COMMUNITY-BASED NATURAL RESOURCE USE MONITORING

AT THE OLIFANTS RIVER ESTUARY

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Declaration

I, Nadine Soutschka know the meaning of plagiarism and declare that all the work in the 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.

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Abstract

Small-scale fisheries are increasingly seen as complex socio-ecological systems, requiring alternative management approaches. These new approaches to natural resource management advocate the inclusion of resource users in all aspects of management, including monitoring. Research suggests that involvement of local resource users in resource monitoring is beneficial as it promotes local empowerment, community stewardship and contributes to social and resource sustainability.

This study aims to contribute knowledge about the nature and effectiveness of a community-based fisheries monitoring system at the Olifants River estuary in South Africa and documents lessons learned. This research reports on the revision and revitalisation of an existing community monitoring program operating at the Olifants River estuary and presents the results of data gathered from this one year monitoring program. It also compares these results with data gathered from previous years when the monitoring system was operational. Finally, the strengths and weaknesses of the community monitoring system are discussed.

A participatory research approach was followed by employing members of the Olifants River community as catch monitors and working closely with the fishers and monitors to better understand their perceptions of the strengths and weaknesses of the monitoring system. Findings of this research suggest that despite weaknesses in the community monitoring system, the data gathered provided useful information about the catch effort trends for the fishery for the year under consideration and also enabled some comparisons of selected fisheries indicators with previous data to be made. These comparisons suggest that catch per unit effort for the target species, harder (*Liza richardsonii)* is stable and there is no indication of overexploitation of this resource. A key weakness of the monitoring is that it is ad hoc and funding is insecure. Due to poverty levels in the community, local monitors may take up short-term employment opportunities in the community and thus neglect their monitoring responsibilities. This means that the data sets are not comprehensive. Key strengths include the fact that it is simple, cost effective and can be implemented by community members. Furthermore, local involvement in resource monitoring builds capacity and skills as well as local empowerment. Finally, this research contributes to knowledge that can inform the implementation of community monitoring programs proposed by the recently published Small-scale fishing policy of South Africa.

Key Words: Small-scale fisheries; natural resource management; participation, community monitoring, local empowerment

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To my family and friends I extend my gratitude and appreciation for their love and constant support.

"*The world needs monitoring that makes a real contribution to improving natural resource management*"   (Danielsen et al. 2008)


"Die bestaan van die gemeenskap hang van die gesondheid van die rivier af"
Ebenhaeser Fisherman

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Nature and the resources it supplies is the basis of our well-being and prosperity. Ecosystem services such as wood for fuel, freshwater flow and fish for food are provided to people by functional ecosystems. A loss of biodiversity and degradation of land and ecosystems impact all of earth's populations particularly the world's poor who rely most directly on natural resources and services (WWF et al., 2012). Especially in times of scarcity do the poor fall back on natural resources for food and essentially for their livelihood and well-being (Béné and Heck, 2005; Godfray et al., 2010; Kent, 1997a). Fish is a natural resource that is a critical source of dietary protein for many human populations, especially for communities that are poor and isolated (Béné and Heck, 2005; FAO, 2012a). Yet, globally marine resources are overexploited or heading towards overexploitation (FAO, 2012a) and hence an effective management approach is needed. To ensure the fair availability of resources, such as fish for food to current and future generations, resources need to be managed sustainably and equitably. The conventional approach to management focuses mainly on the resource to be managed and relies on command and control to achieve compliance. The conventional approach is largely top-down, centralised and relies on expert knowledge for decision-making. Scholars, managers and resource users are increasingly questioning this approach to resource management as resource degradation, overexploitation, poverty and illegal harvesting persist.

In order to address these problems it has become crucial for managers and decision makers to rethink conventional management and better understand the relationship between people and the natural environment and to integrate this understanding into natural resource management (Berkes et al., 2000). As the demand for and pressure on natural resources increases, novel approaches towards natural resource management are being advocated as a more viable solution (Allison and Ellis, 2001; Armitage et al., 2009; Bellamy et al., 2001; Berkes, 2003; Berkes et al., 2007, 2001; Folke et al., 2005; Kennedy and Koch, 2004; Kessler et al., 1992; Lal et al., 2002; Rammel et al., 2007). These approaches require linking human-ecological systems, understanding their complexity and applying integrated management approaches (Berkes et al., 2001, 2000). The new approach advocates resource user group participation in management. Excluding people from decision-making and management of the resources they use can cause social injustice and unsustainable resource use (Agrawal, 2001; Kessler et al., 1992; Sowman, 2011). Hence, the idea is to involve community members in management initiatives to further encourage the interest of local communities in sustainable use and management of resources. Transnational goals of social justice, environmental health and sustainability are supported through community empowerment and stewardship. Community-based natural resource management (CBNRM) and co-management are thus alternative approaches that addresses some of the shortcomings of the conventional approach (Berkes, 2003; Hauck and Sowman, 2003; J. R. Nielsen et al., 2004).

Small-scale fisheries are an example of a complex socio-ecological system where alternative management that promotes the inclusion of people has shown to be more successful (Allison and Ellis, 2001; Castilla and Fernandez, 1998; M. King and Faasili, 1999; Sowman, 2011). Much of the world population relies on fisheries resource for food and as a source of livelihood (Allison and Ellis, 2001; Allison and Horemans, 2006; