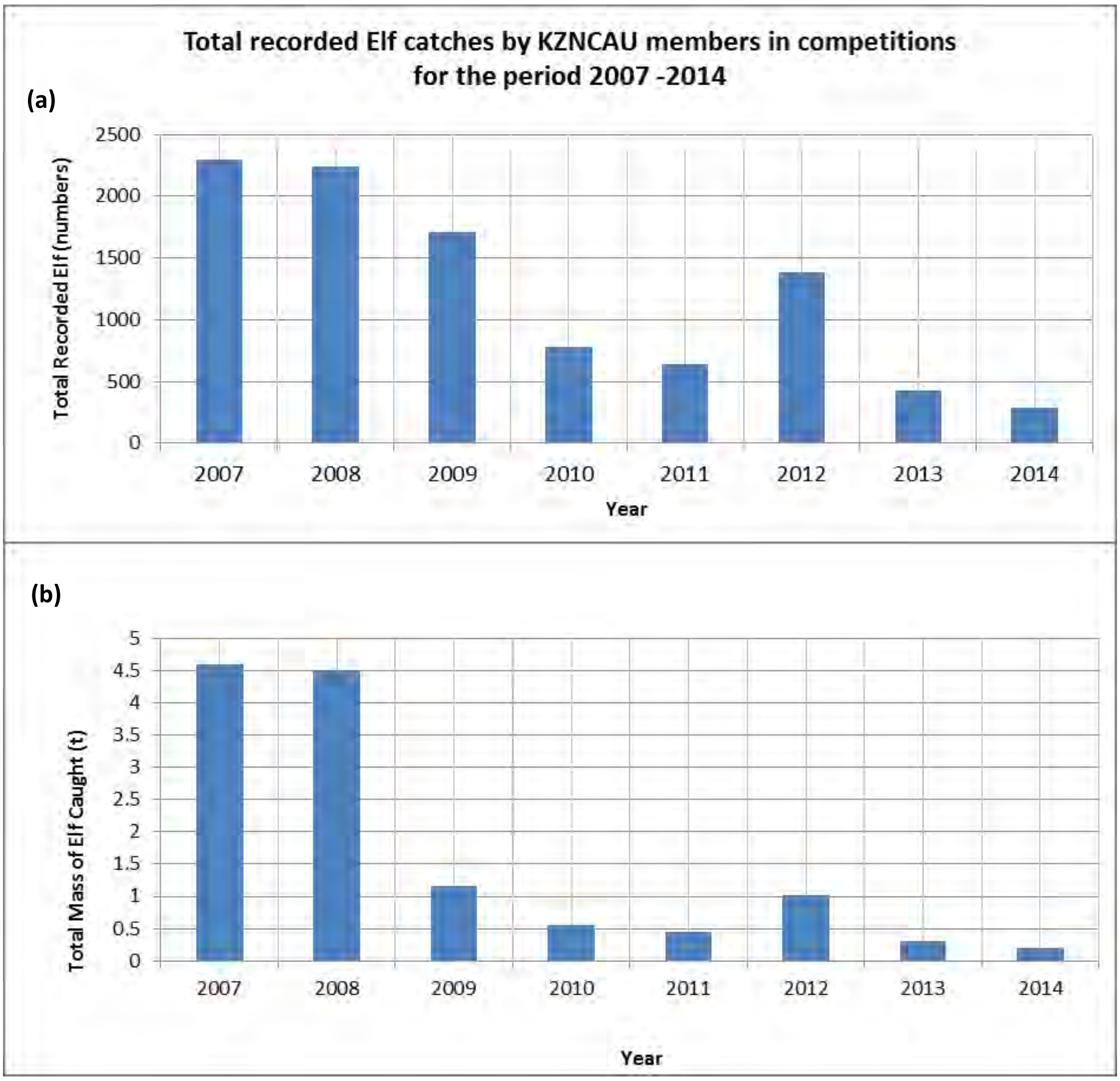

Figure 24: Total recorded Elf catches by KZNCAU members in competitions by **(a)** numbers and **(b)** mass (in tons) for the period 2007 to 2014. **Source: KZNCAU.**

Other South African Net Fisheries

Lamberth et al. (1994) offers some insight into the frequency of occurrence of Elf (62.1%) and the significant percentage of immature (55%) Elf in beach-seine catches forming approximately 2.4% of the total catch. They also estimate the relative contribution (for the period 1985-1992) of the beach-seine, commercial linefishery and recreational shore-angling fisheries to pressure placed on this species in False Bay. The most notable contribution is that of the commercial linefishery (48%) and shore-angling (42%) (Lamberth et al., 1994). This work in particular, showcases the potential of recreational shore-angling to contribute significantly to local exploitation of a species. According to Hutchings & Lamberth (2002b) the most common bycatch in gillnets in the Berg River was Elf, which appeared in 50% of the landings monitored, and they estimated an annual catch of 70 692–362 420 fish (approximately 14–72 t), although this is a very big range, the maximum extent of which may be unrealistic. In fact, Hutchings and Lamberth (2002a) suggested that most marine gillnetters who were targeting harders reported Elf as one of their primary bycatch species, with the exception of fishers from Saldanha Bay/ Langebaan Lagoon which listed White Stumpnose among others as their major bycatch species. More recently, as mentioned previously, the total annual national landings of Elf for 2012 within the beach-seine and gillnet fishery were reported to be 4 t (FIHB, 2013; see Table 6 above).

Summary of findings

The levels of historical commercial catches of Elf, specifically those pertaining to the commercial linefishery, have been shown to be substantial with the average annual landing for this time period being approximately 42.7 t (SAEON database). Elf represents not only the most prominent bycatch species of the Olifants estuary small-scale gillnet fishery, but is a principle component of the current commercial linefishery (with ineffective current species-specific management regulations). Its popularity as a recreational linefishery species was also highlighted in the findings of the online national recreational survey conducted for this study as well as from previous studies. The reported national landings of the beach seine and gillnet fishery for 2012 (approximately 4 t) are significantly smaller than the commercial linefishery (national landings of approximately 11 t for 2012) while the recent landings of the commercial trawl fishery are unknown. Elf's distribution range spans the entire South African coastline and it undertakes large scale migrations to spawn, although a proposed mixed migratory/residential strategy has been suggested (though not clearly established), indicating that the species requires both regional and national management strategies across all fisheries. Figure 25 below displays the relative national contributions by fishery to the harvesting of Elf (in 2012) according to FIHB (2013). Figure 26 below, presents an attempt to contextualise the relative contributions, and spatial distribution, of the different fishery sectors that contribute to Elf exploitation based on the data available. It is by no means conclusive, but attempts to provide a more holistic perspective of the contributions of different fishery sectors to the national status of the species.

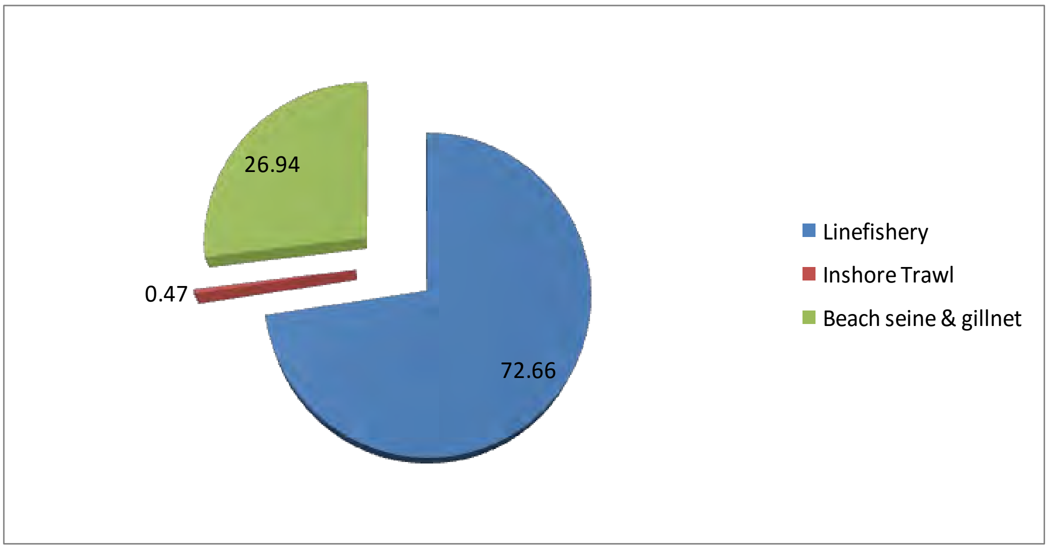

Figure 25: Pie chart of the relative national contributions (by percentage) for 2012 of the fisheries known to catch Elf. **Source: FIHB (2013). Note:** It is important to note that relative contributions should also be regionally appraised and that Linefishery contributions do not include the recreational fishery.

Figure 26: Map of South Africa indicating the relative national contributions of the fisheries known to catch Elf. **Note:** Size of icons attempts to provide an indication of relative contributions when compared to other fisheries and within each fishery sector itself from the data available. Commercial Trawl and Linefishery icons in the figure are placed throughout the range where catches are known to possibly occur and do not necessarily indicate specific locations. **Mapped using Google Earth.**

5.2.2 Silver Kob

An overview of the species:

Argyrosomus inodorus also known as Silver Kob, is a migratory, benthopelagic sciaenid fish, endemic to the south-eastern Atlantic (Griffiths & Heemstra, 1995). Its distribution range is restricted to cold temperate waters (13—16 °C), from the nearshore environment to depths of 100 m (Henriques et al., 2014), and occurs southwards from Namibia around the Cape of Good Hope and north-eastwards to the vicinity of the Kei River in South Africa (Smith et al., 2013). However, according to Griffiths & Heemstra (1995) it is not all that common between Cape Point and central Namibia (Griffiths & Heemstra, 1995). It rarely enters estuaries or the surf zone between the Kei River and Cape Agulhas, and is caught mostly by skiboat fishermen and trawlers at depths of 10-100 metres (Griffiths & Heemstra, 1995). However, when entering the cooler waters along the west coast, past Cape Agulhas, the species becomes more abundant in the surf zone, with the proportion of Silver Kob found in *Argyrosomus* catches (catches recorded by *Argyrosomus* genus) declining in northern Namibia, as water temperatures increase. It is not known to occur in Angola (Griffiths & Heemstra, 1995). Silver Kob also known locally as kabeljou (the latter a confusing name as it is shared by *Argyrosomus japonicus*, i.e. dusky Kob), is a large, slow growing fish reaching sexual maturity at 400 cm (3.5 years), with a maximum recorded length and weight of 1300 cm and 34kg respectively (Griffiths, 1997c). Until recently it was misidentified as *A. hololepidotus* throughout its distribution, and off South Africa it was also confused with a sympatric species *A. japonicus,* by Griffiths & Heemstra (1995), based on the distribution patterns of the two species, the catch localities, the sizes of the specimens examined and the descriptions of the caudal fin. These authors suggest that it is almost certain that many previous authors were inadvertently referring to Silver Kob*,* in part or in full. Specifically, several South African publications on "*A. hololepidotus*", which include those on: feeding (Nepgen, 1982, Smale & Bruton, 1985); reproduction (Smale, 1985); juvenile distribution (Wallace et al., 1984a; Smale, 1984; Smale & Badenhorst, 1991); and descriptions of the early life-history stages (Beckley, 1990), deal either exclusively or predominantly with Silver Kob (Griffiths, 1996b). Furthermore, the occurrence of possible hybridization has been suggested (Mirimin et al., 2014).

Adult Silver Kob disperse offshore in winter (100m) and concentrate nearshore in summer (20m), whereas juveniles are found mainly over soft substrata of sand or mud between 5-120m in depth (Smith et al., 2013). In the south-western Cape, adult Silver Kob feed predominantly on pelagic fish, mainly anchovy *(Engraulis capensis)* (Nepgen, 1982), but in the south-eastern Cape, even though pelagic bait-fish are consumed, the principal diet is larger demersal teleosts and squid (Smale & Bruton, 1985; Kirchner, 1999). Griffiths (1996a) suggests it is plausible therefore that anchovies provide optimal growth for Silver Kob of 400-800 mm (Total Length)*,* but for predators larger than that length range, prey size becomes limiting. The Silver Kob occurring in the South-Eastern Cape, Southern Cape and South-Western Cape have been pointed out by Griffiths (1997c) to represent three different stocks and that these stocks should therefore be managed separately. The notion of three separate Silver Kob stocks is further supported by the following aspects: regional differences in annulus structure (Griffiths, 1996a); low rates of exchange between regions, as determined from tagging data; differences in the sizes at maturity between the Southern and South-Eastern Cape; and discontinuity in the distribution of juvenile Silver Kob trawled between Cape Agulhas and Port Alfred (Griffiths, 1997c). Each stock (or region) possesses its own nursery and spawning area, with young juveniles recruiting to the nurseries (5-10 m) before moving into deeper waters as they grow (Smith et al., 2013). According to Griffiths (1997a), Silver Kob appears to be resident to specific areas with few fish migrating further than 50 km from where they were tagged. This notion would seem to be consistent with ORI Tagging, data prepared for this study (Dunlop & Mann, 2015), which indicated no recapture events occurring over 140 km apart. Nonetheless, the possibility of separate stocks needs to inform fisheries management strategies for this species and its regional and national sustainable harvesting.

Silver Kob is an essential component of multiple coastal fishery sectors, and an especially important species within the linefishery (Griffiths, 1997c). The spatial distribution of the species as noted in commercial linefishery recordings, between 1985 and 2005, is represented in Figure 27 below. It is highly regarded as a 'table' fish and is an important commercial and recreational species in all localities, with the majority of the South African catch made between the Cape of Good Hope and the Kei River (Griffiths and Heemstra, 1995). As a result of the exploitation pressure of multiple sectors, throughout its range the species has become severely depleted, with spawning stocks estimated to be 69% of unexploited values (Kirchner, 1998; DAFF, 2012b; FAO, 2012a) and models estimating spawner-biomass-per-recruit (SBPR) ratios as low as 2.9-12.5% (SBPR; $_{F=0}$) (Griffiths, 1997c). Interestingly, line catches are known to decrease during winter months while catches made by trawlers at depths of 50–120m increase, which might suggest movement to deeper water during the winter months (Griffith, 1997a) and fuel continued conservation concerns for this species due to their extended temporal exploitation. Due to misidentification issues mentioned above, in addition to many recordings being grouped by genus, it is challenging to attempt to consolidate data on the species. However, it is safe to say that Silver Kob has been exploited in South African waters for more than 150 years (Pappe, 1866), and is thought to be the most valuable species caught by the linefishery between Cape Point and East London (Griffiths, 1997c; Smith et al., 2013). A selection of key sources of data on Silver Kob that were consulted for this study can be found in *Appendix 5.*

Figure 27: Spatial distribution of Silver Kob caught by the commercial linefisherry along the South African coastline. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped using Google Earth.

The following sections will address the occurrence and relative contributions of Silver Kob to the landings of all fisheries known to capture this species and present both historical and more recent data.

Historical Commercial Fishery Findings

In historical catch records, all Kob (genus *Argyrosomus*) have been recorded together, and recordings refer to Kob as *Kabeljaauw*. However, it is safe to assume that this is predominantly referring to Silver Kob (in line with Griffiths & Heemstra, 1995) with respects to trawl catches, and was assumed as such for the purposes of this study. However, in the case of linefishery catches it is not as safe to assume as much. The extent of the possible implications of past landings on potential future landings for Silver Kob is emphasised by the historical South African Commercial Trawl and Linefishery landings for the periods of 1921 - 1942, and 1922 - 1935 respectively (see Figures 28 and 29 below). Annual Silver Kob trawl landings are especially extensive (i.e. consistently over 1000 t) between the years 1924 and 1938 (with the exception of the lack of recordings for the years 1932 – 1935) and indicates a maximum landing of approximately 1 769 t in 1938. The annual average annual landing for the period 1921 to 1942 (18 years due to the lack of recordings for the years 1932 – 1935), even with some leaner years, can be represented as approximately 1118 t. This level of harvesting is especially noteworthy considering that recent national inshore trawl landings for the period 2001 to 2012 indicate an average annual landing of approximately 174 t with a maximum of 282 t in 2002 (see Table 7 below). The decreased trawl landings of Silver Kob could be the result of a variety of factors including depleted stock, market value, gear modifications, or new restrictions on bycatch among many, and only further long term monitoring data will provide a more accurate picture of the status of Silver Kob in this fishery.

The South African Commercial Linefishery historical landings for the period 1922 – 1935 for Kob (i.e. the *Argyrosomus* genus) are substantial (i.e. consistently over 1000 t) between the years of 1925 and 1930, and indicates a maximum annual landing of approximately 1303 t in 1926. However, this would include all species of the *Argyrosomus* genus. The annual average landing for the period 1922 – 1935 (i.e. 13 years due to the lack of recordings for 1933) in spite of some years with significantly decreased landings, is approximately 633 t. This level of harvesting is especially noteworthy considering that recent national linefishery landings for the period 2001 to 2012 indicate an average annual landing of approximately 361.3 t with a maximum of 442 t in 2009, again grouping the *Argyrosomus* genus. As with trawl landings, the decreased landings could be the result of a variety of factors and only further long term monitoring data will provide a more accurate picture of the status of this species in this fishery.

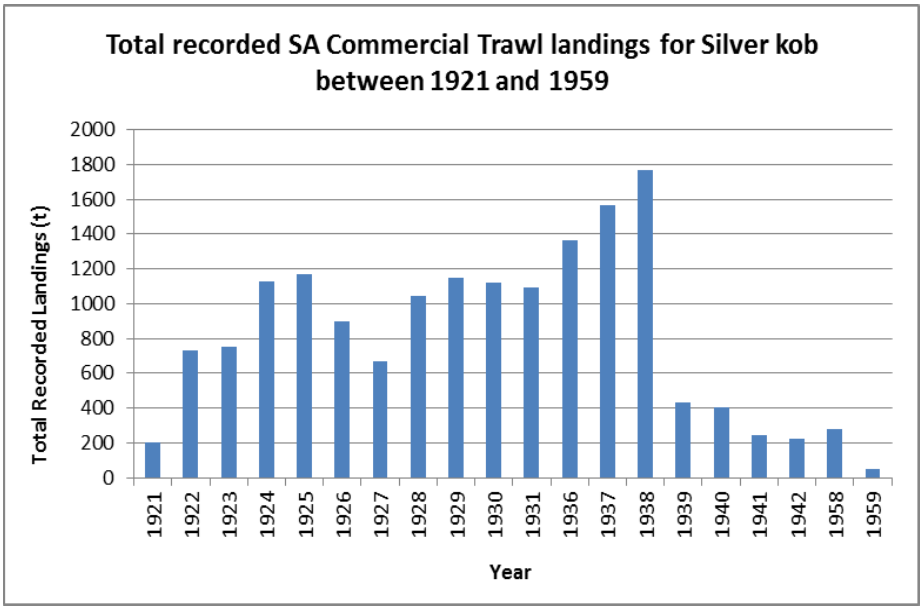

Figure 28: Total recorded South African Commercial Trawl landings for Silver Kob in tons between 1921 and 1959. **Source: SAEON database.**

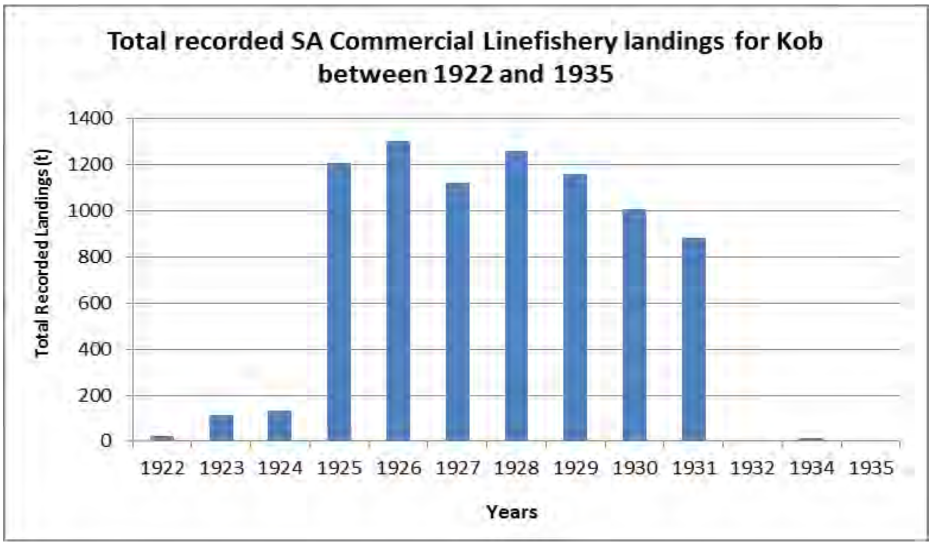

Figure 29: Total recorded South African Commercial Linefishery landings for Kob in tons between 1922 and 1935. **Source: SAEON database.**

Recent Landings: an overview

Recent figures for the total annual landings of Silver Kob or Kob (in the case of the commercial lInefishery) by sector for the year 2012 are presented in Table 7 below. Upon initial inspection of the figures, possible concerns regarding the exploitation of this species by different fishery sectors is noted: 3 t of beach seine and gillnet catches, which have been shown to often include undersized individuals; the extent of the impact of the exploitation of commercial fisheries on the species most notably the linefishery (approximately 215 t); and the contribution of the inshore trawl (approximately 120 t), although the commercial linefishery represents the combined totals of all Kob. Another point of interest is the presence of the species in a wide variety of fisheries (especially noteworthy is the 2.5 t occurring in the hake longline fishery), which substantiates conservation concerns for this species. Griffiths (2000) provides some insight into recent levels of catch contribution of Silver Kob (1986-1997) to the Southern Cape, in comparison to historical catches (1927-1931 and 1898-1906 - see Table 8 below). Duncan & Burgener (2013) also offer an insight into the relative regional nature of the exploitation of Silver Kob for the period 2000-2010, with total catches by mass of 565 t and 2920 t, and percentage catch 13% and 56% respectively for the South Eastern and Southern Cape regions.

Table 7: Total recorded national landings of Silver Kob (or Kob in the case of the commercial linefishery) for 2012 by fishery sector. **Source: FIHB (2013)**

Fishery	Total Landings (t)
Commercial Linefishery	**214.67**
Inshore Trawl	**119.76**
Beach seine and gillnet	**3.00**
Hake Longline	**2.50**
Demersal Trawl	**0.71**
Grand Total	**340.64**

Table 8: Stock status indicators calculated from commercial and fishery-independent datasets for Silver Kob for the Southern Cape. %C is percentage change in contribution to catch, and %cpue is percentage change in cpue between sampling periods. **Source: Griffiths (2000).**

Dataset Comparison			
1986-1997* **1898-1906**		**1986-1997*** **1927-1931**	
%C	**%Cpue**	**%C**	**%Cpue**
67.0	21.5	29.8	7.8

The South African Commercial Linefishery

Griffiths & Heemstra (1995) estimated commercial linefishery catches of Silver Kob at an average of 835 t per annum (1988-1992). Griffiths (2000), provides a comparison of historical catches (1897-1906 and 1927-1931) and more recent catches (1986-1998) of Silver Kob by region in the linefishery (see Table 9 below). The spatial distribution of commercial linefishery catches of Silver Kob, as recorded by the MCM Linefish dataset between the years 1985 and 2005 and represented by Figure 30 below, begin to exhibit the quantity and spatial concentration of catches been made by the commercial linefishery sector along the South African coastline for that period, noteworthy recordings exist for Cape Agulhas and Port Elizabeth. The South African Commercial Linefishery has shown variable annual landings between 2001 and 2012 (with minimum and maximum annual landings of 217 t in 2012 and 442 t in 2009 (Figure 31 below), but as mentioned previously landings have been much depreciated in comparison to historical values. Additionally, Attwood et al. (2011) provide an estimation of an average annual landing for the period 2003 – 2006 of 339 t. However, the aforementioned average annual landing of 361.3 t for the period of 2001 to 2012 (FIHB, 2013), the Attwood et al. (2011) estimated landing of 339 t, as well as more specifically the 2012 landing of approximately 215 t (FIHB, 2013), is still indicative of a substantial catch in comparison to the recorded national beach-seine and gillnet fishery and inshore trawl annual landings of 3 t and 120 t respectively (FIHB, 2013). However, once again the grouping of the *Argyrosomus* genus in commercial linefishery catches must be kept in mind. Interestingly, the gillnet and beach seine catches of Silver Kob for 2012 represent merely 0.002 % of the total catch of Mullet, the main target species of that fishery (FIHB, 2013).

Table 9: Mean catch/boat/year (±SD) of Silver Kob by the linefishery, during the three periods 1897-1906, 1927-1931, and 1986-1998 for the South-Western (SW) Cape, Southern (S) Cape, and South-Eastern (SE) Cape. % current is the 1986-1998 CPUE value calculated as a % of the highest of the 1897-1906 or 1927-1931 values. Figures below converted to tons (from kg) and rounded up to 1 decimal place from the original figures. **Source: Griffiths (2000).**

Region	Mean catch/boat/year (t)			% current
	1897-1906	***1927-1931***	**1986-1998**	
SW Cape	2.8 (0.711)	1.2 (0.280)	0.26 (0.068)	9.24
S Cape	3.6 (0.976)	9.7 (1.739)	0.76 (0.174)	7.83
SE Cape	14.9(9.448)	13.5 (5.244)	0.58 (0.130)	3.89

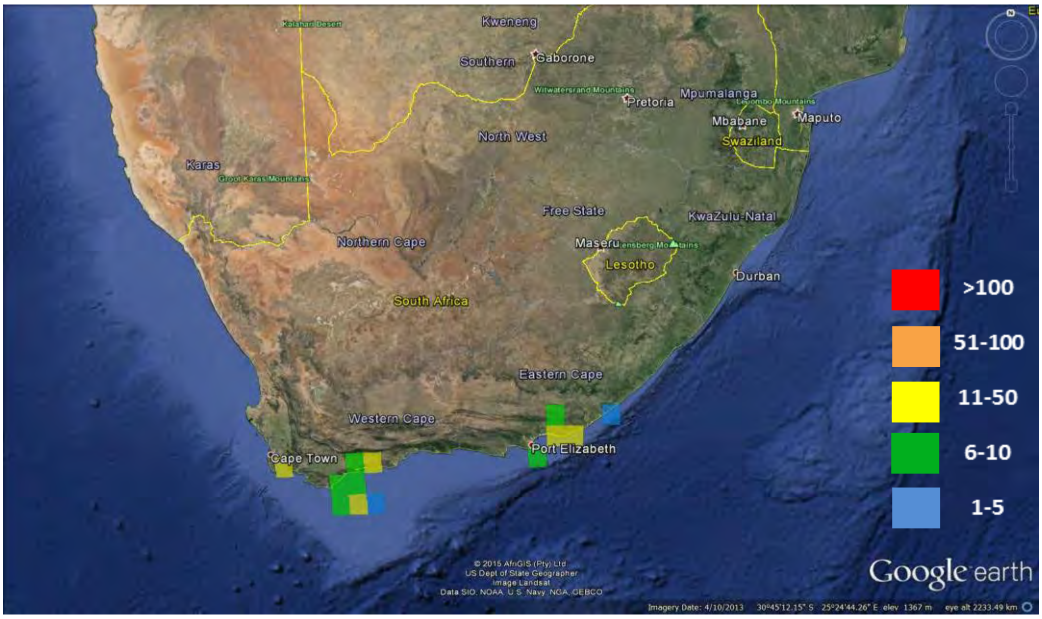

Figure 30: Occurrence of Silver Kob (by numbers of recordings) in commercial linefishery catches along the South African coastline between 1985 and 2005. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped using Google Earth.

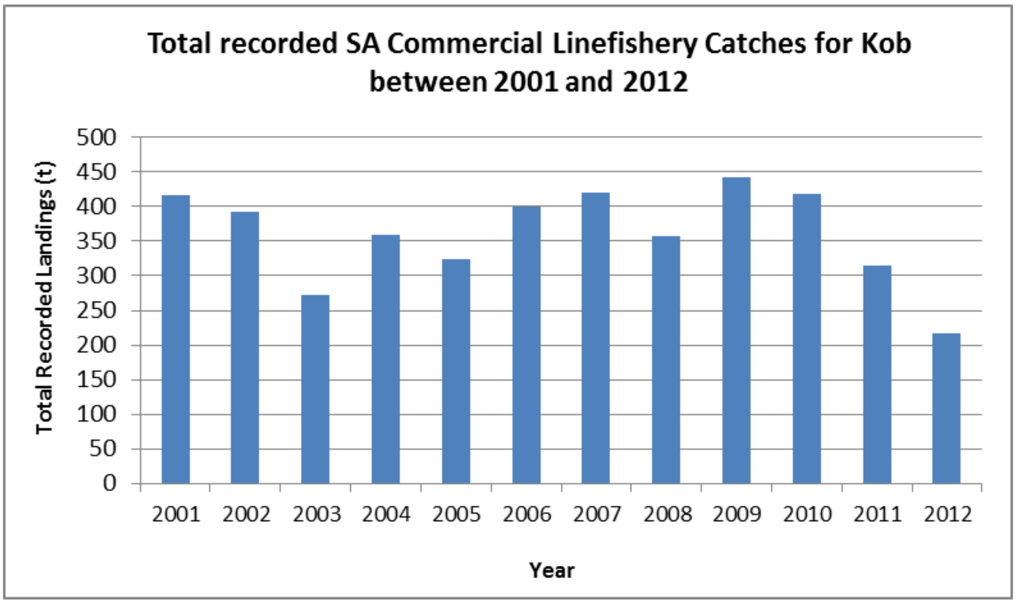

Figure 31: Total recorded South African Commercial Linefishery landings for Kob in tons between 2001 and 2012. **Source: FIHB (2013).**

The South African Commercial Trawl

The South African trawl fishery has been shown to be responsible for an average bycatch of 217 tons per annum (Griffiths & Heemstra, 1995) and Silver Kob represents a major "joint product" (i.e. marketable bycatch species) in the inshore hake- and sole-directed trawl (Japp et al., 1994; Nel et al., 2007; Attwood et al., 2011). Griffiths (2000), provides a comparison of historical catches and more recent catches of Silver Kob by region by inshore trawlers showing a decline in mean annual catch per boat from approximately 56.6 t (1944-1954) to 4.7 t (1985-1994) in the southern Cape. Similiarly, the south-eastern Cape is represented by a decline from an approximate 97.0 t (1944-1954) to 6.7 t (1985-1994). Recent Silver Kob landings for the national commercial inshore trawl fishery, for the period 2001 to 2012, also depict a decreasing trend from 229 t in 2001 to 120 t in 2012, and a low of 94 t in 2007 (see Figure 32 below). Attwood et al. (2011), when assessing unsorted samples assessed by observers between 2003 and 2006, provided an estimated average annual landing of 294.3 t, which when compared to recent recorded landings spanning the same period (see Figure 32 below) brings to light the possible implications of discards in the fishery. Discarded Silver Kob were estimated by Attwood et al. (2011) to total 2059 individuals with an average annual weight of discards of 0.35 t. The main concern with discards is that of smaller individuals, which is estimated by the same study to represent a total length of 339mm, as larger individuals are still marketable (see Attwood et al., 2011).

Walmsley et al. (2007) provide further insight into both the hake- and sole- directed fisheries, retained and discarded Kob catches in demersal trawls, with effort-based and landings-based tonnage for the south coast (calculated from observer data in 1997 and extrapolated) at 124.2 t and 10.0 t respectively. Kerwath et al. (2013) highlight the occurrence of barotrauma as a major concern with discards. All above sources of data point to the decline in inshore trawl landings of Silver Kob. However, Booth and Hecht (1998) when assessing the percentage contribution of Silver Kob to inshore trawl catches operating out of Port Elizabeth found an increasing contribution, with a mean percentage catch contribution of 1.6 % between 1967 and 1975, as opposed to 1.9% between 1985 and 1995 (see Table 10 below). This could be due to the changes in marketability of the fish as has been seen in recent times with shifting total bycatch allowances of the fishery. Smith et al. (2013) offer a summary of the current parameters of Silver Kob/ Kob in both hake- and sole-directed trawls. Noteworthy figures in this report are the 447 t abundance estimate for 2010, the increasing annual CPUE trend from 2007 to 2010, with a seasonal CPUE peak in winter, and the existence of high CPUE values in sole grounds and inshore bay areas of Mossel Bay and Port Elizabeth. Smith et al. (2013) citing S.E.C.I.F.A figures highlight the unavoidable percentage catch of Kob in the hake-directed (0.6%) and sole-directed (12.85%) trawl fisheries, and the precautionary catch limit for Kob in 2013 of 200 t. Moreover, they also stress the relative catch contributions of the west coast (0.08 t) and south coast (50.67 t) to annual Kob landings (S.E.C.I.F.A. cited in Smith et al., 2013).

Attwood et al. (2011) provide an interesting comparison of estimated landings, for the period 2003-2006, for the commercial linefishery (339 t) and inshore trawl fishery (pre-discard 294.3 t and landed 197 t), although once again the Kob recording for the commercial linefishery is by genus. In addition to the inshore trawl, the Deepsea trawl fishery also features a small but nonetheless significant contribution of 0.7 t in total landings for 2012 (FIHB, 2013). Moreover, while not part of the trawl fishery, Silver Kob has also been shown to occur in relatively small yet significant quantities (i.e. 2.5 t) in Hake Longline catches as indicated by the 2012 landings for that fishery (FIHB, 2013).

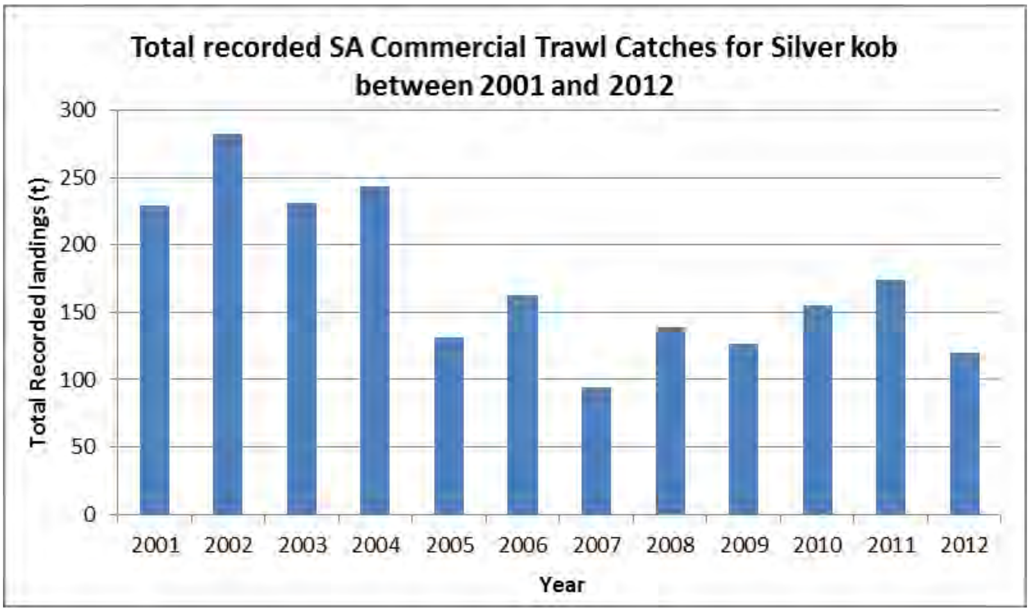

Figure 32: Total recorded South African Commercial Trawl landings for Silver Kob in tons between 2001 and 2012. **Source: FIHB (2013).**

Table 10: Percentage contribution of Silver Kob to the annual trawled catch from vessels operating from Port Elizabeth for the periods 1967 - 1975 and 1985 - 1995. **Source: Booth & Hecht (1998).**

Year	% trawl catch contribution	Year	% trawl catch contribution
1967	0.7	**1985**	1.1
1968	3.5	**1986**	1.6
1969	2.4	**1987**	1.1
1970	2.5	**1988**	1.2
1971	1.9	**1989**	1.9
1972	0.8	**1990**	1.4
1973	0.3	**1991**	1.9
1974	0.6	**1992**	1.1
1975	1.6	**1993**	2.1
Mean	1.6	**1994**	3.2
		1995	4.4
		Mean	**1.9**

The South African Recreational Fishery

Griffiths & Heemstra (1995) estimated commercial linefishery catches of Kob at an average of 835 t per annum (1988-1992) and suggest that recreational boat-based catches, although a lack of reliable statistics exists, are suspected to be of a comparable magnitude. Brouwer et al. (1997) provide an indication of the popularity, particularly in the southern Cape (22% target rate), of Silver Kob with recreational fishers, when they report on the preferred shore-angling target species by region. The popularity of the species has possibly grown, as is emphasised by the results obtained from the online national recreational survey conducted for this study, albeit with a limited sample size, with the percentage of respondents targeting (81.8%) and commonly catching (45.5%) Silver Kob in the southern Cape highlighted in Figure 33 below. The greatest targeting percentage (86.4%) was identified for the Western Cape (WC), with the highest commonly catching percentage from the Eastern Cape (59%). However, it is important to be keep in mind when interpreting these results, that the sample size was small, with the number of respondents from the the Eastern Cape (EC - 39) and Western Cape (WC – 44, which includes the southern Cape (11) and west coast (11) and the category of "the rest of the WC" (14). Moreover, while the presence of Silver Kob in the Eastern Cape is acknowledged, it does coincide with the sympatric Kob species *Argyrosomus japonicus*, and therefore this may have resulted in some inaccurate responses from this group of respondents. KwaZulu-Natal (KZN) did receive some responses for targeting and commonly catching Silver Kob but as the species is not known to occur in this region it was thought that it may have been confused with *A. japonicus* and these responses were omitted. Nonetheless, the spatial extent of Silver Kob exploitation by recreational fisheries remains a concern and therefore is in need of further study, as is the case with many South African linefish species. While long known to encompass a significant recreational species in the southern Cape, the results of the survey do strongly suggest its importance in Western Cape recreational catches (54.5% of respondents commonly catching this species). Bennett et al. (1994), analysed the catch records of three local recreational clubs, and if allowing for species misidentification issues of the time, found that Silver Kob formed a substantial component of historical shore-angling catches (10.34% by number and 14.85% by mass) in the South-Western Cape (Bennett et al., 1994; see Table 11 below). According to Lamberth et al. (1994) annual landings of Silver Kob in Western Cape shore angling at the time were estimated at 26 t, however, the current status of the species in this fishery remains unclear.

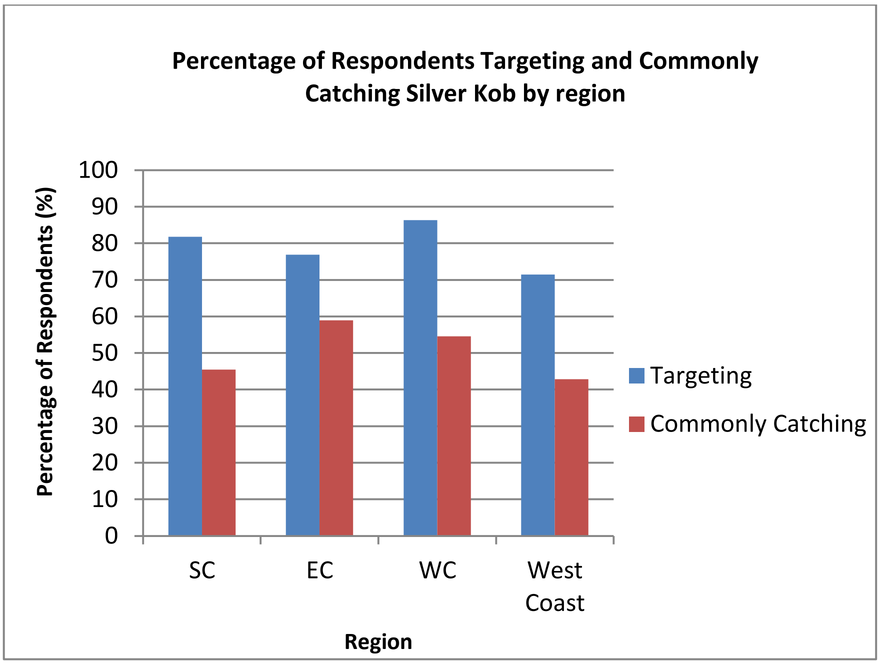

Figure 33: Percentage of respondents from the online national recreational survey targeting and commonly catching Silver Kob by region. Note: WC (Western Cape) represents the entire WC provincial area and therefore incorporates the three regional distinctions made in the survey of the Southern Cape (SC), the West Coast, and The rest of the Western Cape. EC – Eastern Cape.

Table 11: Percentage contributions in numbers (%N) and mass (%M) of *A. hololepidotus* (assumed to be *Silver Kob* in line with Griffiths & Heemstra, 1995 for this study) in shore-angling catches of the Old Mutual, Liesbeek Park, and Oceans 50 angling clubs. Old Mutual data are from the period 1978-1992, the Liesbeek Park data from 1938-1990 and the Oceans 50 data from 1971-1986. **Source: Bennett et al. (1994).**

Old Mutual		Liesbeek Park		Oceans 50		All three clubs	
%N	%M	%N	%M	%N	%M	%N	%M
15.22	21.12	8.69	10.70	9.54	15.78	10.34	14.85

Other South African Net Fisheries

Lamberth et al. (1994) offer some insight into the frequency of occurrence (45.7%) and percentage of immature (11%) *Argyrosomus hololepidotus,* (assumed to be mistaken for *Argyrosomus inodorus*, i.e. Silver Kob for the purposes of this study in accordance with Griffiths & Heemstra, 1995), in beach-seine catches in Flase Bay between 1991 and 1992. Furthermore, they provide estimates of the relative contribution of the beach-seine (2%), commercial line (80%), and recreational shore-angling (18%) fisheries to this species in False Bay for the period 1985-1992. According to Hutchings & Lamberth (2002a) some beach-seine permit holders interviewed admitted to substantial landings of up to 0.5 t of Silver Kob. In addition, more recently the total landings for Silver Kob for 2012 within the national beach-seine and gillnet fishery were reported at 3 t (FIHB, 2013). Therefore, this data coupled with previous data on the national commercial fisheries and recreational linefishery indicate that greater attention needs to be paid to the relative contributions of all contributing fisheries to Silver Kob landings.

Summary of findings

The considerable levels of historical commercial exploitation, by both the commercial trawl and linefishery, of Silver Kob have been well established in this study. Furthermore, the sporadic occurrence of Silver Kob in gillnet catches, and specifically in the Olifants estuary small-scale gillnet fishery, has been noted. However, the greatest contributor to overall landings of the species is the commercial sector, and more specifically the Linefishery (2012 landings of approximately 215 t – though based on Kob recordings) and the Inshore Trawl (2012 landings of approximately 120 t). These landings are orders of magnitude greater than the reported national beach seine and gillnet fishery landings for 2012 of approximately 3 t, which are incidentally almost equivalent to the levels of bycatch of this species in the hake longline fishery (national landings of approximately 2.5 t for 2012). It continues to be a highly popular recreational fishing species, with between 70-87% target and 40-60% commonly catching rates across the Western, Southern and Eastern Cape, as emphasised by the findings of the online national recreational survey conducted for this study. Although no official landings are available for the recreational fishery based on the data reviewed, collected and analysed it would seem that this fishery is quite possibly making a very significant contribution to the overall exploitation of the species, and is in definite need of further study. Research suggesting three separate stocks of the species would indicate that regional management efforts may be required, specifically in the case of the southern Cape region where the species is known to be exploited by the commercial and recreational linefishery as well as the inshore trawl fishery. Silver Kob is perhaps South Africa's best example of overlapping harvesting by multiple fishery sectors and is therefore a species requiring urgent attention. Figure 34 below displays the relative national contributions by fishery sector to the harvesting of Silver Kob (in 2012) according to FIHB (2013) (excluding the recreational fishery sector). Figure 35 below, presents an attempt to contextualise the relative contributions, and spatial distribution, of the different fishery sectors contributing to Silver Kob exploitation considering the data available. Linefishery icons in the figure are placed throughout the range where catches are known to possibly occur and do not necessarily indicate specific locations. The size of icons indicates the fishery's relative contribution when compared to other fisheries and within each fishery itself.

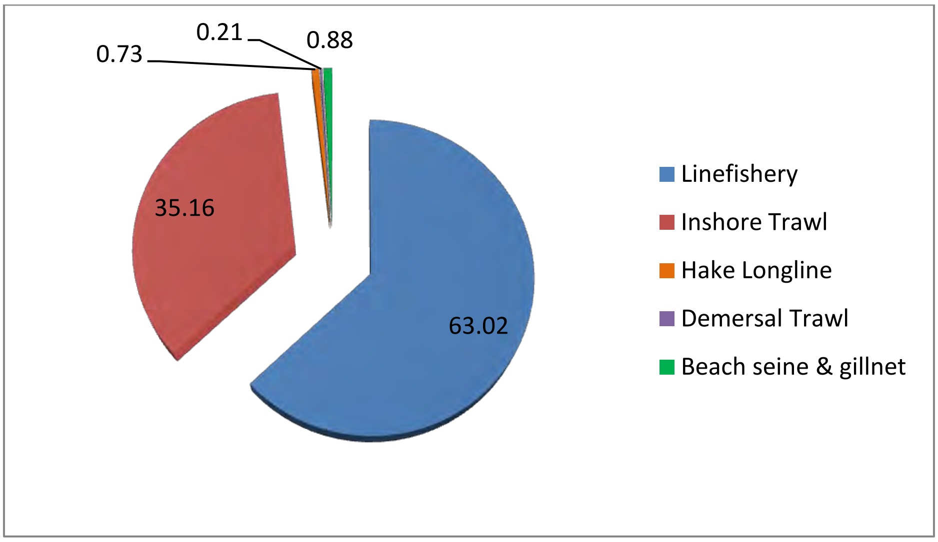

Figure 34: Pie chart of the relative national contributions (by percentage) for 2012 of the fisheries known to catch Silver Kob. **Source: FIHB (2013).** Note: It is important to note that relative contributions should also be regionally appraised and that Linefishery contributions do not include the recreational fishery.

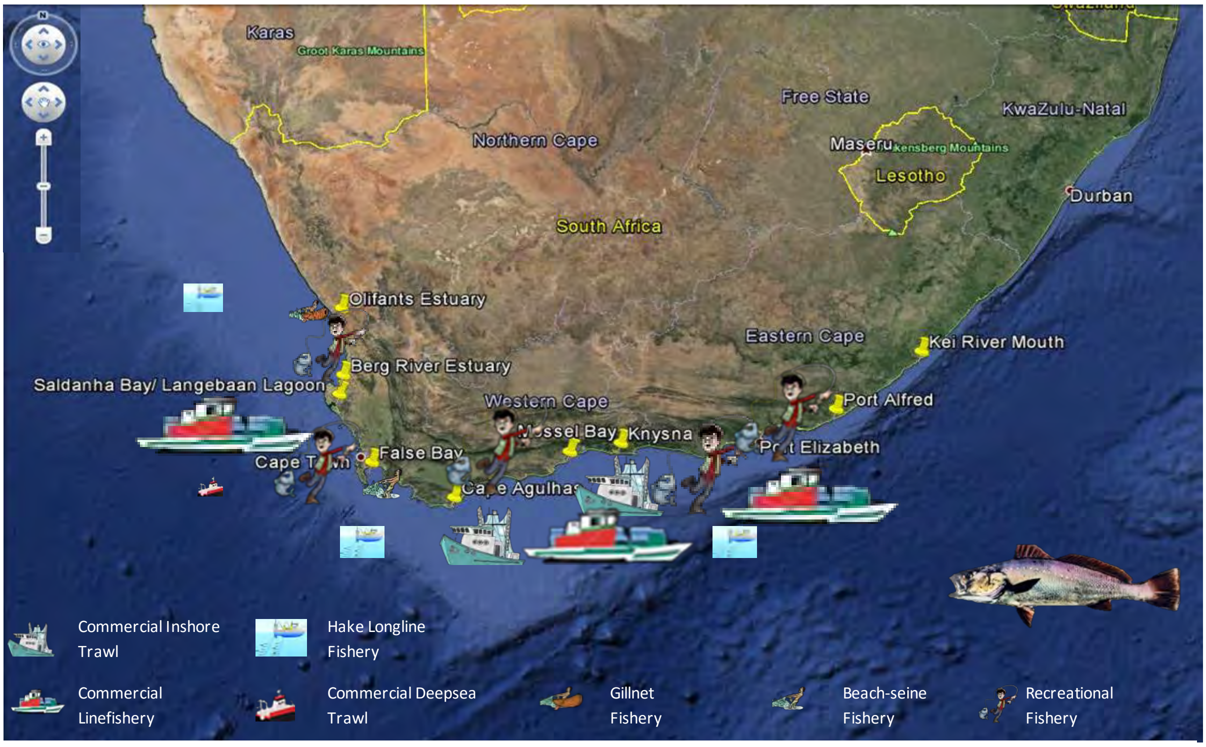

Figure 35: Map of South Africa attempting to consolidate, from best available data, the relative national contributions of the fisheries known to catch Silver Kob. **Note:** Size of icons attempts to provide an indication of relative contributions when compared to other fisheries and within each fishery sector itself from the data available. Commercial Trawl and Linefishery icons in the figure are placed throughout the range where catches are known to possibly occur and do not necessarily indicate specific locations. **Mapped using Google Earth.**

5.2.3 White Stumpnose

An overview of the species:

Rhabdosargus globiceps (also known as White Stumpnose) is a common South African inshore (Talbot, 1955), long-lived (approximately 21 years), medium-sized temperate sparid, reaching a maximum approximate weight of 3.5 kg (Kerwath et al., 2009). It is endemic to Southern Africa, having been recorded from southern Angola to the Kei River on the east coast of South Africa (Whitfield, 1998; Griffiths et al., 2002; Kerwath et al., 2009). White Stumpnose is slow-growing, reaching sexual maturity at 17-23 cm (2-4 years) and can attain a maximum size (total length) of 50 cm (Van der Elst, 1993; Attwood et al., 2010). Suggested movement patterns postulated for this species include an alongshore migration (Biden, 1930) and a seasonal offshore migration on the south coast (Talbot, 1955; Griffiths et al., 2002). In addition, short-term telemetry studies in Saldanha Bay and Langebaan Lagoon displayed possible residentary behaviour interspersed with rapid nocturnal and crepuscular movements with a range of up to 15 km per day, and limited to areas deeper than 2 m (Attwood et al. 2007; Kerwath et al., 2009). Evidence from tagging (Wilke & Griffiths, 1999) and spatial catch analyses (Griffiths & Beckley, 2000) suggest that White Stumpnose in the Western Cape, South-Western Cape and Southern Cape exist as three separate stocks. More recently, Griffiths et al. (2002) described four discrete areas of abundance for White Stumpnose in South African waters based on catch statistics, and proposed their constituting separate populations. Four proposed stocks of White Stumpnose have now been recorded, off Algoa Bay, the central Agulhas Bank, off False Bay and in Saldanha Bay (Whitfield et al., 1989; Griffiths et al., 2002; Hutchings & Lamberth 2002b; Pradervand & Baird; 2002). These four stocks are thought to form separate stocks due to the differences in growth rates, size at maturity and lack of movement between stocks, as shown by tagged fish recoveries, and telemetry studies (Attwood et al. 2010). Griffiths et al. (2002) further suggest that range contractions related to population declines, associated with exploitation, may have ceased movement between the False Bay and Saldanha Bay stocks, with catches of White Stumpnose by netfishers in the area between False Bay and Saldanha Bay now very rare (Hutchings & Lamberth, 2002b).

Greater certainty of the above restrictions in movement of the species and the existence of separate possible stocks of this species could not be further ratified by the ORI Tagging program data on this species for a 20 year period (i.e. 1^{st} of January 1984 – 31^{st} December 2014), with only 5 recapture events recorded and within the same location as their capture (i.e. 4 in Langebaan Lagoon/ Saldanha Bay and 1 in Macassar) (Dunlop & Mann, 2015). This lack of clarification is in line with the findings of Attwood et al. (2010). The challenge remains, however, to ascertain where White Stumpnose are spending their time between tagging and recapturing events, for even recaptured individuals occurring in the same site as their initial capture may have travelled great distances in the time between these two events. It is only with greater long-term studies, involving technology like acoustic telemetry, that we may gain a better understanding of their movements, and clarify the existence of potentially different stocks, and therefore the extent to which they are spatially exploited. White Stumpnose are known to spawn between September and February in the South-Western Cape (Talbot, 1955), occurring inshore in that region (Biden, 1930; Bennett, 1989a; Griffiths et al., 2002). There is, however, evidence which suggests that White Stumpnose move offshore to spawn as there are seasonal differences in catch rates of the species (Talbot, 1955; Griffiths et al., 2002). Griffiths et al. (2002) postulated that White Stumpnose migration would be limited on the cold temperate west coast as a result of a limited inshore-offshore temperature gradient during the winter months.

A study by Attwood et al. (2010) found that adult female White Stumpnose collected over a one year period within the confines of Saldanha Bay displayed all gonad maturity stages, from active to spent, therefore suggesting that spawning may occur within Saldanha Bay. Juveniles occur within the surf zone, lagoons, shallow embayments and estuaries (Talbot, 1955; Bennett, 1989a, b; Griffiths et al., 2002), where they can stay until they reach > 20 cm total length (Lamberth et al., 1994). Larger fish inhabit the marine environment to depths of 80 m (Barnard, 1927; Talbot, 1955; Lasiak, 1983; Wallace et al., 1984b; Whitfield & Kok, 1992; Lamberth et al., 1995b). The growth rate of juveniles in estuaries of the South-Western Cape has been described for the first three years of life (Talbot, 1955). Griffiths et al. (2002) suggest that the maximum size of fish within the surf-zone or estuarine habitats could be connected to water temperature, as fish leave the surf-zone for deeper waters sooner in areas with higher average water temperature, thus accounting for the smaller size of juveniles in estuaries along the east coast. Juvenile White Stumpnose are omnivorous, feeding on small crustaceans, polychaetes and molluscs, and cropping plants such as *Zostera capensis*, *Ruppia maritime* and filamentous algae (mainly *Enteromorpha* spp.) (Talbot, 1955). Adult White Stumpnose feed mainly on benthic invertebrates such as crabs, polychaetes, amphipods, barnacles and molluscs (Van der Elst, 1993; Griffiths, 2000; Heemstra & Heemstra, 2004).

White Stumpnose represent an important recreational and commercial linefish off the west and south coasts of South Africa (Bennett, 1991). Moreover, it is also taken as bycatch by inshore trawlers (Japp et al., 1994) and beach-seine fishers (Lamberth et al., 1994). The spatial distribution of the species as noted in commercial linefishery recordings can be represented by Figure 36 below. Annual landings in the 1990's have been estimated at around 40 t for shore-anglers, 147 t for commercial linefishers, 12.5 t for beach-seine operators and 14 t for inshore trawlers (Japp et al., 1994, Lamberth et al., 1994, Lamberth and Joubert, 1999). Catch rates have been estimated to have declined by up to 99.8 % in some areas during the 19990's (Griffiths, 2000). According to Griffiths (2000), while once an important linefish resource in the southern Cape, the mean annual CPUE of White Stumpnose is now < 1% of historical values and since the southern Cape stock is the only stock exposed to trawling, it would appear that trawling has contributed to its decline. A selection of key sources of data on White Stumpnose that were consulted for this study can be found in *Appendix 6.*

Figure 36: Spatial distribution of White Stumpnose caught by the commercial linefishery along the South African coastline. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped using Google Earth.

Historical Commercial Fishery Findings

In the historical trawl catch records White Stumpnose has been recorded in two different ways, i.e. White Stumpnose as well as simply Stumpnose when combined with Red Stumpnose. The extent to which these figures apply to White Stumpnose alone is uncertain, but for the purposes of this study both series of data are included. Fortunately, this is not the case for the commercial linefishery recordings, which were recorded as merely White Stumpnose. The extent of the possible implications of past landings on future potential landings for White Stumpnose is emphasised by the historical South African Commercial Linefishery and Trawl landings for the periods 1922 – 1934, and 1921 – 1960 respectively (see Figures 37 and 38 below). Commercial Linefishery annual landings are especially substantial between the years of 1925 and 1931 and are represented by a maximum landing of approximately 540 t in 1925 (see Figure 37 below). The average annual landings for the period 1922 to 1934 (i.e. 12 years due to the lack of recordings for 1932), even with some leaner years (1922; 1933; and 1934), is 215 t. This level of harvesting is especially noteworthy considering that the recent national commercial linefishery landings of approximately 39 t for 2012 (FIHB, 2013). The decreased landings of White Stumpnose could be the result of a variety of factors including depleted stock, changing market value, new restrictions or gear modifications among many, and only further long term monitoring data will provide a more accurate picture of this species' status in this fishery.

The South African trawl fishery historical catches likewise display significant levels of harvesting for the period of 1921 to 1940 (see Figure 38 below) especially in the years 1931 (88 t of White Stumpnose), 1936 and 1937 (97 t and 93 t of Stumpnose respectively). Issues with identification of species in recordings aside, Figure 38 indicates a substantial increase in landings to a significant peak followed by a pronounced decrease thereafter. These figures are particularly significant when compared to landings from 2001 to 2012 (see Figure 40 below) which represent an average annual landing of approximately 60 t, with a maximum of 108.4 t in 2003 and an overall decreasing trend. These decreased trawl landings of White Stumpnose, like the linefishery, could be the result of a variety of factors and only further long term monitoring data will provide a more precise picture of its status in this fishery.

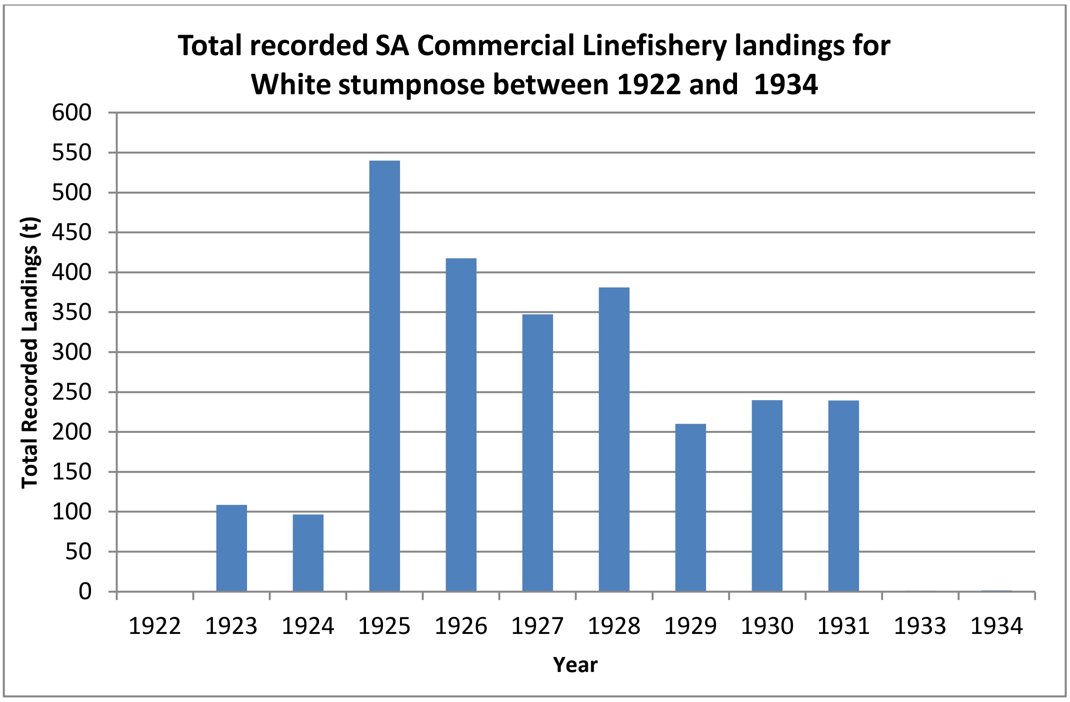

Figure 37: Total recorded South African Commercial Linefishery landings for White Stumpnose in tons between 1922 and 1934. **Source: SAEON database.**

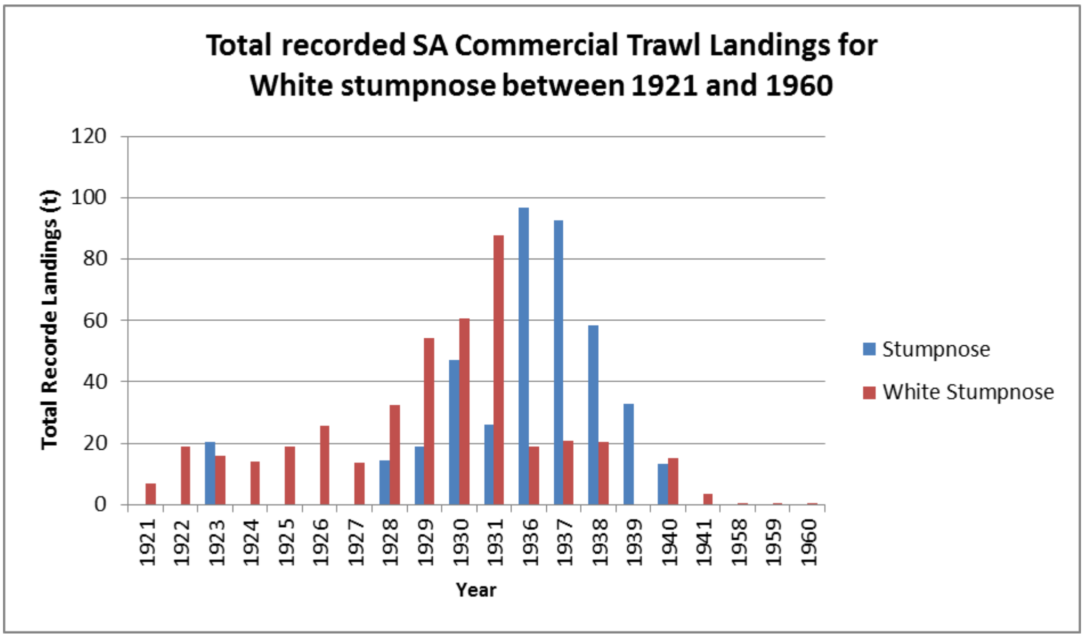

Figure 38: Total recorded South African Commercial Trawl landings for White Stumpnose in tons between 1921 and 1960. **Source: SAEON database.**

Recent Landings: An Overview

Recent figures for the total annual landings in tons of White Stumpnose by sector for the year 2012 are presented in Table 12 below. Upon initial inspection of the 2012 national landings possible concerns over the overall levels of exploitation of this species may be the 1 t of beach seine and gillnet catches, which are often undersized individuals, and more specifically the magnitude of the impact of commercial fisheries, most notably the inshore trawl (approximately 50 t) and linefishery (approximately 39 t). Another point of interest is the extent of the overlapping nature of the exploitation of this species in a wide variety of fisheries, which additionally includes a significant contribution from the Deepsea trawl (approximately 6 t in 2012), substantiating conservation concerns for this species. Moreover, Duncan & Burgener (2013) offer an insight into the overall regional exploitation of White Stumpnose in the Western Cape (387.3 t) for the period 2000-2010 (excluding the hake, squid and tuna fisheries), which echoes concerns for levels of exploitation of this species in the region in the netfishery (Hutchings & Lamberth, 2002a).

Table 12: Total recorded national landings of White Stumpnose in tons (t) for 2012 by all fishery sectors. **Source: FIHB (2013)**

Fishery	Total Landings (t)
Inshore Trawl	49.51
Commercial Linefishery	38.54
Deepsea Trawl	5.83
Beach seine and gillnet	1.00
Grand Total	**94.89**

The South African Commercial Linefishery

Griffiths (2000), provides a comparison of historical catches (1897-1906 and 1927-1931) and more recent catches (1986-1998) of White Stumpnose by the commercial linefishery by region in the South African Linefishery, with the highest mean annual catch per boat for each of the first two time periods coming from the southern Cape and the most recent figure from the south-western Cape (see Table 13 below). Additionally, Attwood et al. (2011) provide an estimation of average annual landings for this sector for the period 2003 – 2006 of 30 t. However, considering the aforementioned recent commercial linefishery landings for 2012 of 39 t (see Table 12), as well as the Attwood et al. (2011) figure of 30 t, it is still indicative of a substantial catch in comparison to the 2012 beach-seine and gillnet landing of 1 t (FIHB, 2013), which interestingly represents merely 0.0006 % of the catch of Mullet, the main target species of the fishery (FIHB, 2013). The spatial distribution of commercial linefishery catches of White Stumpnose, as recorded by the MCM Linefish dataset between the years 1985 and 2005 and represented by Figure 39 below, exhibits the quantity of catches been made by the commercial linefish sector along the entire South African coastline for that period, most notably for the South Western Cape, in accordance with Griffiths (2000).

Table 13: Mean catch/boat/year (±SD) in tons (t) of White Stumpnose by the linefishery, during the three periods 1897-1906, 1927-1931, and 1986-1998 for the Western (W) Cape, South-Western (SW) Cape, and Southern (S) Cape of White Stumpnose. % current is the 1986-1998 CPUE value calculated as a % of the highest of the 1897-1906 or 1927-1931 values. **Source: Griffiths (2000).**

Region	Mean catch/boat/year (t)			% current
	1897-1906	1927-1931	1986-1998	
W Cape	0.052 (0.045)	0.247 (0.082)	0.079 (0.060)	31.94
SW Cape	0.173 (0.179)	0.260 (0.149)	0.126 (0.053)	48.27
S Cape	0.344 (0.159)	0.416 (0.090)	0.00008 (0.0008)	0.20

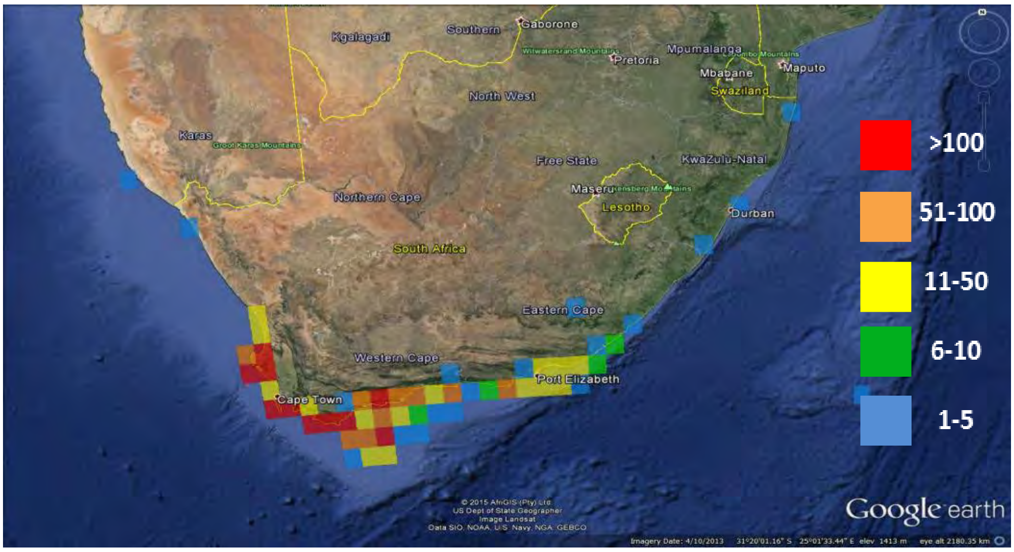

Figure 39: Occurrence of White Stumpnose (by numbers of recordings) in commercial linefishery catches along the South African coastline between 1985 and 2005. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped using Google Earth.

The South African Commercial Trawl Fishery

More recent White Stumpnose landings in the South African Commercial Inshore Trawl Fishery, between 2001 and 2012, have exhibited high variability and a declining trend, with a minimum average annual landing of 29 t in 2009 and a maximum annual average landing of 108.4 t in 2003 (see Figure 40 below). Attwood et al. (2011), when analysing unsorted samples assessed by observers between 2003 and 2006, provide an estimated average annual landing of 230.5 t (or 1.3% of the total catch by mass), which when compared to recent recorded landings spanning the same period (see Figure 40 below) brings to light the possible implications of discards in the fishery. This could be indicative of the current market value of this species and therefore its retention rates, however, the concern with discards remains that of smaller individuals (see Attwood et al 2011). All sources of data above point to the decline in inshore trawl landings of White Stumpnose. This could be due to the changes in marketability of the fish as has been seen in recent times with shifting total bycatch allowances of the fishery. Smith et al. (2013) offer a comparison of west (0.05 t) and south coast (13.36 t) hake trawls, between 2000 and 2010, emphasizing the significant levels of catch existing in the south coast region. In addition, Attwood et al. (2011) provide an interesting comparison of estimated landings for the commercial line- (30 t) and inshore trawl fisheries (pre-dicard - 231 t and landed - 83 t), between 2003 and 2006, with the landed trawl fishery catch contributing almost triple that of the commercial linefishery for this species.

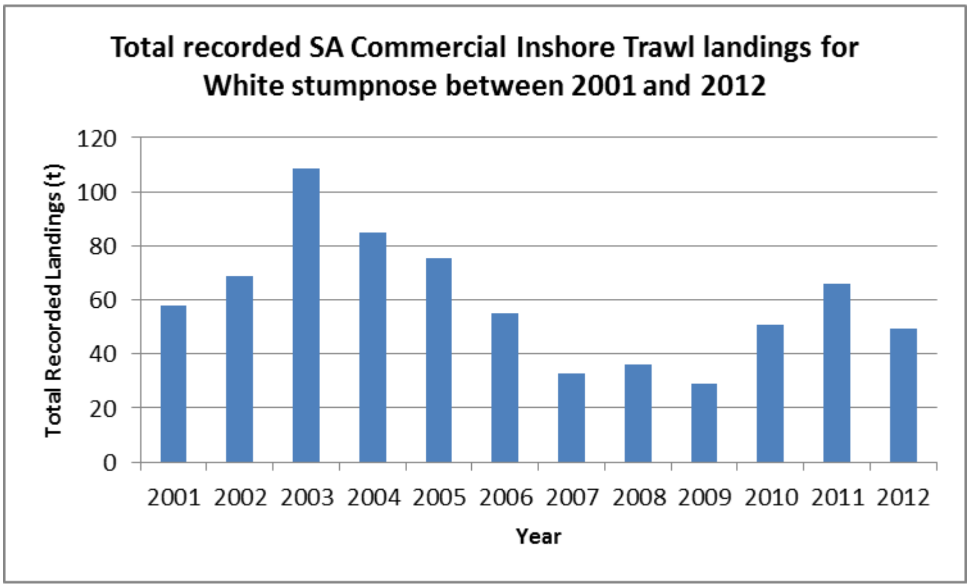

Figure 40: Total recorded South African Commercial Trawl landings for White Stumpnose in tons between 2001 and 2012. **Source: FIHB (2013).**

The South African Recreational Fishery

White Stumpnose has long been known to represent a very popular recreational angling species (Joubert, 1981; Brouwer et al., 1997; Sauer et al., 1997) and is especially targeted by fishers on the west coast, with Brouwer et al. (1997) obtaining 19% of shore-angling respondents of the region targeting the species. The popularity of the species has endured, and perhaps grown based on the results obtained from the online national recreational survey conducted for this study (see Figure 41 below), with a high percentage of respondents from the Western Cape targeting (86.4%) and commonly catching (54.6%) White Stumpnose. More specifically the West Coast received a targeting rating of 71.4% and a commonly catching rating of 42.9%. The presence of White Stumpnose in the Eastern Cape is known to ocurr, however it is possible that these responses may be misleading as it could have been mistaken for the sympatric species of Natal Stumpnose (*Rhabdosargus sarba)* or Cape Stumpnose *(Rhabdosargus holubi)*, and therefore this may have resulted in some inaccurate responses from this group of respondents, as is the case for the KwaZulu-Natal, which was the reason for omitting the later regions scores from the data analysis. The popularity of the species in the southern Cape is also significant producing a targeting rate of 81.8% and a commonly catching rate of

45.5%. Nonetheless, the extent of White Stumpnose exploitation by recreational fisheries remains a concern and is therefore in need of further study, as is the case with many South African linefish species. Nevertheless, the results of the survey do strongly reiterate the importance of this species in Western and Southern Cape recreational catches. Furthermore, Bennett et al. (1994) depicted the species as having a small contribution to historical South-Western Cape club catch records, by numbers (4.5 %) and mass (5.4%) (Bennett et al., 1994). Competition data gathered by the West Coast Shore-Angling Association (WCSAA), between 2011 and 2013, showed consistent White Stumpnose catches, although these were not substantial (minmum of 0.004 t and maximum of 0.079 t - see Figure 42 below). However, as competition catches are scored on points for weight and therefore usually involve fishers targeting sharks and skates, these numbers are expected to be relatively low. Competition data provides interesting insights into biomass of species, and its frequency in catches, however, as most competitive fishing events involve catch-and-release these figures do not necessarily contribute to overall landings of the species. However, the figures do attest to the potential catches that could possibly be occurring by recreational fishers all along the South African coastline, especially along the west coast, and only more rigorous monitoring of the open-access recreational fishing sector will confirm the contributions of this sector to the overall exploitation of this species.

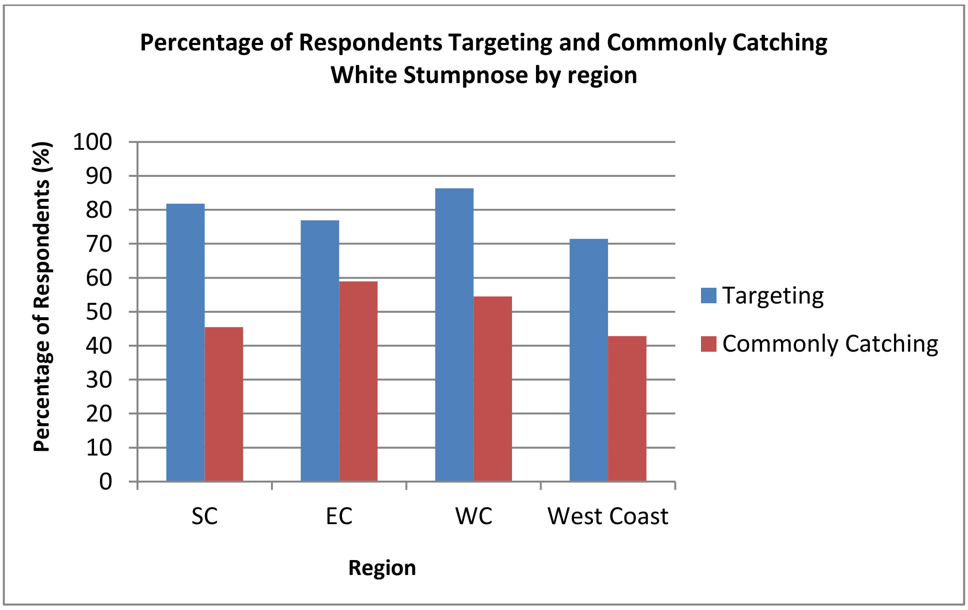

Figure 41: Percentage of respondents from the online national recreational survey targeting and commonly catching White Stumpnose by region. Note: WC (Western Cape) represents the entire WC provincial area and therefore incorporates the three regional distinctions made in the survey of the Southern Cape (SC), the West Coast, and The rest of the Western Cape. EC – Eastern Cape.

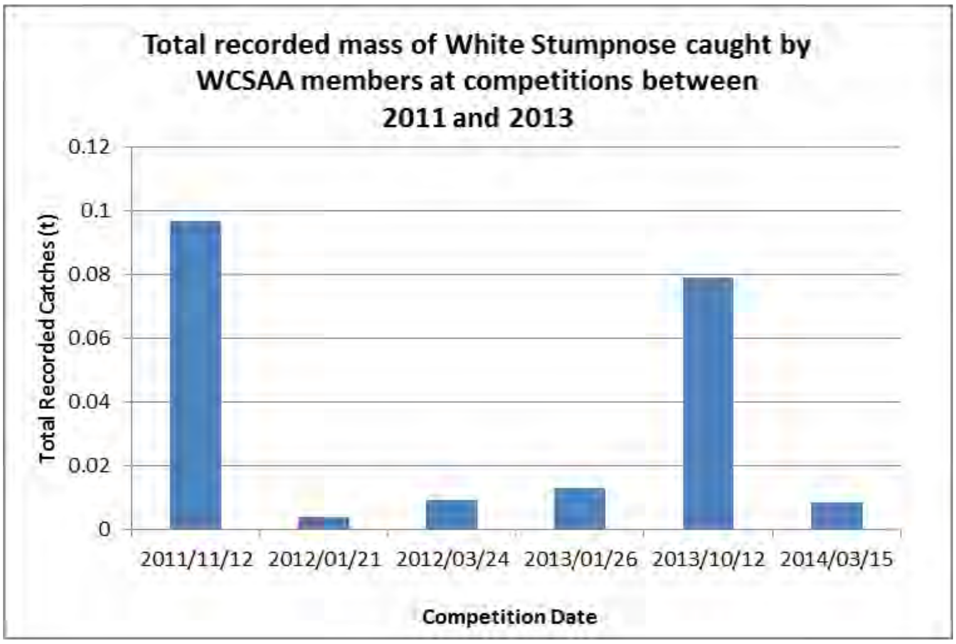

Figure 42: Total recorded catches of White Stumpnose in tons by WCSAA members in competitions between 2011 and 2014. **Source: WCSAA dataset**.

Other South African Net Fisheries

Lamberth et al. (1994) shed some valuable light on the frequency of occurrence of White Stumpnose (68.8%) in beach-seine catches in False Bay, and estimating the species contribution to the total catch at 1.5%. The levels of immature individuals in catches (95%) is of concern and more research to establish the status of immature individuals more recently should be carried out (Lamberth et al., 1994). Furthermore, Lamberth et al. (1994) estimate the relative contribution of the beach-seine (12%), commercial linefishery (85%), and recreational shore-angling (3%) fisheries to White Stumpnose in this area. The beach-seine contribution of 12% is relatively small compared to that of the commercial linefishery (85%) but significant in comparison to that of the shore-angling contribution (3%). This species is also known to form a significant bycatch component of the gillnet fishery in Saldanha Bay and Langebaan Lagoon (Hutchings & Lamberth, 2002a). More recently, the total landings of White Stumpnose for 2012 within the national beach-seine and gillnet fishery were reported at 1 t (FIHB, 2013).

Summary of findings

The substantial the levels of historical commercial catches, specifically those made by the commercial linefishery, of White Stumpnose have been well established in this study. Furthermore, the sporadic occurrence of White Stumpnose in gillnet catches, and specifically in the Olifants estuary small-scale gillnet fishery, has been noted. White Stumpnose provides a further example of the extent of overlapping exploitation, with significant and consistent catches being made in the commercial inshore trawl (national landings of approximately 50 t in 2012) and commercial linefishery (national landings of approximately 39 t in 2012). These landings are orders of magnitude greater than the reported national beach seine and gillnet fishery landings for 2012 (approximately 1 t), which are incidentally still small in comparison to the levels of bycatch of this species by the deepsea trawl fishery (national landings of approximately 6 t in 2012). Furthermore, it is a preferred recreational linefishery species in the Western Cape (with an approximately 37% target and 32% commonly catching rate), and more specifically along the west coast (with an approximately 71% target and 64% commonly catching rate) as emphasised by the findings of the online national recreational survey conducted for this study. Due to the proposed existence of four separate stocks, regional fishing pressure, most notably once again for the Southern Cape (specifically due to inshore trawling and recreational fishing), and the Western Cape (especially due to the suggested two separate stocks for False Bay and Saldanha Bay/ Langebaan Lagoon), is of regional management concern to the species. Figure 43 below displays the relative national contributions by fishery to the harvesting of White Stumpnose for 2012 according to FIHB (2013). Figure 44 below, presents an attempt to contextualise the relative contributions, and spatial distribution, of the different fishery sectors contributing to White Stumpnose exploitation considering the data available. Commercial Linefishery icons in the figure are placed throughout the range where catches are known to possibly occur and do not necessarily indicate specific locations of landings.

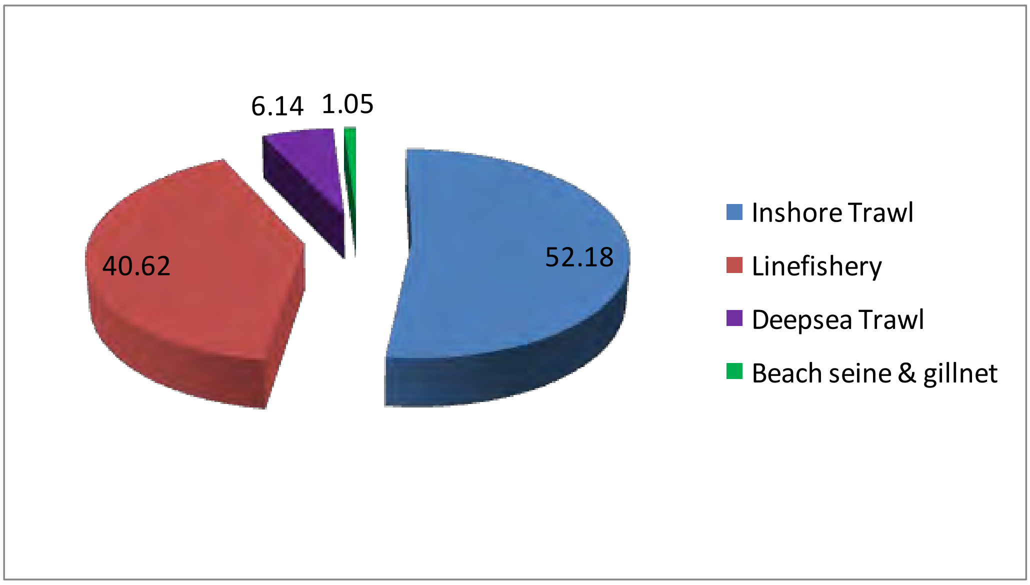

Figure 43: Pie chart of the relative national contributions (by percentage) for 2012 of the fisheries known to catch White Stumpnose. **Source: FIHB (2013). Note:** It is important to note that relative contributions should also be regionally appraised and that Linefishery contributions do not include the recreational fishery.

Figure 44: Map of South Africa attempting to consolidate, from best available data, the relative national contributions of the fisheries known to catch White Stumpnose. **Note:** Size of icons attempts to provide an indication of relative contributions when compared to other fisheries and within each fishery sector itself from the data available. Commercial Trawl and Linefishery icons in the figure are placed throughout the range where catches are known to possibly occur and do not necessarily indicate specific locations.
Mapped using Google Earth.

5.2.4 White Steenbras

An overview

Lithognathus lithognathus (Cuvier, 1829), known commonly as White Steenbras, is an important euryhaline, estuarine-dependent coastal fishery species, which is endemic to South Africa (Smith & Smith, 1986; Kandjou & Kaiser, 2014). White Steenbras occurs between the mouth of the Orange River on the west coast and KwaZulu-Natal on the east coast (Smith & Smith, 1986; Lamberth & Mann, 2000) to a depth of 25 m (Bennett, 2012). The core distribution of this species ranges from just north of Cape Columbine in the west to the Mbashe Estuary in the east (Lamberth & Mann, 2000). White Steenbras are long-living (25-30 years of age; Bennett, 1993b), slow-growing, late-maturing Sparidae (Mann et al., 2014) with a maximum length and weight of 137.6 cm and 26.3 kg, respectively (Bennett, 1993b; SASAA, 2012). According to Bennett (1993b) the life history of White Steenbras can be split into two pre-recruit and two post-recruit stages (Bennett, 1993b). Adults are known to spawn off the coast of Transkei in August; thereafter the larvae drift westwards along the coast of the Eastern Cape where they enter estuaries, which would be flushed open by winter rainfall (Attwood & Bennett, 1995b). Juveniles have an obligatory estuarine-dependent phase (Wallace et al., 1984c), with samples from estuaries in the Eastern, Southern and Western Cape showing that the majority of White Steenbras in these habitats are <250 mm long, i.e. less than two years old (Mehl, 1973; Blaber, 1974; Beckley, 1984; Bennett, 1989a; Whitfield & Kok, 1992). The majority of these juveniles enter estuaries during spring and summer when less than 50 mm long (Bennett, 1993b). After their estuarine phase they enter the surf zone and later recruit into the fishery at the age of 4 years (Attwood & Bennett, 1995b). Maturity is reached between the ages of 5 and 8 years, when the fish largely escape the shore fishery by moving to deeper water and commence annual spawning migrations to Transkei waters (Bennett, 1993b). Recruitment appears to exhibit a temporal trend, originating in the Eastern Cape in August/September (Beckley, 1984), in the Southern Cape in September/October (Whitfield & Kok, 1992) and in the Western Cape in October/November (Bennett, 1989a). There is also a trend in the size at which recruitment takes place, recruits being smaller in the Eastern than in the Western Cape. Published information on the juvenile life stage, within estuaries, specifically occurrence, size composition and relative abundance, in a number of estuaries, has been well established (Millard & Scott, 1954; Talbot, 1955; Mehl, 1973; Blaber, 1974; Beckley, 1984; Bennett, 1989a; Whitfield & Kok, 1992). Furthermore, diets have been described by Mehl (1973), Whitfield (1985) and Bennett (1989b), in addition to growth rates by Mehl (1973), Blaber (1974), Beckley (1984), Bennett (1989a), and Whitfield & Kok (1992). However, information on adult White Steenbras is more limited. White Steenbras have been shown to be most active during daylight hours when oxygen consumption was 28% higher than during the scotophase (Kandjou & Kaiser, 2014). Temporal activity patterns of a fish species may be diurnal and controlled by endogenous rhythms (Bennett, et al. 2012), and its ability to cope with fluctuating salinity determines its distribution range and survival in estuaries (Bennett, 2015).

According to Bennett (2012) White Steenbras exists in a single, well-mixed population with the core portion of the stock located inshore and in estuaries along the east and west coasts (Brouwer et al., 1997; Lamberth & Mann, 2000; Brouwer & Buxton, 2002). Furthermore, the distributional range of this species does not have any major geographical barriers to impede gene flow resulting in a well-mixed population with no subpopulation structure (Bennett, et al., 2011). Greater certainty of the above restrictions in movement of the species and or the existence of possible separate stocks of this species could not be further ratified by the ORI Tagging program which prepared data for this study on this species for a 20 year period (i.e. 1st of January 1984 – 31st December 2014), with only 24 recapture events, occurring within roughly the same location as their initial capture (i.e. no distances greater than 200 km) (Dunlop & Mann, 2015), which is in accordance with the findings of several studies mentioned above. The challenge remains as to ascertain where White Steenbras are spending their time between tagging and recapturing events, for even recaptured individuals occurring in the same site as their initial capture may have travelled great distances in the time between these two events. Only with greater long-term studies, involving technology like acoustic telemetry, may we gain a better understanding of their movements, and potentially different stocks, and therefore the extent to which they are spatially exploited. The spatial distribution of White Steenbras as recorded by the commercial linefishery between 1985 and 2005 can be depicted by Figure 45 below.

White Steenbras have long been highly sought-after by recreational shore-anglers (Biden, 1930, Schoeman & Schoeman, 1990) and have provided a considerable proportion of their historical catch (Bennett, 1991). Prior to 1983 they were also an important component of commercial beach-seine catches (Penney, 1991). Both recreational and commercial catches have, however, declined markedly in comparison to the past decades (e.g. the 1980's) as identified by past studies (Bennett, 1991; Penney, 1991). Bennett (1993a) suggests that the overexploitation within all fishery sectors has resulted in stock collapse. More recently Mann et al. (2014) suggested that the core range of White Steenbras may have contracted as shore-angler catches recorded along the west coast of South Africa have been limited as have gillnet catches from Cape Point to the Olifants River Mouth from 1997 to 1999 (Lamberth et al., 1997; Hutchings & Lamberth, 1999). This is once again a prime example of the importance of having a broader perspective as if stocks have contracted then the appearance of less White Steenbras in catches of the Olifants gillnet fishery could be understandable and not necessarily due to overfishing in the area, however, greater research would be needed to confirm this line of reasoning. A selection of key sources of data on White Steenbras that were consulted for this study can be found in *Appendix 7.*

Figure 45: Spatial distribution of White Steenbras caught by the commercial linefishery along the South African coastline. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped with Google Earth.

Historical Commercial Fishery Findings

In historical catch records three recording formats are found which explicitly pertain to White Steenbras namely, “Steenbras (Red and White)” and “White Steenbras”, however, recordings for “Steenbras”, could laso pertain to White Steenbras and therefore all are included for the purposes of this discussion (see Figures 46 and 47 below). The extent of the possible implications of past landings on potential future landings for White Steenbras are equally strongly emphasised by the historical South African Commercial Linefishery and Trawl landings for the periods of 1922 - 1934, and 1922 - 1960 respectively (see Figures 46 and 47 below). The South African Commercial Linefishery historical annual “Steenbras” landings are significant (i.e. consistently over 50 t) between the years of 1927 and 1931, and are represented by a maximum annual landing of approximately 123 t in 1929. The annual average landings for the period 1922 – 1934 (i.e. 13 years) in spite of some years with significantly decreased landings (most notably 1933 - 0.091 t and 1934 - 0.191 t) is represented by an average annual landing of approximately 34 t (Steenbras) and 2.8 t (White Steenbras) (see Figure 46 below).

White Steenbras annual historical trawl landings are also extensive yet highly variable between the years of 1922 and 1960 (with the exception of the lack of recordings for the years 1932 – 1935 and 1943 - 1957) and indicates a maximum landing of approximately 270 t in 1938 (see Figure 47 below). The average annual landings (Steenbras) for the period 1922 to 1939 (i.e. 14 years due to the lack of recordings for the years 1932 – 1935) even with some leaner years is approximately 70 t. These figures represent very significant levels of harvesting which could very well have contributed to the decline of the species in current catches and ultimately led to its recent ‘*Endangered’* listing on the IUCN red list (Mann et al., 2014).

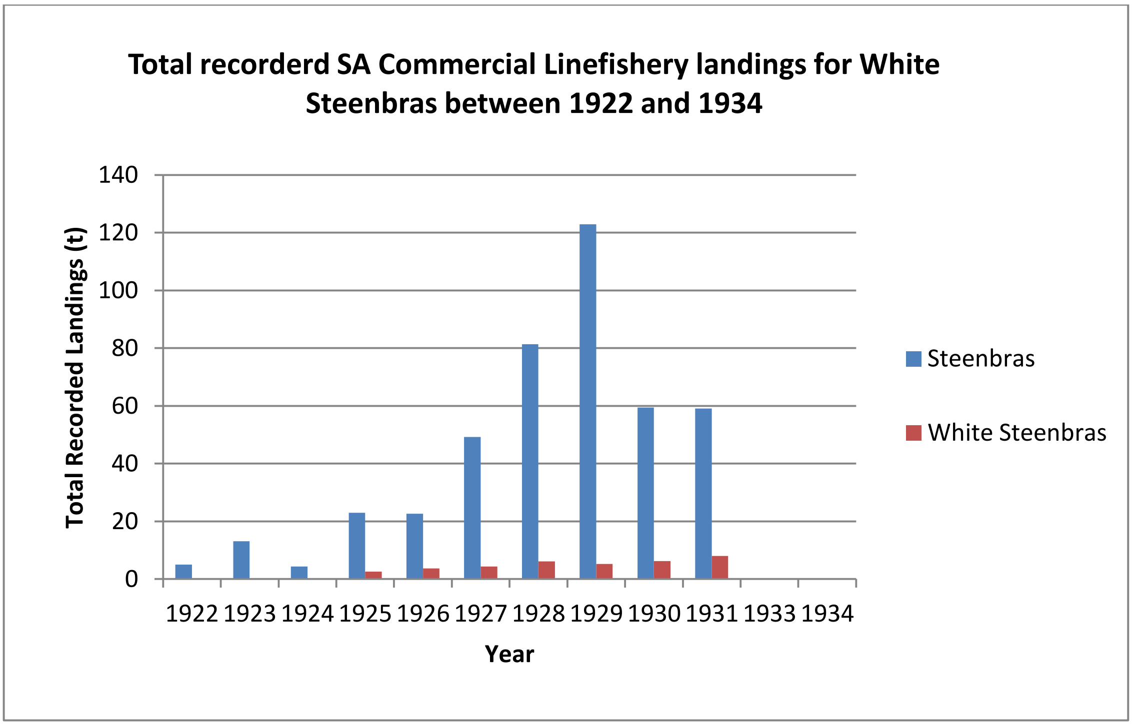

Figure 46: Total recorded South African Commercial Linefishery landings for White Steenbras in tons between 1922 and 1934. **Source: SAEON Database.**

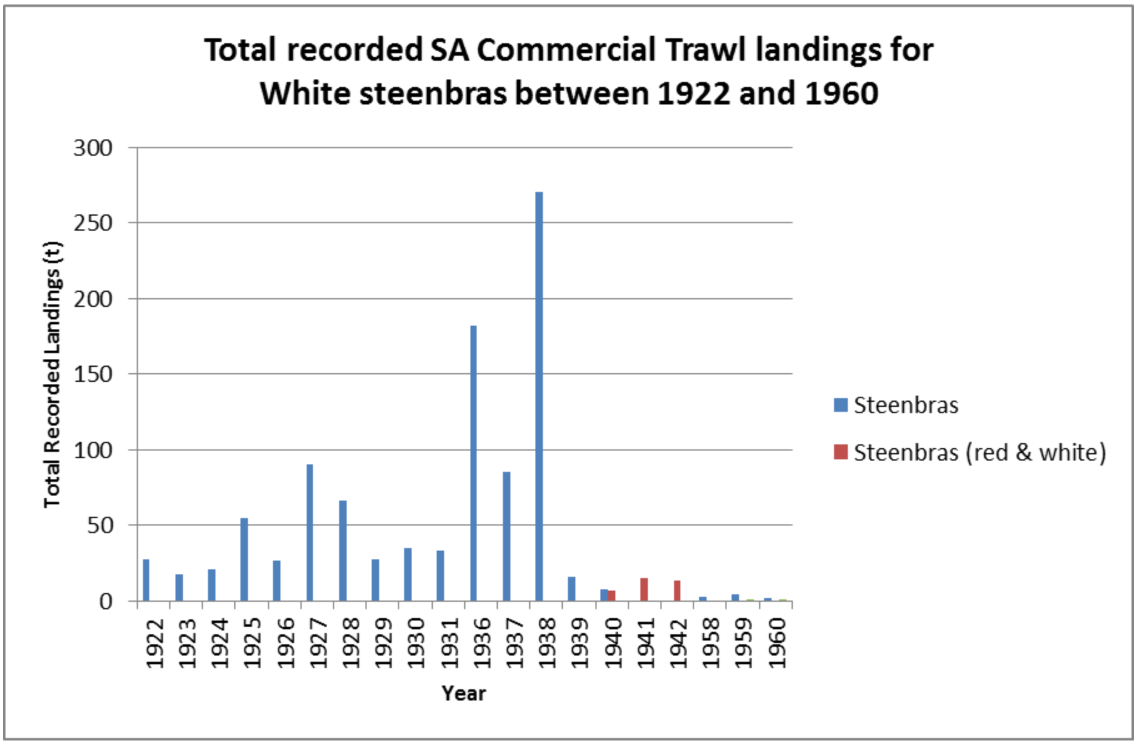

Figure 47: Total recorded South African Commercial Trawl landings for White Steenbras in tons between 1922 and 1960. **Source: SAEON Database.**

Recent Landings: an overview

Recent landings for White Steenbras were not available in the recent Fishing Industry Handbook of 2013 (FIHB, 2013) by fishery sector as was the case for the other three selected species investigated in this study. In reality, limited recent data is available for the status of the species in national catches in general. However, the spatial distribution of commercial linefishery catches between 1985 and 2005 are indicated in Figure 48 below. Recreational catches are thought to have had the greatest impact on this species and as such are discussed below.

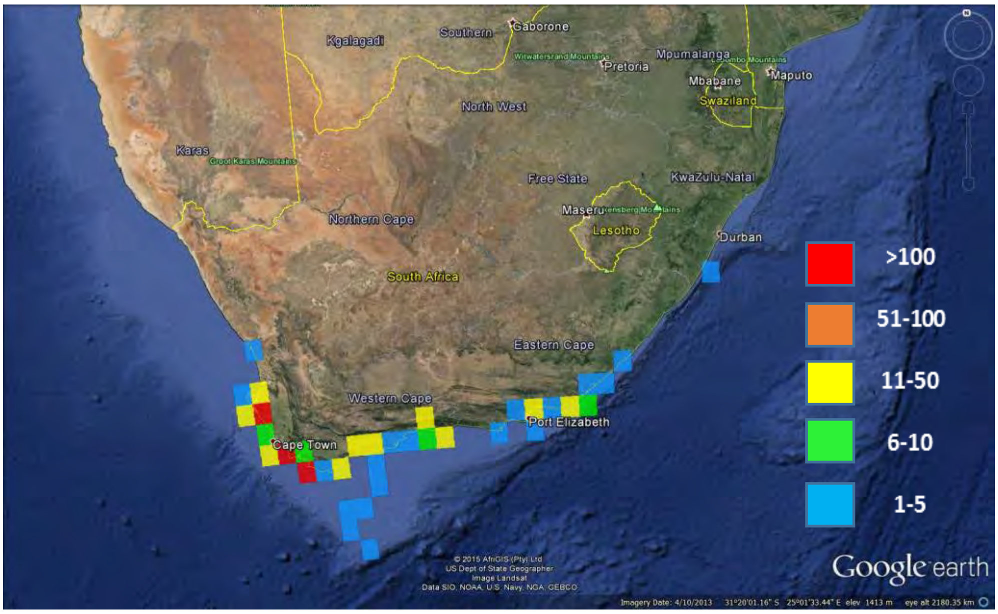

Figure 48: Occurrence of White Steenbras (by numbers of recordings) in commercial linefishery catches along the South African coastline between 1985 and 2005. **Source: MCM Linefish Dataset (AfrOBIS).** Note: Accessed via the OBIS facility (http://www.iobis.org) and mapped using Google Earth.

The South African Recreational Fishery

Brouwer et al. (1997) provided an indication of the popularity of White Steenbras with recreational fishers in the late 1990's, when they suggest the preferred shore-angling target species by region, with the highest and lowest targeting of the species occurring on the southern coast (17%) and west coast (4%) respectively. The eastern coast is represented by 11% targeting (Brouwer et al., 1997). The popularity of the species among recreational fishers continues, as observed from the results from the online recreational survey of this study for targeting and commonly catching White Steenbras (see Figure 49 below). Significant results of this survey are the high percentages of targeting of this species, most notably the Southern (54.6%), Eastern (51.3%) and Western Cape (34.1%), and commonly catching respondents, particularly in the Southern Cape (36.7%) and to a lesser extent the Eastern (20.5%) and Western Cape (11.4%). The limited mention of White Steenbras with KwaZulu-Natal respondents is to be expected as this is on the edge of the species known distribution range. These results, while representative of a limited sampling population, emphasise the extent to which this species is targeted and more importantly commonly caught along an extensive amount of the coastline. Bennett et al. (1994) suggest White Steenbras has been a more popular recreational species for many years particularly along the south and south-eastern Cape coastlines, when compared to Brouwer et al. (1997)

results. It has also formed a substantial component of certain historical recreational club catches in the south-western Cape in terms of numbers (29.5%) and mass (31.8%) (Bennett et al., 1994). These findings correspond with those of the spatial distribution of catch recordings by the MCM Linefish Dataset for the commercial linefishery between 1985 and 2005 (see Figure 48 above).

Smith & Kruger (2013) provide insight into targeting rates of the species in Knynsa (10% in 2008-2009, and 12% in 2009-2010) and Swartvlei (7% in 2008-2009, and 12% in 2009-2010) estuaries. In addition, the percentage of the total catch for Knysna (12% in 2008-2009, and 12% in 2009-2010) and Swartvlei (30% in 2008-2009, and 8% in 2009-2010) estuaries also depict significant figures. A particularly noteworthy result of this study, however, is the retention rates of the species for both Knysna (67% in 2008-2009, and 63% in 2009-2010) and Swartvlei (82% in 2008-2009, and 81% in 2009-2010). Moreover, of significant conservation concern, taking these retention rates into consideration, is the percentage of undersized individuals observed in monitored catches over this time period, for Knysna (89% in 2008-2009, and 65% in 2009-2010), and Swartvlei (100% in 2008-2009 and 2009-2010). Dicken et al. (2012) when analysing data captured at *Angling Week*, in the Eastern Cape, between 1999 and 2010, reported a total mass of 0.86 t, however, as mentioned previously, this low number is influenced by the fact that competition fishers usually target species of greater mass such as sharks and skates as this is how points are allocated to catches. Furthermore, of concern is the potential for the capture of immature individuals by recreational fishers, as emphasised by the findings of this paper (62.2% immature). Competition data from all RASSPL events in 2013 and 2014 depict similar low levels of catches (see Figure 50 below), and once again the potential for undersized catches is highlighted by the minimum White Steenbras total length (in cm) caught at these competitions (between 23 and 40 cm - see Figure 51 below) strongly suggests the potential of the recreational sector, especially in the Southern Cape, to land undersize individuals (i.e. less than 60 cm – DAFF minimum recreational size limit). Unfortunately no length recordings were made for the Eastern Cape catches.

Competition data provides interesting insights into relative biomass of species, and its frequency in catches, however, as most competitive fishing events involve catch-and-release, as was the case with all of the above competition data, these figures do not necessarily contribute to overall landings of the species. Nonetheless, the figures do attest to the potential catches, and the levels of undersized catches, that could be occurring by recreational fishers all along the South African coastline. Only more rigorous monitoring of the open-access and essentially unknown recreational fishing sector will confirm the contributions of this sector to the overall exploitation of White Steenbras. As established by the findings of this study, White Steenbras continues to be an important recreational linefish species, however, the consensus among many of the fishers encountered in this study, is that catches have declined drastically, in line with the previously mentioned recent '*Endangered'* IUCN Red List status of the species (Mann et al., 2014). The decline of White Steenbras, which has represented an important component of the catches of coastal and estuarine anglers in the greater Cape region, has long been noted (Day et al., 1981; Coetzee et al., 1989; Bennett, 1993a). Bennett (1993a) suggests that the catch rate of the species by recreational shore anglers had declined by 90% since the mid-1970s. Bennett (1993b) postulated that the high degree of estuarine dependence, confinement of juveniles and sub-adults to the surf zone, large size at maturation, and predictable aggregation of mature individuals, make the White Steenbras particularly vulnerable to estuarine degradation and overfishing. Additional concerns for this species in this fishery are levels of compliance as highlighted by Brouwer et al. (1997).

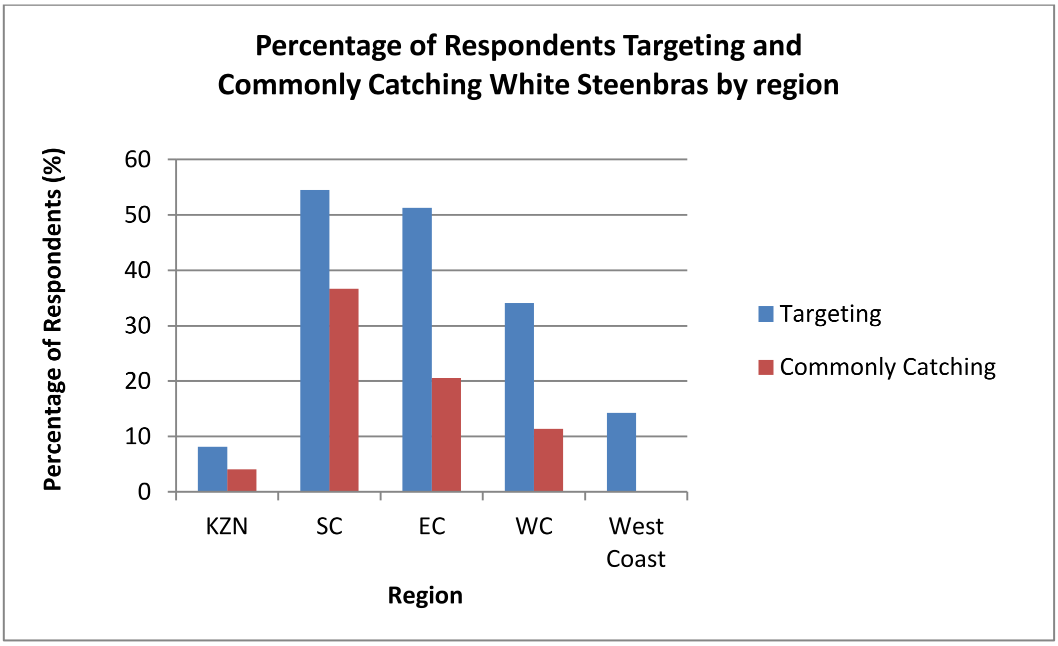

Figure 49: Percentage of respondents from the online national recreational survey targeting White Steenbras by region. Note: WC (Western Cape) represents the entire WC provincial area and therefore incorporates the three regional distinctions made in the survey of the Southern Cape (SC), the West Coast, and The rest of the Western Cape. KZN – KwaZulu Natal; EC – Eastern Cape.

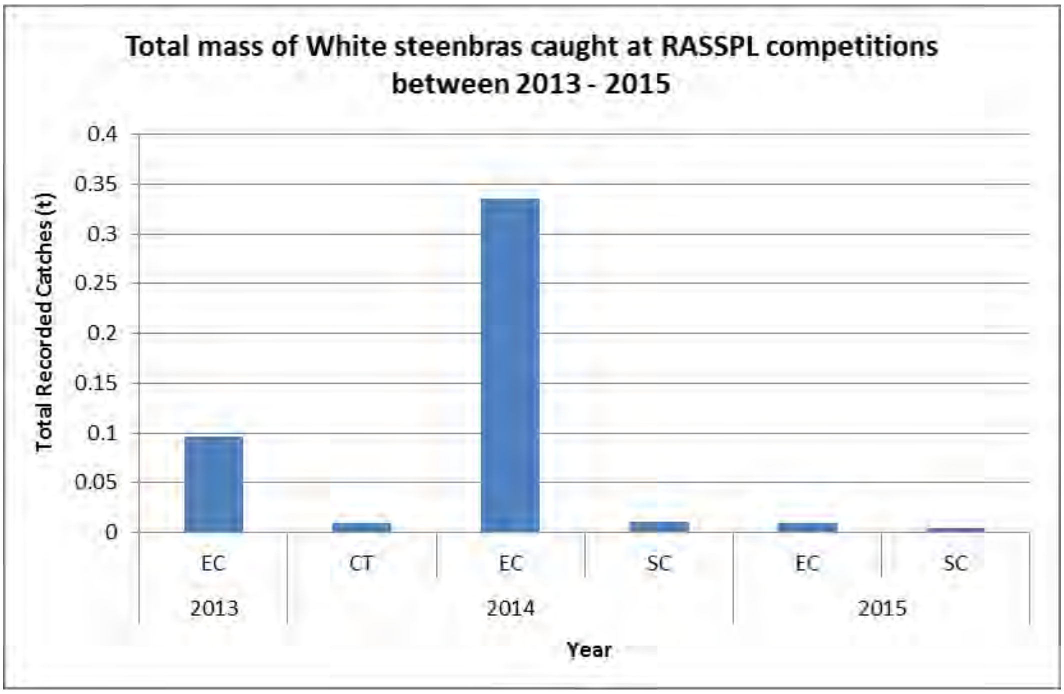

Figure 50: Total recorded White Steenbras catches in tons at RASSPL competitions by region and year between 2013 and 2015. **Source: RASSPL.** Note: EC – Eastern Cape; CT – Cape Town; SC – Southern Cape.

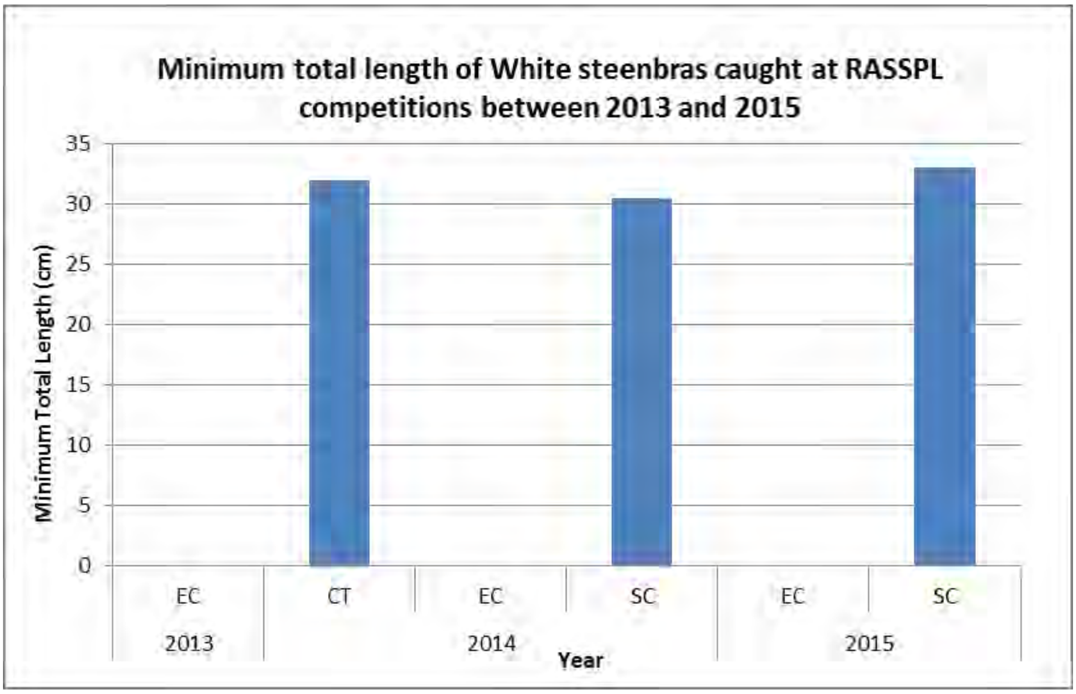

Figure 51: Minimum total length in cm of White Steenbras caught at RASSPL competitions between 2013 and 2015. **Source: RASSPL.** Note: It is interesting to note that the minimum recreational size limit for White Steenbras is 60 cm (based on the DAFF Marine Recreational Use Brochure 2014/2015). EC – Eastern Cape; CT – Cape Town; SC – Southern Cape.

Other South African Net Fisheries

Bennett (1993a) provides a historical (1897-1906) perspective on seine catches of White Steenbras from the Western Cape in comparison to the period of 1983-1991, which represent only 14% of historical values (see Table 14 below). Moreover, Lamberth et al. (1994) offer insight into the frequency of occurrence (56.6%) and percentage of total catch (0.59%) of White Steenbras in beach-seine catches in False Bay between 1991 and 1992. Perhaps of greater concern, however, is the level of immature individuals (44%) estimated bin the catch by the above study. The relative contribution of the beach-seine (40%), commercial linefishery (1%), and recreational shore-angling (59%) fisheries to the total catch of this species in False Bay is also highlighted (Lamberth et al., 1994). The beach-seine contribution of 40% is notable; however, the figure for recreational shore-angling (59%) provides some insight into the potential levels of exploitation that shore-angling may have had on this species. However, beach-seine catches have been shown in the past by certain studies to represent approximately 25% of the national catch of White Steenbras and therefore represent a substantial component of the harvesting of this species (Bennett, 1993a). It is important to take note that these studies were conducted in the 1990’s and that much may have changed in current landings. Furthermore, sexually immature White Steenbras have been postulated to be widespread, but mature individuals predominantly resident (Bennett & Attwood, 1991; Bennett, 1993b). Bennett (1993b) suggests that the concentrations of adult White Steenbras within specific areas of False Bay during summer, may represent a large proportion of the sexually mature population and therefore it has been proposed that the stock decline that has occurred may be a result of over-exploitation by the beach-seine fishery (Bennett 1993a). According to Hutchings and

Lamberth (2002a) some beach-seine permit holders interviewed admitted to substantial landings of up to 3 t of White Steenbras.

Table 14: Reported mean annual seine-net catches (by numbers) and percentage of mean annual catch (by numbers) of White Steenbras from areas of the Western Cape for the years 1897-1906 and 1983-1991. Catch during 1983-1991 is also expressed as a percentage of the catch during 1897-1906. **Source: Bennett (1993a)**

Area	Mean annual catch (numbers)				1983-1991 catch as % of 1897-1906 catch
	1897-1906	*%*	1983-1991	%	
North of Cape Columbine	*1 893*	*8*	374	12	20
Cape Columbine to Cape Point	*1 665*	*7*	179	6	11
Western coast to False Bay	*2 548*	*11*	557	18	22
Northern coast of False Bay	*11 648*	*51*	1 848	59	16
Cape Hangklip to Cape Agulhas	*879*	*4*	145	5	16
East of Cape Agulhas	*4 429*	*19*	44	1	1
All areas	*23 061*	-	3 147	-	14

Summary of findings

The significant levels of historical commercial catches of White Steenbras have been established above. Furthermore, the sporadic occurrence of White Steenbras in gillnet catches, and specifically in the Olifants estuary small-scale gillnet Fishery, has been noted. However, the greatest contributor to overall landings of the species is likely to be the recreational sector. White Steenbras continues to be a highly prized recreational fishing species, although catches are thought to have declined, specifically in the Southern Cape region (approximately 35% target and commonly catching rate) as well as the Eastern Cape (approximately 20% target and commonly catching rate), and to a lesser extent the Western Cape (approximately 12% target and commonly catching rate), as established by the findings of the online national recreational survey conducted for this study, and figures from past studies. Furthermore, its targeting and common occurrence in False Bay beach seine catches adds to concerns. Due to it being proposed as one well-mixed stock, regional fishing pressures (most notably perhaps in the Southern Cape) have undoubtedly led to current national management dilemmas.

Although no official figures are available for the recreational linefishery, based on the data reviewed, collected and analysed it would seem that this fishery is quite possibly making a very significant contribution and is in definite need of further study. It is suggested that White Steenbras exists in a single well-mixed population with the core portion of the stock located inshore and in estuaries along the east and west coasts, as mentioned previously and therefore the implications for regional management of the species are evident. Once again the Southern Cape would fall within the central region of this species range and therefore possibly require the greatest management focus. Nonetheless, the Western Cape also represents an area of concern due to the presence of White Steenbras in beach seine and gillnet catches in addition to suggested recreational exploitation. Limitations in data collection existed for this species as overall landings by fishery sector were not located, however, the well-established concern for the species in the recreational fishery would seem validated. Figure 52 below, presents an attempt to contextualise the relative contributions, and spatial distribution, of the different fishery sectors contributing to the exploitation of White Steenbras considering the data available. The size of icons indicates the fishery's relative contribution when compared to other fisheries and within each fishery itself.

Figure 52: Map of South Africa indicating the relative contributions of the fisheries known to catch White Steenbras.
Note: Size of icons attempts to provide an indication of relative contributions. **Mapped using Google Earth.**

5.3 Relative contributions of different fisheries to bycatch concerns of four species

An attempt has been made to bring together all available primary and secondary data on these four species, in order to take a broader and more holistic approach to understanding the relative contributions by all known fishery sectors to total landings. While there are gaps in the data and some uncertainty regarding reliability of certain datasets, it is clear that the landings of the national commercial fisheries are significant and, in comparison to the national beach-seine and gillnet fishery, orders of magnitude greater for all four species. More to the point, commercial landings are orders of magnitude greater when compared to the Olifants gillnet fishery for all species of concern to this study. Nevertheless, the levels of exploitation by the national beach-seine and gillnet fishery, and the Olifants gillnet fishery for that matter, and the impact of the proportions of juveniles of important linefish species contained in the catches of this sector, require continued monitoring and research. Significant levels of bycatch have been shown for Elf in the aforementioned fishery sector, and these are worth noting, however, levels of exploitation of the other three species represented by this study are less substantial. Furthermore, the recreational fishery sector has not been accurately represented in this study and further research is required to confirm the contribution of this fishery sector to the overall landings of several potentially overexploited species, including the four that make up this study.

Chapter 6: Overall Discussion

In this chapter the findings described in the previous chapter will be discussed in relation to the literature presented in Chapter 2, and key insights obtained from the data collected and analysed will be highlighted. Furthermore, the discussion will attempt to better contextualise bycatch in the Olifants estuary small-scale gillnet fishery and showcase some areas of management and conservation concern, in addition to providing suggestions for the way forward.

6.1. The issue of bycatch

Bycatch can be considered a misleading notion as sustainable harvesting can provide a 'basket of species' or 'joint product' which provides for the livelihoods of countless fishers, especially those most dependent on marine living resources such as those found in small-scale fisheries, in addition to contributing to increased economic stability in commercial fisheries. The findings of interviews with the small-scale fishers of the study area clearly established that *incidental catch* is sporadic, with the exception of Elf, and not considered *bycatch* but as an additional source of livelihood and personal nourishment. The concern for capture of undersized important linefish species by small-scale fisheries in South Africa continues. However, the negative perception of bycatch in conventional fisheries management approaches in all fisheries is increasingly being challenged by those that propose a more *balanced harvesting approach* and the importance of incidental catch species for human livelihoods (Conover & Munch, 2002; Bundy et al., 2005; Frid et al., 2006; Fenberg & Roy, 2008; Zhou et al., 2010; Rochet et al., 2011; Garcia et al., 2011, 2012, 2015; Law et al., 2012, 2014, 2015; Charles et al., 2015). An argument has been made which contradicts this negative misconception, most notably within the contexts of small-scale multi-species and/or multi-gear fisheries, which tend to be less selective (see Kolding & van Zwieten, 2011, 2014; Garcia et al., 2012). Multispecies fisheries have been shown not to react to fishing pressures in accordance with unimodal stock-production models. These models typically depict increasing yields with increasing efforts to a point of maximum yields, after which increases in effort bring decreasing yields (see Schaefer, 1954). Multispecies fisheries have been shown to indicate a rise in catch levels with increasing effort, then a stabilisation and don't even show a decline at very high effort levels (see Laë, 1997; and Lorenzen et al., 2006). Fishing effort, in small-scale fisheries in particular, has been shown to be habitually regulated for the most part by natural production, as is the case for other top predators, and many targeted fish stocks and fish communities (albeit in inland fisheries) have been shown to display a high degree of resilience (see Kolding & van Zwieten, 2014). Whilst the size distributions in the above mentioned graphs (see Figures 12 and 13 in Chapter 5), indicate the capture of smaller individuals than those stipulated in recreational regulations (see Table 4 in Chapter 5), according to a *balanced harvesting* approach, which attempts to mimic natural mortality as closely as possible, these can be considered ecosystemically conserving, subject of course to overall sustainable harvesting and proportional fishing mortality of larger individuals of species, and across all other fishery sectors (see Garcia et al., 2012; 2015).

It should also be noted that conventional fisheries management measures such as mesh size and gear restrictions have perhaps been more appealing as they are cheaper and more readily applied than measures such as catch quotas or effort restrictions, which require more expensive biological monitoring and enforcement requirements, however the failure of these management strategies has become increasingly evident (Kolding & van Zwieten, 2011). It has been suggested that small-scale fishing communities’ interpretation of fishery management can be considered as more *ecosystem-conscious* than the modern, conventional management of large-scale fisheries (Garcia & Cochrane, 2005). The need to manage and monitor the harvesting of all fisheries is undeniable, however, in certain instances the failure of current fisheries management approaches to successfully address the issue of bycatch through sector-based or silo approaches and top-down management regimes, stresses the necessity for more holistic approaches to address the issue. An exception is the inshore trawl fishery, which has attempted to minimise bycatch. Nevertheless, it is important to consider how bycatch is being viewed and managed in general across all fisheries. This new perspective should be considered by different stakeholders in the South African context and more specifically as it pertains to the netfisheries.

This thesis has alluded to the complexity of fishery systems and how they are affected by an abundance of environmental and social drivers interacting across a multitude of temporal and spatial levels and scales (see Berkes et al. 2001, 2003; Kooiman et al., 2005; Castilla & Defeo, 2005; Garcia & Charles, 2008; McClanahan et al., 2009; Basurto et al., 2013; Kittinger et al., 2013). A social-ecological systems analysis of a fishery system endeavours to encompass greater considerations within fishery systems in order to better manage and conserve marine living resources (Garcia et al., 2003; FAO, 2003b). The Olifants estuary small-scale gillnet fishery provides a dynamic example of such a complex social-ecological system, requiring a holistic and integrated approach in order to promote ecological integrity, social equity and the sustainable use of its natural resources. This study has highlighted the continued dominance of Elf as an *incidentally* caught species in gillnet catches in the Olifants estuary small-scale gillnet fishery, with seasonal and sporadic contributions from the other selected key linefish species. This is emphasised by fisher interviews as well as recent landings data for 2012 by the national beach-seine and gillnet fishery as highlighted in this study (Elf – 26.94%; Silver Kob – 0.88%; White Stumpnose – 1.05%; FIHB, 2013). The landing of juvenile linefish species by the Olifants estuary small-scale gillnet fishery is acknowledged, however, the size-distributions of bycatch species in the fishery may be broader than suspected for gillnet fisheries (see Figures 12 and 13 in Chapter 5), and therefore questions the notion of the size-selectivity of gillnets. However, more rigorous long term research would be needed to shed greater light on this. While a high level of size-selectivity is evident in brand new gillnets, this is less evident in old and adapted fishing gear, characteristic of many small-scale fisheries. Selectivity has been postulated by many as the panacea to almost all fisheries management issues but there is growing evidence of the negative effects of selectivity on narrow subclasses of the target species in terms of fish assemblages and populations, and subsequent ecosystemic interactions (see Garcia et al., 2012; Kolding & van Zwieten, 2014). The selective removal of large fish from the system ultimately affects not only the life history characteristics of individual fish populations, but the overall fish community structure, and in so doing the internal food-web processes that represent a major part of ecosystem functioning (see Pauly et al, 1998). Likewise the removal of juveniles, as is the case in small-scale gillnet fisheries, may have implications for species of concern based on specific life history characteristics, including the four species of focus here.

The location of catches in the Olifants estuary based on fisher interviews, and corroborated by the monitoring data, indicate highly productive fishing occurring nearest to the mouth. The increased occurrence of bycatch is also noted in this area. Therefore the *no-take* zone between the Baken and the Mouth, as indicated previously and represented by Figure 14 (see Chapter 5) could represent a significant contribution to conservation efforts, although with livelihood implications for the fishers concerned.

Balanced harvesting, as mentioned throughout, has been promoted as a possible solution to conventional fishing practices which have been increasingly shown to be contrary to natural predation and mortality. That said, while the *balanced harvesting* approach may show great promise, it has still received much criticism and implementation will be challenging (see Froese et al., 2015; Burgess et al., 2015). Further research on adopting this approach in the Olifants fishery needs to be conducted, and this approach should be implemented within a *precautionary approach* and *adaptive governance system*. In addition, the already degraded nature of many of the ecosystems in which we find such fishery concerns as bycatch, means that this approach is not being implemented into a pristine system, and therefore considerations of the factors impacting the system will need to be made. The knowledge base of small-scale fisheries in South Africa is improving and while concerns exist over key linefish species occurring as bycatch in other fisheries, it is necessary to approach the issue of bycatch more broadly and consider the contributions to harvesting of these species by all different fishery sectors. The following section will attempt to consolidate the relative catch contributions of other fisheries with regards to the selected linefish species of this study.

6.2 EAF as a framework for addressing bycatch concerns

Many species are known to be exploited by a variety of different fisheries, the relative exploitation patterns of which should be documented as best as possible, although uncertainty in many fisheries persists. Findings of this study have attempted to indicate the overlapping nature, and the sector-specific magnitude, of exploitation of the selected linefish species, whilst fully acknowledging the limitations of the data and the approach. Certain species (e.g. Elf) occurring within small-scale fisheries are known to make large scale migrations (see Van der Elst, 1976; and Dunlop & Mann, 2015) and therefore small-scale fisheries cannot be expected to manage these species alone, as many species are known to be caught as either target or bycatch species within numerous fisheries (see FIHB, 2013). Moreover, additional species (as identified in this study) are thought to be represented by separate stocks (e.g. Silver Kob and White Stumpnose) and therefore management strategies should reflect as much. The high level of cross-sectorial exploitation of these species by numerous other fisheries has been made clear by this study, in particular for Silver Kob and White Stumpnose and to a somewhat lesser extent Elf and White Steenbras.

Silver Kob represents the best example of overlapping exploitation by multiple fisheries. For Silver Kob this pattern is present in historical (i.e. with peak landings of 1769 t in 1938 [Commercial Linefishery] and 1303 t in 1926 [Commercial Trawl Fishery], SAEON database) as well as more recent catches, as it is a substantial component in the current commercial linefishery catches (63% - FIHB, 2013) and a prominent bycatch component within the commercial inshore trawl (35% - FIHB, 2013). Furthermore, it is also found, but to a lesser extent, in the beach-seine and gillnet (0.88%), hake longline (0.73%), and demersal trawl fisheries (0.21%, all values from FIHB, 2013. Moreover, its enduring popularity within the recreational fishery sector, as indicated by results of the online national recreational survey conducted for this study (i.e. especially in the southern Cape -respondents targeting [81.8%] and commonly catching [45.5%]; and in the Western Cape [targeting percentage -86.4%]) and past studies (Brouwer et al., 1997; Bennett et al., 1994; Lamberth et al., 1994), increases conservation concerns for the species. The limitations in recording methodology (i.e. often recorded simply as Kob or *Argyrosomus* genus) and species confusion and the monitoring of the open-access recreational sector for this species have also sought to compound the problem, as past and present landing records have been unclear and thus unreliable. Regionally speaking the southern Cape represents an area of extreme conservation concern for this species, where it is caught by inshore trawlers and targeted and commonly caught by recreational linefishers, as indicated in the findings of this study. Furthermore, the apparent stock separation of the species accentuates this regional concern, and further complicates the assessment of the exploitation of numerous different fisheries that harvest this species across the three proposed stocks (see Griffiths, 1997c).

White Stumpnose provides a further example of the extent of overlapping exploitation, with significant and consistent catches being made in the commercial inshore trawl and linefishery both historically (peak of 540 t in 1925 [Commercial Linefishery] and between 80-100 t in the 1930s [Commercial Trawl Fishery – subject to identification issues], SAEON database) and at present. In addition, it is a favoured recreational linefishery species based on results of the online survey conducted, particularly in the Western Cape (86.4% targeting rating) and more specifically along the west coast (targeting and commonly catching rating of 71.4% and 42.9% respectively), and as indicated by WCSAA competition data, as well as past studies (see Brouwer et al., 1997). Moreover, it has been shown to have a presence in deepsea trawl catches (5.83 t in 2012, FIHB, 2013), as well as in gillnet catches (national landings of 1 t in 2012, FIHB, 2013) particularly in Langebaan Lagoon and Saldanha Bay (see Hutchings & Lamberth, 2002a). These exploitation patterns will have regional concerns due to the proposed existence of four separate stocks, most notably once again for the southern Cape, specifically due to inshore trawling and recreational pressure, and the Western Cape, as two separate stocks have been postulated for False Bay and Saldanha Bay/ Langebaan Lagoon (see Griffiths et al., 2002; Attwood et al., 2010).

Elf and *White Steenbras* are two additional recreationally popular species featured in this study, the status of each species being a matter of concern to scientists. Elf forms a prominent bycatch component of gillnet fishers along the west coast (including in the Olifants Estuary, and prior to its closure the Berg River Estuary). However, this bycatch is comparatively small when compared with the linefishery, and the potential landings of the recreational fishery sector. In addition, the occurrence of Elf within commercial linefishery catches has been recorded in historical catches (peak of 90 t in 1928, SAEON database). The popularity of the species with recreational linefishers along the Kwazulu-Natal and Eastern Cape coasts is well established within previous studies (see Smale & Buxton, 1985; Brouwer et al., 1997; Mann et al., 2002, 2003, 2012; Hutchings et al., 2008), and recent KZNCAU recreational competition data (see Figure 24) used in this study indicate continued substantial catches specifically within this region. Furthermore, results from the online recreational survey conducted for this study revealed that this regional pattern endures, with KwaZulu-Natal receiving between 80-90% respondent targeting and commonly catchings rate, and the southern, Eastern and Western Cape between 40-65% rate for targeting and commonly catching Elf.

Furthermore, the potential for undersized catches of the species by the recreational linefishery sector is alluded to in the RASSPL recreational competition data (see Figure 23, Chapter 5). The proposed possible stock separation or 'mixed evolutionary strategy' (see Hedger et al., 2010) of this species adds to conservation concerns, but as this has not been clearly established, regional exploitation could continue to have both regional and national implications for the species.

White Steenbras represents a species of great conservation concern in South Africa, with very low numbers being reported within numerous different fisheries over the past few decades (see Bennet, 1991; Penney, 1991; Lamberth et al., 1997; Hutchings & Lamberth, 1999; Mann et al., 2014). It is a species that has long been targeted by recreational linefishers (see Biden, 1930; Day et al., 1987; Bennett, 1993a; Schoeman & Schoeman, 1990) and historically by the commercial linefishery (peak landing of 123 t in 1929, SAEON database), and has even been caught as bycatch in the inshore trawl (peak recording of 270 t in 1938, SAEON database) and beach-seine fisheries (see Penney, 1991). Analysis of the online national recreational survey conducted for this study, indicates the continued popularity of the species with recreational linefishers in the southern and Eastern Cape (targeting ratings of 54.6% and 51.3%) and to a lesser extent the Western Cape (34.1%), echoed by the RASSPL recreational competition data (see Figure 50) and in particular this data points to the likelihood of undersized catches (see Figure 51). Furtehrmore, it has always been an established component of the beach-seine fishery in False Bay (see Lamberth et al., 1994), itself an area of high shore-based recreational fisher landings of the species. Furthermore, more recent findings suggest that it continues to make a significant contribution to the recreational shore-based fishery, with severe compliance issues, in the Knysna and Swartvlei estuaries in the southern Cape (see Smith & Kruger, 2013). It is suggested that this species is represented by one well-mixed population and therefore regional exploitation will have (and evidently already has had) far reaching impacts on the status of the species nationally, as has been witnessed with its current IUCN Red List status (see Mann et al., 2014).

EAF offers a holistic social-ecological systems approach to fisheries management and is epitomized by endeavouring to avoid adverse ecological and socio-economic consequences in fisheries. Therefore, in order to realise this undertaking in the context of this study there is a need to account for all known fisheries that exploit the species of concern as well as their ecological interactions. Ecological interactions include competition and predation. Predation of these linefish species is mainly on small pelagic fish, squid and crustaceans (the specific diets of each linefish species has been established previously in Chapter 5). Small pelagic fish species such as Anchovy (*Engraulis encrasicolus*) or Sardine (*Sardinops sagax*) have themselves shown high variability in recent catches, and at times significant declines as a result of increased commercial fishing activity as well as numerous other possible factors (FIHB, 2013). It is well established that short-lived species (e.g. Anchovy and Squid) have been shown to exhibit high levels of recruitment variability, which can result in substantial interannual fluctuations in population size, and this has implications for the species reliant on them. Moreover, the East Coast Prawn Fishery has shown increased landings over the past two years (FIHB, 2013) and this again would have implications for those species reliant on these organisms for their survival.

The evidence presented here seeks to better inform and contextualise the issue of bycatch. The Olifants estuary small-scale gillnet fishery is known to contribute to the overall harvesting of these selected linefish species, most notably Elf, and to capture juvenile individuals. However, the relative contributions of other fisheries have been shown to be substantial and in most cases orders of magnitudes greater than the catches of the Olifants estuary small-scale gillnet fishery. Therefore, the closure of this complex small-scale fishery to address concerns regarding bycatch is not necessarily the solution. There is a need to address species of conservation concern more holistically by accounting for all landings, by all fisheries, and managing the relative contributions of each fishery and the species as a whole. Whilst the Olifants estuary small-scale gillnet fishery requires continuous monitoring and should not be left unmanaged, it is important to manage the harvesting patterns of all fisheries contributing to the species of concern. In line with an EAF, there are additional concerns which require attention, although no data was collected on these factors for this study, and a few of these are discussed next.

6.3 Additional concerns within a complex social-ecological system

In order to adopt an EAF, additional concerns within this social-ecological system need to be addressed. Whilst the limited scope of this study prevented the collection and analysis of data on various additional components, they are nonetheless equally important and have therefore been included in this discussion. Several human activities, which take place in estuaries and their catchment areas, have been shown to impact directly on estuarine biodiversity and resources, and these activities, are often in conflict with one another through such impacts (see Lamberth & Turpie, 2003). Some of the additional local ecological concerns which need to be kept in mind are the influences of surrounding economic and industrial activities, which in the case of the Olifants estuary include agriculture and mining, and the existence of Clanwilliam Dam which reduces freshwater flow.

The key concerns associated with agricultural activity are containment run-off, water abstraction, and reduced flow. The levels of pollutants that are released into the Olifants estuary, are a concern, however, the severity is unclear (see Turpie et al., 2006). Water abstraction and altered flow of freshwater into the estuary affect the estuarine environment and therefore fish assemblages. The catchment area of the Olifants River is characterized by 90% untransformed land, much of which is zoned for nature conservation and the rest is used for livestock, and some dryland farming (e.g. rooibos tea) (Anchor, 2007). However, agriculture on the immediate surrounding lands of the Olifants River is intensive on both banks (e.g. especially viniculture) and effects include significant irrigation demands (e.g. for citrus and grapes) (Anchor, 2007). According to Lamberth et al. (2008), the Olifants estuary has experienced a more than 35% reduction in mean annual runoff from a historical reference condition (i.e. 100 years prior to the study was assumed to be equivalent to a pristine state) to the present day and an associated 60% or greater reduction has been deemed possible under future flow scenarios (Lamberth et al., 2008). An adequate freshwater supply has been identified as an essential driver of productivity in estuaries (Mallin et al., 1993) and in establishing the characteristic physico-chemical and biological structure of these systems (see Bate et al., 2002; Whitfield, 2005). Several South African larval fish studies have highlighted that the middle to upper reaches of estuaries are particularly rich in catches of marine larval fishes, principally associated with mesohaline salinity (0.5-17‰) conditions, characterizing productivity hotspots (Strydom et al., 2003; Pattrick et al., 2007; Montoya-Maya & Strydom, 2009). The majority of completely and partially estuarine-dependent marine fish species found in the Olifants estuary (commonly juveniles), based on extensive sampling, have been shown to occur in the middle to lower reaches, whilst freshwater tolerant species occur in the middle reaches (Lamberth et al., 2008).

Additional flow concerns are centred around predicted changes in precipitation, runoff and storm frequencies (believed to be due to climate change) which will drive modifications in saline water intrusion in estuaries, the frequency and duration of mouth closure; nutrient fluxes; the magnitude and frequency of floods and related sediment deposition/erosion cycles, the dilution and/or flushing of pollutants (Alber, 2002) and a loss of nursery function. The life-histories of estuarine-dependent fish are adapted to the natural flood regime of estuaries and any deviation from these natural cycles, such as a succession of atypical floods, may affect successful recruitment in the system. The recruitment and emigration of estuary-dependent fish to and from estuaries varies as a result of the magnitude, frequency and timing of freshwater flow and the flooding regime (Turpie et al., 2002; Taljaard et al., 2009). Therefore reductions in freshwater flow reaching the sea, result in a weakening of recruitment cues and possibly recruitment failure for the estuary-dependent fish. In addition, reduced freshwater flow will lower the extent to which wastewater discharges may be diluted before they reach estuaries, and thus increase the concentration of pollutants in the coastal zone, limiting their capacity to support natural biota. The Olifants estuary fish assemblage has experienced an overall 20% decrease in abundance, excluding species with both marine and estuarine breeding populations, when compared with reference points (i.e. pristine states), and is predicted to progressively decline to 55% of reference with the predicted future 60% reduction in mean annual runoff (Lamberth et al., 2008). Therefore, future reductions in flow are likely to result in the Olifants estuary moving towards a low biomass, low diversity, and marine-dominated system (Lamberth et al., 2008). The raising of the Clanwilliam Dam wall, which is imminent, will further affect water flow downstream and ultimately reaching the estuary (see Brown & King, 2012).

Mining for gypsum, salt, sand and diamonds take place in the greater Olifants coastal area (Anchor, 2007), however, mining operations are small and mainly comprise quarrying or the dredging for marine diamonds (DWAF, 2002). Offshore mining operations are also currently restricted to the concession areas north of the Olifants estuary but a number of diamond boats involved in mining activities within surrounding concession areas are known to be moored from time to time in the mouth of the estuary and have been highlighted as a potential threat to fish stocks in the system (CSIR, 1991). Since mining concessions do occur in the vicinity of the estuary mouth, and on the terrestrial and seaward sides, indirect negative impacts would still need to be considered. Salt mining is practiced on the south bank of the Olifants estuary, immediately adjacent to the mouth (Anchor, 2007). This is believed to be an unobtrusive operation, and while construction of the salt pan itself has resulted in the loss of some salt marsh vegetation, overall impacts of this operation on the estuary are believed to be low (Anchor, 2007). Greater research into the possible overall ecological impacts of mining, in addition to agriculture, in the area, however, needs to be undertaken.

The complexity of the Olifants estuary is therefore clear from the above discussion. In order to manage this complex system it is necessary to not only evaluate the impact of the local fishery and the relative contributions of other species-related fisheries, but also address a variety of additional social and ecological dimensions that influence the health (i.e. social and ecological) of the system. The limited additional ecological concerns very briefly highlighted here could possibly be having an even greater effect on the estuary than the gillnet fishery. Thus, the closure of this fishery will not necessarily address broader ecosystem concerns and may in fact undermine ecological objectives due to socio-economic pressures in the community.

Picture 7: Gillnet in the water at the Olifants estuary near Papendorp. **Photography:** Wayne Rice.

6.4 The Way Forward

This study has attempted to provide a preliminary assessment of a specific issue (i.e. bycatch) in a specific fishery by utilising an EAF framework, and although significant gaps exist in this endeavour, it does provide a starting point to enhance understanding of, and highlight the necessity for, greater ecosystemic considerations. In accordance with the EAF process, as discussed previously (see Figure 2, in Chapter 2) *implementation* and subsequently *monitoring and evaluation* can provide a starting point to addressing issues such as bycatch. The use of an EAF in this study has promoted a more holistic and in depth understanding of bycatch and assisted in contextualising this issue in relation to other fishery sector impacts on these bycatch species, as well as (to a limited extent) how land-based activities contribute to ecosystem health. The substantial overlapping nature of exploitation of these four linefish species has been most revealing. The extensive consolidation, review and analysis of available data on these species have assisted in exposing some of the gaps in our knowledge, the bridging of which should be priority. The greatest concern identified by this study for South African fisheries is arguably the lack of knowledge on the essentially unknown, yet considerable, recreational linefishery. The lack of monitoring data, the open-access nature of this fishery and poor compliance have gone unchecked for the most part and the uncertainty of the magnitude of this fishery's impact on species of high conservation concern only accentuates the limitations on successfully managing these complex social-ecological systems. Limitations in accuracy of monitoring data across all fisheries continues to be a concern, with limited observations of commercial vessels (specifically pertaining to the issue of discards), and the somewhat unreliable, or unreported, nature of community-catch monitoring data in small-scale fisheries. Economic (e.g. marketability of catch) and political influences (e.g. perceptions of inadequate social equity) have sought to counter the accuracy of such data. Mistrust between fishers, and fishery scientists and government officials, has led to unproductive relationships, which are in urgent need of improvement. Additionally, species specific knowledge relating to possible separate stocks (with implications for regional fisheries management) and life history characteristics require continued research.

Clearly, the closure of the Olifants estuary small-scale gillnet fishery is not necessarily an effective solution to address concerns regarding bycatch. The improved holistic understanding of such a complex fishery system is better suited to addressing management issues present and in the case of this specific study the issue of bycatch. Greater consideration for the bigger picture that exists in South African fisheries and the spatial extent and magnitude of exploitation of these species by multiple fisheries, in addition to other ecological and social concerns, is the only way to attempt to solve such modern complex natural resource management problems. With this in mind, greater encouragement of interdisciplinary research which seeks to connect natural and social sciences, and integrate the views and knowledge of multiple experts from different disciplines and sectors in tackling resource management problems, is required. An additional challenge being faced is the diverse views and values of various stakeholder groups. Harmonization amongst groups is best achieved through a participatory, integrated planning and management strategy whereby all the stakeholders are involved in the decision making process, and their concerns are heard. Whilst the uncertainty of fishery systems has received much debate, the uncertainty of human behavior has received less consideration (see Fullon et al., 2011). Thus a change in how fisheries management operates is required if broader ecosystem considerations are to be integrated, by acknowledging the need for both broad scale approaches and stakeholder support. Compliance with fisheries regulations has been shown to be improved with greater stakeholder involvement and perceptions of greater legitimacy created thereby (see van Sittert, 2003). The possible derailment of the implementation of EAF, and in the case of South Africa the South African Small-Scale Fisheries Policy, can occur when social and economic implications of management decisions are not given adequate consideration. This serves to further emphasise the need for a holistic approach to fisheries management that encompasses both ecological and social dimensions. In contrast to the school of thought which stresses simplicity in the pursuit of understanding (i.e. Occam's razor or 'the law of parsimony'), EAF promotes increasing complexity in order to promote holistic understanding. Therefore, one of the significant challenges facing fisheries management is to determine the levels beyond which increased complexity will reduce management performance instead of improve it.

While South Africa appears to have good intentions in terms of policy provisions, it is yet to be seen whether implementation (in the case of the Small-Scale Fisheries Policy) will be successful. The need has arisen to address the negative ecosystemic impacts of fishing, while simultaneously accounting for increasing food security and livelihood requirements. Small-scale fisheries are providing livelihoods for many coastal communities when other economic opportunities are failing. While much of the management literature advocates providing alternative livelihoods in order to reduce overfishing, the key point remains that fishing is still an important alternative when other livelihood options, if they do even exist, fail. Greater examination of the costs of closing these natural *social safety nets* at national, regional or even global scales needs to occur, in order to evaluate the appropriateness of such actions. The recent Small-Scale Fisheries Policy (DAFF, 2012a) seeks to provide redress for the past inequitable distribution of living marine resources, and thereby address livelihood concerns. By promoting an EAF, and the sustainable and balanced harvesting of species known to occur incidentally in catches, social wellbeing can be provided without adverse ecological consequences.

Picture 8: Looking out at the Olifants estuary near Papendorp. **Photography:** Nolene Rice.

Chapter 7: Conclusion

Conventional fisheries management approaches have been shown, in many instances, to have been ineffective in dealing with complex conservation concerns within fisheries. The issue of bycatch (i.e. undersized and unselective catches) continues to plague modern fishery managers; however greater considerations for broader scale and holistic approaches, as proposed by the *'Ecosystem Approach to Fisheries'* (EAF) and the '*balanced harvesting approach'*, are beginning to challenge some of the negative misconceptions around bycatch, especially in small-scale fisheries. In accordance with EAF thinking and practice, it is essential that consideration of the magnitude and extent of the overlapping exploitation of species by all species-related fisheries (in addition to other social-ecological components) be accounted for if sustainable harvesting objectives are to be accomplished and complex issues such as bycatch better addressed. The approach taken to managing a fishery needs to encompass and address all relevant environmental and social drivers of the system. In light of this, the present study has endeavoured to take a preliminary step towards showcasing, and attempting to adopt such a holistic approach, utilising EAF as a framework in addressing the issue of bycatch. It has attempted to highlight some of the various ecological and social components, within the scope of this study, that would need to be considered in the case of the Olifants estuary small-scale gillnet fishery, and in particular examine the contributions of other fishery sectors to the status of the selected linefish species.

An extensive review and analysis of available secondary data, as well as primary data collected for this study, has identified and emphasised, with acknowledged limitations and knowledge gaps, the potential magnitude of the exploitation of these species by numerous species-related fisheries. The fact that the Olifants estuary small-scale gillnet fishery, known to capture juvenile linefish species, requires continuous monitoring is undisputed; however, it is important to manage the harvesting patterns of all fisheries contributing to the decline of species of concern, whilst taking life history characteristics and the existence of possible separate stocks into consideration. Key findings of this study are the substantial levels of overlapping exploitation of these four species by numerous fisheries; which is particularly true for Silver Kob and White Stumpnose, and to a somewhat lesser extent Elf and White Steenbras. Silver Kob has been shown to exist as three separate established stocks and therefore the species is not only of national but perhaps more importantly regional management concern, most notably in the Southern Cape region where it is heavily exploited by the commercial inshore trawl fishery (national landings of approximately 120 t in 2012), commercial linefishery (national landings of approximately 215 t in 2012 – although this is a *Argyrosomus* genus figure) and the recreational linefishery (with a between 70-87% targeting and 40-60% commonly catching rate across the Western, Southern and Eastern Cape – as emphasised the findings of the online national recreational survey conducted for this study). These landings are orders of magnitudes greater than the reported national beach seine and gillnet landings for 2012 of approximately 3 t, which are incidentally almost equivalent to the levels of bycatch of this species in the hake longline fishery (national landings of approximately 2.5 t for 2012).

White Stumpnose provides a further example of the extent of cross-sectorial exploitation, with significant and consistent catches being made in the commercial inshore trawl (national landings of approximately 50 t in 2012) and commercial linefishery (national landings of approximately 39 t in 2012). These landings are orders of magnitudes greater than the reported national beach seine and gillnet fishery landings for 2012 (approximately 1 t), which are incidentally still small in comparison to the levels of bycatch of this species by the deepsea trawl fishery (national landings of approximately 6 t in 2012). Furthermore, it is a preferred recreational linefishery species in the Western Cape (with an approximately 37% targeting and 32% commonly catching rate), and more specifically along the west coast (with an approximately 71% targeting and 64% commonly catching rate) as emphasised by the findings of the online national recreational survey conducted for this study. Due to the proposed existence of four separate stocks, most notably once again for the Southern Cape, (specifically due to inshore trawling and recreational fishing pressure) and the Western Cape (especially due to the suggested two separate stocks for False Bay and Saldanha Bay/ Langebaan Lagoon), the species is of regional management concern.

Elf represents not only the most prominent bycatch species of the Olifants estuary small-scale gillnet fishery, but is a principle component of the commercial linefishery (with ineffective current species-specific management regulations) and its popularity as a recreational linefishery species endures (with a 40-90% targeting and 50-80% commonly catching rate across the Southern and Eastern Cape, and KwaZulu Natal), as highlighted by the findings of the online national recreational survey conducted for this study, as well as previous studies. Once more the reported national landings of the beach seine and gillnet fishery for 2012 (approximately 4 t) are significantly smaller than the commercial linefishery (national landings of approximately 11 t for 2012). Elf’s distribution range spans the entire South African coastline and it is recognised to make large scale migrations to spawn, although a proposed mixed migratory/residentary strategy has been suggested (though not clearly established), indicating that the species requires both regional and national management strategies across all fisheries. White Steenbras, represents an example of failed efforts to curb overfishing, most likely as a result of its recreational popularity. However, it was also caught historically in commercial trawls and the commercial linefishery, as well as presently in the beach seine fishery (most notably in False Bay). White Steenbras remains a conservation concern especially due to its proposed continued popularity with recreational linefishers (with an approximately 35% targeting and commonly catching rate), as emphasised by the findings of the online national recreational survey conducted for this study. Due to it being proposed as one well-mixed stock, regional fishing pressures (most notably in the Southern Cape) have quite possibly led to current national management dilemmas.

Other factors influencing the fishery system (e.g. freshwater flow, water abstraction, and chemical run-off) that are not assessed in this study are equally important contributing factors that need to be taken into account. In conclusion, the levels of exploitation by numerous other fisheries has been identified to be orders of magnitude greater than that of the national beach seine and gillnet fishery, in general, and particularly that of the Olifants estuary small-scale gillnet fishery, in the case of all four of the key selected linefish species of this study. Consequently, the closure of the Olifants estuary small-scale gillnet fishery would not necessarily address conservation concerns of these important linefish species, but would have significant socio-economic implications for the local community. It can therefore be concluded that the management of complex fisheries as single isolated entities within vast and complex ecosystems, and with single-species targeting agendas, is dated and ecosystemically and socially inadequate. Greater ecosystem considerations can lead to the more sustainable management of natural resources, which will better balance the need to provide for human wellbeing whilst avoiding adverse ecological consequences.

Picture 9: Access to the Olifants estuary at Papendorp. **Photography:** Nolene Rice.

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Appendices:

Appendix 1: Sample small-scale fisher interview sheet

Small-Scale/Subsistence Fishing Survey

Researcher:	**Wayne Rice**
University:	**University of Cape Town**
Masters research thesis for the degree of:	**MPhil in Environment, Society and Sustainability**
Contact Details:	**mr.waynerice@gmail.com**
Please be assured that this is a confidential survey, and that this research project is subject to UCT's ethical standards. Your answers will help to contribute to an enhanced understanding of the small-scale/ subsistence fishing sector, which represents an important stakeholder group within South African Fisheries.	

1. **For how many years have you been a fisher?**

0-5	6-10	11-20	20+

2. **Do you possess an interim relief permit? Yes/No**
3. **What are some of your favourite fishing spots? Please list**

4. **What species do you usually target?**

Harders	
Elf/Shad	
White Stumpnose	
White Steenbras	
Hottentot	
Kabeljou	
Galjoen	
Springer	
Leervis	
Gurnard	
Snoek	
Other (Please specify)	

5. **What species do you most commonly catch?**

Harders	
Elf/Shad	
White Stumpnose	
White Steenbras	
Hottentot	
Kabeljou	
Galjoen	
Springer	
Leervis	
Gurnard	
Snoek	
Other (Please specify)	

6. **Have you noticed any changes in fish catches? Has it …**

Got better over time?	
Got worse over time?	
Stayed the same?	

Comments: On numbers, size of fish, species compositions

7. **What types of fishing gear do you use? List**

8. **Do you make use of different fishing gear depending on the time of year or target species? Explain. (Mesh sizes; etc…)**

9. **What are some of the resource conflicts that exist in your fishing area? List and Explain. (Other SSF/ Recreational/Commercial/Environmental, e.g. seals)**

10. **In your opinion, who do you think is having the greatest impact on local fish stocks?**

Commercial		Recreational		SS/Subsistence	

11. **On a scale of 1-10 how would you rate the performance of fisheries compliance in the area (1=very bad, 10=excellent)**

1	2	3	4	5	6	7	8	9	10

12. **On a scale of 1-10 how would you rate the level of respect for fisheries compliance in the area (1=very bad, 10=excellent)**

1	2	3	4	5	6	7	8	9	10

13. **On a scale of 1-10 how would you rate the scale of illegal fishing in the area (1=very little, 10=prolific)**

1	2	3	4	5	6	7	8	9	10

14. **Do you think that the area requires greater marine conservation efforts? Yes/No. Suggestions**

15. **Do you have a fishing licence? Yes/No**

Appendix 2: Sample recreational shore-angling fisher interview sheet for the greater Olifants Estuary

Recreational Fishing Survey

Researcher:	**Wayne Rice**
University:	**University of Cape Town**
Masters research thesis for the degree of:	**MPhil in Environment, Society and Sustainability**
Contact Details:	**mr.waynerice@gmail.com**
Please be assured that this is a confidential survey, and that this research project is subject to UCT's ethical standards. Your answers will help to contribute to an enhanced understanding of the recreational fishing sector, which represents an important stakeholder group within South African Fisheries.	

1. **For how many years have you been a recreational fisher?**

0-1	**1-3**	**4-9**	**10+**

2. **How often do you fish along the West Coast/ Strandfontein/Olifants?**

More than once a week	**WC**	**Strandfontein/Olifants**
Every weekend		
Twice a month		
Once a month		
6 times a year		
4 times a year		
Twice a year		
Once a year		
Other (please specify)		

3. **How many days (on average) do you spend on each fishing trip?**

Day trip	
2-4 days	
4-7 days	
1-2 weeks	
2-4 weeks	
More than a month	

4. **Do you participate in: shore-based angling; boat-based angling; spear fishing?**

Shore-based	
Boat-based	
Spear fishing	

5. **Do you practice catch and release? Yes/No**
6. **Do you belong to a recreational angling club? If so, please state which one.**

7. **What are some of your favourite fishing spots? Please list**

8. **What do you usually use for bait?**

9. **How would you rate the fishing on WC/ Strandfontein/ Olifants?**

Extremely Poor	**WC**	**Strandfontein/ Olifants**
Poor		
Average		
Good		
Excellent		

10. **What species do you usually target?**

Elf/Shad	
White Stumpnose	
White Steenbras	
Hottentot	
Kabeljou	
Galjoen	
Springer	
Leervis	
Gurnard	
Snoek	
Other (Please specify)	

11. **What species do you most commonly catch?**

Elf/Shad	
White Stumpnose	
White Steenbras	
Hottentot	
Kabeljou	
Galjoen	
Springer	
Leervis	
Gurnard	
Snoek	
Other (Please specify)	

12. **Have you noticed any changes in fish catches? Has it …**

Got better over time?	
Got worse over time?	
Stayed the same?	

Comments: On numbers, size of fish, species compositions

13. In your opinion, who do you think is having the greatest impact on local fish stocks?

Commercial		**Recreational**		**SS/Subsistence**	

14. On a scale of 1-10 how would you rate the performance of fisheries compliance in the area (1=very bad, 10=excellent)

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

15. On a scale of 1-10 how would you rate illegal fishing in the area (1=very little, 10=prolific)

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

16. Do you think that the area requires greater marine conservation efforts? Yes/No

17. Do you possess a recreational fishing permit? Yes/No

18. Would you be willing to pay more to fish in order to support greater fisheries compliance? Yes/No

Additional Notes/Comments

Appendix 3: Sample online national recreational fisher survey

National Recreational Fishing Survey

This study forms part of a masters thesis project attempting to gain a better understanding of the relative contributions of the three fishing sectors (commercial, recreational & small-scale/subsistence) to five key nominated linefish species, namely Elf/Shad, Silver kob, White Steenbras, White Stumpnose, and Garrick/Leervis. Your participation in this survey will help to better inform management options and conserve these species so many future fishers may enjoy the angling experience.

Please complete all questions. Your completion of this short survey is greatly appreciated.

***1. Please select your region below.**

- ○ West Coast
- ○ The rest of the Western Cape
- ○ Southern Cape
- ○ Eastern Cape
- ○ KwaZulu-Natal

***2. For how many years have you been a recreational fisher?**

- ○ 0-5
- ○ 6-15
- ○ 16-25
- ○ +25

***3. What is your average time spent fishing per year?**

- ○ Once per week
- ○ Twice per month
- ○ Once per month
- ○ Four - Five times per year
- ○ Once a year

Other (please specify)

***4. How would you rate fishing in your selected region?**

Very Poor	Poor	Average	Good	Excellent
◯	◯	◯	◯	◯

You may clarify below (only if necessary)

***5. What species do you target on an average fishing trip?**

- ☐ Elf/Shad
- ☐ Silver Kob
- ☐ White Steenbras
- ☐ White Stumpnose
- ☐ Garrick/Leervis

Other (please specify)

***6. What species do you most commonly catch?**

- ☐ Elf/Shad
- ☐ Silver kob
- ☐ White Steenbras
- ☐ White Stumpnose
- ☐ Garrick/Leervis

Other (please specify)

***7. How would you rate fishing effort (i.e. numbers of fishers) in your region?**

- ◯ Very Low
- ◯ Low
- ◯ Medium
- ◯ High
- ◯ Very High

***8. Have you noticed any changes in catches (especially of the 5 key nominated linefish species of this study)**

- ◯ They have gotten worse over time
- ◯ They have stayed the same over time
- ◯ They have gotten better over time
- ◯ The peak seasons of fish have just shifted but the catches remain good

You may clarify (only if necessary)

***9. In your opinion which sector is having the greatest impact on the five focus species of this survey?**

- ◯ Commercial
- ◯ Recreational
- ◯ Small-scale/ Subsistence

You may clarify (only if necessary)

***10. Please rate the performance (i.e. the enforcement of permits, size & bag limits, and closed seasons & areas) of fisheries monitoring in your region.**

Very Poor	Poor	Average	Good	Excellent
◯	◯	◯	◯	◯

You may clarify (only if necessary)

Appendix 4: Selected key sources of data consulted on ***Elf,*** for this study indicating region, location, and fishery sector/ experimental sampling method concerned; as well as the type of data, and the time period of the study.

Region	Location	Fishery sector/Sampling	Data	Time Period	Source
National	National	Recreational SBA	PTS; TAngEf; CPUE; %TC in NC and M; and FC	Apr 1994 – Feb 1996	Brouwer et al. (1997)
National	National	Commercial Inshore-Trawl	CC; and %TC	2003 - 2006	Attwood et al. (2011)
National	National	Commercial Linefishery	TLands	2001 – 2010	DAFF (2012b)
WC	Bot River Estuary	Experimental Sampling (using gillnet)	NC; and MM	Apr 1980 – Apr 1983	Bennett (1985)
WC	De Hoop Nature Reserve	Recreational SBA	NC; and %TC	May 1984 – Jul 1992	Bennett and Attwood (1993)
WC	False Bay	Commercial Beach-Seine Fishery	Ab; NR; PU; CC by sectors (1985-1992)	Jan 1991 – Dec 1992	Lamberth et al. (1994)
WC	False Bay	Commercial Beach-Seine Fishery	Mean monthly catch beach-seine hauls	Jan 1991 – Dec 1992	Lamberth et al. (1995a)
WC	False Bay	Commercial Beach-Seine Fishery and Experimental Sampling (beach-seine)	Ab; and Size-Comp	Feb - Mar 1993	Lamberth et al. (1995b)
WC	South -Western Cape	3 x Club Recreational SBA Records	%TC in NC and M. mM, monthly/annual CPUE	1938 - 1990 1971 - 1986 1978 - 1992	Bennett et al. (1994)
WC	South -Western Cape	Recreational SBA	Effects DBLs; and Conservation Status	1956 - 1990 1978 - 1992	Attwood and Bennett (1995a)
WC	Saldanha Bay / Langebaan Lagoon	Experimental Sampling (research angling)	Acoustic Telemetry Study (Tracking)	May 2006 – Dec 2007	Hedger et al. (2010)
WC	Saldanha Bay / Langebaan Lagoon	Experimental Sampling (using seine net)	Ab ($NC.m^{-2}$)	1994 – 2012	Anchor (2012)
SC	Tsitsikama NP	Experimental Sampling (research anglers)	Mean CPUE in TNP MPA	1998 - 2005	James et al. (2012)
SC	Southern Cape	Fishery-Independent Linefishery Survey	NC; and CPUE	1931 – 1933 1987 -1993	Griffiths (2000)
SC	Agulhas Bank	Commercial Linefishery	NOC; %OC; M	2000 – 2013	Götz et al. (2014)
EC	Algoa Bay	Experimental Sampling (using seine net)	NC; %TC in NC; consistency in catch; and TL	1980 - 1982	Lasiak (1982)
EC	East London – Jeffrey's Bay	Recreational BBA	Catch importance	1978 - 1982	Smale and Buxton (1985)
EC	Great Fish and Kowie Estuaries	Experimental Sampling (using gill/seine nets)	CPUE; FD; and Species Rank	Feb 1981- Feb 1982	Whitfield et al. (1994)
EC	Kei Mouth – Port Edward	Recreational SBA	NC; %Tar; and %TC in NC and M	Apr 1997-Jan 1998	Mann et al. (2003)
EC	East Kleinemonde Estuary	Experimental Sampling (using variety gear)	NC; and CPUE	1996-2005	James et al. (2008)
EC	SE Coast Estuaries	Experimental Sampling (using gill/seine nets)	RB; NC and %TC in NC for gill and seine nets	Sep – Oct 1995	James and Harrison (2010)

EC	EC	EC Commercial Inshore-Trawl	Ab status	1967 - 1995	Booth and Hecht (1998)
EC	Port Ngqura	Experimental Sampling (research SBA and BBA anglers)	NC; mean CPUE by Rec-SBA and Rec-BBA and combined angling	Sep 2006 – Sep 2007	Dicken (2010)
EC	Port Alfred - Robberg	Recreational SBA Competition Records ("Angling Week")	NC; %TC; W; %Mat	1999 - 2010	Dicken et al. (2012)
EC	King's Beach, PE	Experimental Sampling (using seine net)	NC; consistency species occurrence, %Juv; CPUE; TL	Feb – Aug 2011	Rishworth et al. (2013)
EC	Shark Bay	Experimental Sampling (using seine net)	NC; %TC in NC; CPUE; Dev Stage; SV	Sep 2004 – Aug 2005	Strydom et al. (2014)
KZN	Kosi Bay	Recreational SBA	NC	1986 - 1999	James et al. (2001)
KZN	St Lucia Estuary	Recreational Angling	NC; and M Boat-Angling Survey NC and %TC	1986 – 1999 1994	Mann et al. (2002)
KZN	KZN	Recreational Paddle-ski Angling	NC and Freq Rec-Shore vs. Rec-Boat vs Rec-Paddle-ski	2005 - 2008	Mann et al. (2012)
KZN	KZN	Recreational SBA	CC; SV; SD	1977 - 2005	Maggs et al. (2012)
KZN	Kosi Bay	Subsistence / SSF Fish Traps	%TC in NC and M	Mar 1981 – Feb 1985	Kyle (2013)

REGION
WC – Western Cape
EC – Eastern Cape
SC – Southern Cape
KZN – KwaZulu Natal

ABBREVIATIONS
Ab – Abundance; **BBA** – Boat-Based Angling; **BM** – Biomass; **CPUE** – Catch Per Unit Effort; **CC** – Catch Contribution; **CΔ** - Climate Change; **DBLs** – Daily Bag Limits; **Dev Stage** – Developmental Stage; **FC** – Fisher Compliance; **FD** = Fish Density; **Freq** – Frequency of Catch; **GP** - Growth Parameter; **M** – Mass; **MM** – Mass Mortality Estimated Count; **mM** – mean Mass; **NC** – Numbers Caught; **NOC** – Number Occasions Caught; **NR** – Numbers Retained; **Prod** – Production; **PS** – Population Size; **PTS** – Preferred Target Species; **PU** – Percentage Undersized; **RB** – Relative Biomass; **Rec** – Recreational; **RR** – Retention Rates; **SBA** – Shore-Based Angling**; Size-Comp** – Size Composition; **SD** – Spatial Distribution; **SFD** – Size Frequency Distribution; **SV** – Seasonal Variation; **TAngEf** – Total Angler Effort; **TL** – Total Length; **TLands** – Total Landings; **TR** – Target Rates; **%Juv** – percentage Juveniles; **%Mat** - % Mature (Above 50% weight-at-maturity); **%OC** – Percentage Occasions Caught; **%Tar** – Percentage Targeted; **%TC** – Percentage of Total Catch.

Appendix 5: Selected key sources of data consulted on ***Silver Kob,*** for this study indicating region, location, and fishery sector/ experimental sampling method concerned; as well as the type of data, and the time period of the study.

Region	Location	Fishery sector/Sampling	Data	Time Period	Source
Global	Southern Africa, Madagascar, the Mediterranean Sea, the eastern Atlantic Ocean, Japan, and Australia	Analysis of specimens	Tax; SD; LHP	N/A	Griffiths and Heemstra (1995)
National	SW, S and SE Cape	Rec and CL sampling	Age and Growth Rates; LHP	1991 – 1992-	Griffiths (1996a)
National	SW, S and SE Cape	Rec and CL sampling	PRA; YPR; and Size and Age Distribution; andLHP	1990 - 1994	Griffiths (1997a and c)
National	National	Rec SBA	PTS; TAngEf; CPUE; %TC in NC and M; and FC	Apr 1994 – Feb 1996	Brouwer et al. (1997)
National	SW, S, and SE Cape	Historical CL and Fishery-Independent Linefishery Survey	NC; CPUE; SS Indic; mean Catch.Boat^{-1}.yr^{-1}; and LHP	1897 - 1906 1927 - 1931 1931 – 1933 1986 - 1998 1987 - 1993	Griffiths (2000)
National	National	CIT	NC; mM; CC; TC in M; %Dis and %TC; and M CIT vs CL	2003 - 2006	Attwood et al. (2011)
National	National	CL	TLands	2001 – 2010	DAFF (2012b)
National	National	CL	TLands by region (KZN; SE and S Cape)	2001 – 2010	Duncan and Burgener (2013)
National	National	CIT	Annual and mean monthly CPUE; and SD	2000 - 2010	Smith et al. (2013)
National	National	CFS	Param and Historical mTC TC in M CIT	1998 – 2002 2000 - 2010	S.E.I.F.A. (cited in Smith et al. 2013)
National	National	CIT	%TLands	2007 – 2011	Grenston and Attwood (2013)
WC	False Bay	Commercial Beach-Seine and Rec Fishery	Ab; NR; PU; CC by sectors (1985-1992)	Jan 1991 – Dec 1992	Lamberth et al. (1994)
WC	South -Western Cape	3 x Club Recreational Shore-Based Angling Records	%TC in NC and M. mM, monthly/annual CPUE	1938-1990 1971-1986 1978-1992	Bennett et al. (1994)
WC	South -Western Cape	Rec SBA	Effects DBLs; and Conservation Status	1956 - 1990 1978 - 1992	Attwood and Bennett (1995a)
WC/SC	WC and SC	Linefishing Sampling	Barotrauma	-	Kerwath et al. (2013)
SC	South Coast	CIT	TC in M; %TC in M; %Dis in M for Hake- and Sole-Directed	1996 - 2000	Walmsley et al. (2007)
SC	Agulhas Bank	CL	NC; and %TC in NC for linefishery and Traps	2008 – 2010	Götz et al. (2014)
EC	Algoa Bay	ExSam (using seine net)	NC; %TC in NC; consistency in catch; and TL	1980 - 1982	Lasiak (1982)

EC	EC	EC CIT	Ab status; %TC boats op out PE (1967 - 1975 and 1985 – 1995)	1967 - 1995	Booth and Hecht (1998)

REGION
WC – Western Cape
EC – Eastern Cape
SC – Southern Cape
KZN – KwaZulu Natal

ABBREVIATIONS
Ab – Abundance; **BBA** – Boat-Based Angling; **BM** – Biomass; **CBSF** – Commercial Beach-Seine Fishery; **CIT** – Commercial Inshore-Trawl; **CL** – Commercial Linefishery; **CPUE** – Catch Per Unit Effort; **CC** – Catch Contribution; **CFS** – Commercial Fishery sector; **CΔ** - Climate Change; **DBLs** – Daily Bag Limits; **Dev Stage** – Developmental Stage; **ExSam** – Experimental Sampling; **FC** – Fisher Compliance; **FD** = Fish Density; **Freq** – Frequency of Catch; **GP** - Growth Parameter; **M** – Mass; **MM** – Mass Mortality Estimated Count; **mM** – mean Mass; **NC** – Numbers Caught; **NOC** – Number Occasions Caught; **NR** – Numbers Retained; **Prod** – Production; **PS** – Population Size; **PTS** – Preferred Target Species; **PRA** – Pre-Recruit Analysis; **PU** – Percentage Undersized; **RB** – Relative Biomass; **Rec** – Recreational; **RR** – Retention Rates; **SBA** – Shore-Based Angling**; Size-Comp** – Size Composition; **SD** – Spatial Distribution; **SFD** – Size Frequency Distribution; **Subsis** – Subsistence; **SV** – Seasonal Variation; **TAngEf** – Total Angler Effort; **Tax** – Taxonomy; **TL** – Total Length; **TLands** – Total Landings; **TR** – Target Rates; **%Juv** – percentage Juveniles; **%Mat** - % Mature (Above 50% weight-at-maturity); **%OC** – Percentage Occasions Caught; **%Tar** – Percentage Targeted; **%TC** – Percentage of Total Catch; **YPR** – Yield Per Recruit.

Appendix 6: Selected key sources of data consulted on ***White Stumpnose,*** for this study indicating region, location, and fishery sector/ experimental sampling method concerned; as well as the type of data, and the time period of the study.

Region	Location	Fishery sector/Sampling	Data	Time Period	Source
National	National	Recreational SBA	PTS; TAngEf; CPUE; %TC in NC and M; and FC	Apr 1994 – Feb 1996	Brouwer et al. (1997)
National	SW, S, and SE Cape	Historical CL and Fishery-Independent Linefishery Survey	NC; CPUE; SS Indic; mean Catch.Boat^{-1}.yr^{-1}; and LHP	1897 - 1906 1927 - 1931 1931 – 1933 1986 - 1998 1987 - 1993	Griffiths (2000)
National	SW, S, and SE Cape	CL, IT and bottom trawl surveys	LHP; TC in M for CL (SW and W Cape) and CIT (SC)	1987 - 1996	Griffiths et al. (2002)
National	National	CIT	TL; NC; M; %TC in M; and %Dis; ave. annual M Trawl vs. Linefishery	2003 - 2006	Attwood et al. (2011)
National	National	CIT	TLands	2001 - 2012	FIHB (2013)
WC	Klein River; Breede; Milnerton Estaury; Kalk Bay and Cape Infanta	Experimental Sampling (using various nets)	LHP; and LFD	1950 - 1951	Talbot (1955)
WC	Bot River Estuary	Experimental Sampling (using gillnet)	NC; and MM	Apr 1980 – Apr 1983	Bennett (1985)
WC	False Bay	Commercial Beach-Seine Fishery	Ab; NR; PU; CC by sectors (1985-1992)	Jan 1991 – Dec 1992	Lamberth et al. (1994a)
WC	South -Western Cape	3 x Club Recreational SBA Records	%TC in NC and M. mM, monthly/annual CPUE	1938 - 1990 1971 - 1986 1978 - 1992	Bennett et al. (1994)
WC	False Bay	Commercial Beach-Seine Fishery	Mean monthly catch beach-seine hauls	Jan 1991 – Dec 1992	Lamberth et al. (1995a)
WC	False Bay	Commercial Beach-Seine Fishery and Experimental Sampling (beach-seine)	Ab; and Size-Comp	1991 - 1993	Lamberth et al. (1995b)
WC	South -Western Cape	Recreational SBA	Effects DBLs; and Conservation Status	1956 - 1990 1978 - 1992	Attwood and Bennett (1995a)
WC	Saldanha Bay / Langebaan Lagoon	Experimental Sampling (research angling)	Acoustic Telemetry Study (Tracking)	Nov – Dec 2004 (12 days)	Attwood et al (2007)

WC	Berg River Estuary	Recreational SBA	NC; %TC in NC; and Size-Comp	Dec 2002 – Nov 2005	Hutchings et al. (2008)
WC	Saldanha Bay / Langebaan Lagoon	Experimental Sampling (research angling)	Acoustic Telemetry Study (Tracking)	Oct 2005 – Oct 2006	Kerwath et al (2009)
WC	Saldanha Bay / Langebaan Lagoon	Experimental Sampling (research angling)	LHP	Aug 2004 – Oct 2006	Attwood et al (2010)
WC	Saldanha Bay / Langebaan Lagoon	Experimental Sampling (using seine net)	Ab ($NC.m^{-2}$)	1994 – 2012	Anchor (2012)
WC	WC	CL	TC in M (excluding hake, squid and tuna); and %TC in M	2000 - 2010	Duncan and Burgener (2013)
WC and SC	West and South Coast	Commercial Trawl	%TC in M	2000 - 2010	Smith et al (2013)
SC	Agulhas Bank	CL	NC; and %TC in NC for linefishery and Traps	2008 – 2010	Götz et al. (2014)
EC	Algoa Bay	Experimental Sampling (using seine net)	NC; %TC in NC; consistency in catch; and TL	1980 - 1982	Lasiak (1982)
EC	East London – Jeffrey's Bay	Recreational BBA	Catch importance	1978 - 1982	Smale and Buxton (1985)
EC	Great Fish and Kowie Estuaries	Experimental Sampling (using gill/seine nets)	CPUE; FD; and Species Rank	Feb 1981- Feb 1982	Whitfield et al. (1994)
EC	EC	EC CIT	Ab status	1967 - 1995	Booth and Hecht (1998)
EC	Various SE coast estuaries	Experimental Sampling (using seine net)	Ab and RB	Sep 1996	James and Harrison (2011)
EC	King's Beach, PE	Experimental Sampling (using seine net)	NC; consistency species occurrence, %Juv; CPUE; TL	Feb – Aug 2011	Rishworth et al. (2013)

REGION
WC – Western Cape
EC – Eastern Cape
SC – Southern Cape
KZN – KwaZulu Natal

ABBREVIATIONS
Ab – Abundance; **Ave.** – Average; **BBA** – Boat-Based Angling; **BM** – Biomass; **CIT** – Inshore Trawl; **CPUE** – Catch Per Unit Effort; **CC** – Catch Contribution; CL – Commercial Linefishery; **DBLs** – Daily Bag Limits; **Dev Stage** – Developmental Stage; **FC** – Fisher Compliance; **FD** = Fish Density; **Freq** – Frequency of Catch; **GP** - Growth Parameter; **LHP** – Life History Parameters; **M** – Mass; **MM** – Mass Mortality Estimated Count; **mM** – mean Mass; **NC** – Numbers Caught; **NOC** – Number Occasions Caught; **NR** – Numbers Retained; **Prod** – Production; **PS** – Population Size; **PTS** – Preferred Target Species; **PU** – Percentage Undersized; **RB** – Relative Biomass; **Rec** – Recreational; **RR** – Retention Rates; **SBA** – Shore-Based Angling**; Season** – Seasonality; **Size-Comp** – Size Composition; **SFD** – Size Frequency Distribution; **TAngEf** – Total Angler Effort; **TC** – Total Catch; **TL** – Total Length; **TLands** – Total Landings; **TR** – Target Rates; **%Dis** – Percentage Discards; **%Juv** – percentage Juveniles; **%Mat** - % Mature (Above 50% weight-at-maturity); **%OC** – Percentage Occasions Caught; **%Tar** – Percentage Targeted; **%TC** – Percentage of Total Catch.

Appendix 7: Key sources of data consulted on ***White Steenbras*** for this study indicating region, location, and fishery sector/ experimental sampling method concerned; as well as the type of data, and the time period of the study.

Region	Location	Fishery sector/Sampling	Data	Time Period	Source
National	National	Recreational Shore-Based Angling	PTS; TAngEf; CPUE; %TC in NC and M; and FC	Apr 1994 – Feb 1996	Brouwer et al. (1997)
National	National	N/A	Species Status	N/A	Lamberth and Mann (2000)
National	National	N/A	IUCN Red List Status	N/A	Mann et al. (2014)
WC	Bot River Estuary	Experimental Sampling (using gill/seine nets)	SC; Ab; MM	1980-1983	Bennett et al. (1985)
WC	False Bay and De Hoop Nature Reserve	Commercial Beach-Seine Fishery and Recreational Shore-Based Angling	NC; and %TC	1951 – 1968 1977 - 1987 May 1984 – Jul 1992	Bennett and Attwood (1993)
WC	South -Western Cape	3 x Club Recreational Shore-Based Angling Records	%TC in NC and M. mM, monthly/annual CPUE	1938-1990 1971-1986 1978-1992	Bennett et al. (1994)
WC	False Bay	Commercial Beach-Seine Fishery	SC; Ab; NR; PU; CC by sectors (1985-1992)	Jan 1991 – Dec 1992	Lamberth et al. (1994)
WC	False Bay	Commercial Beach-Seine Fishery	Mean monthly catch beach-seine hauls	Jan 1991 – Dec 1992	Lamberth et al. (1995a)
WC	False Bay	Commercial Beach-Seine Fishery and Experimental Sampling (beach-seine)	SC; Ab; and Size-Comp	Feb - Mar 1993	Lamberth et al. (1995b)
WC	South -Western Cape	Recreational Shore-Based Angling	Effects DBLs; and Conservation Status	1956-1990 1978-1992	Attwood and Bennett (1995a)
WC	Berg River Estuary	Recreational Shore-Based Angling	NC; %TC in NC; and Size-Comp	Dec 2002 – Nov 2005	Hutchings et al. (2008)
WC	Knysna and Swarvlei Estuaries	Recreational and Subsistence Shore-Based Angling	TR; SC; %TC; RR; PU; FC	Jul 2008 – Jul 2010	Smith and Kruger (2013)
WC/EC	Tsitsikama NP	Experimental Sampling (research anglers)	mean CPUE in TNP MPA	1998-2005	James et al. (2012)
EC	King's Beach, PE	Experimental Sampling (using seine net)	Ab; Size-Comp; and Diets	1978-1980	Lasiak (1984)
EC	Great Fish and Kowie Estuaries	Experimental Sampling (using gill/seine nets)	CPUE and Species Rank	Feb 1981- Feb 1982	Whitfield et al. (1994)
EC	East Kleinemonde Estuary	Experimental Sampling (using seine net)	GP; PS; BM; and Prod	1994 - 1997	Cowley and Whitfield (2002)
EC	Kei Mouth – Port Edward	Recreational Shore-Based Angling	NC; and %TC	Apr 1997-Jan 1998	Mann et al. (2003)
EC	East Kleinemonde Estuary	Experimental Sampling (using variety gear)	SC; NC; and CPUE	1996-2005	James et al. (2008)
EC	Various SE coast estuaries	Experimental Sampling (using seine net)	Ab and RB	Sep 1996	James and Harrison (2011)

EC	Great Fish, Kowie, Kariega, and Sundays Estuaries	Experimental Sampling (using fyke/seine nets)	SC; NC; and mean CPUE	2009-2010	Wasserman and Strydom (2011)
EC	Great Fish Estuary	Experimental Sampling (using seine net)	Tagging/Tracking Study	29 Sep – 17 Oct 2003	Bennett et al. (2011)
EC	Port Alfred - Robberg	Recreational Shore-Based Angling Competition Records (“Angling Week”)	NC; W; %Mat	1999-2010	Dicken et al. (2012)
EC	East Kleinemonde Estuary	Experimental Sampling (using seine net)	CPUE (fish.haul^{-1})	1996-2010	Bennett et al. (2012)
EC	Kariega Estuary	Experimental Sampling (using demersal otter trawls)	Day/Night SC and NC	Oct-Nov 2007	Bailey and James (2013)
EC	King’s Beach, PE	Experimental Sampling (using seine net)	SC; NC; consistency species occurrence, %Juv; CPUE; TL	Feb – Aug 2011	Rishworth et al. (2013)
EC	Sundays Estuary	Recreational and Subsistence Shore-Based Angling	SC by NC and M; RR; SFD; %TC by sector	Sep 2007 – Aug 2008	Cowley et al. (2013)

REGION
WC – Western Cape
EC – Eastern Cape

DATA
Ab – Abundance; BM – Biomass; CPUE – Catch Per Unit Effort; CC – Catch Contribution; DBLs – Daily Bag Limits; FC – Fisher Compliance; GP - Growth Parameter; M – Mass; MM – Mass Mortality Estimated Count; mM – mean Mass; NC – Numbers Caught; NR – Numbers Retained; Prod – Production; PS – Population Size; PTS – Preferred Target Species; PU – Percentage Undersized; RB – Relative Biomass; RR – Retention Rates; SC – Species Composition; Size-Comp – Size Composition; SFD – Size Frequency Distribution; TAngEf – Total Angler Effort; TL – Total Length; TR – Target Rates; %TC – Percentage of Total Catch; %Mat - % Mature (Above 50% weight-at-maturity); %Juv – percentage Juveniles.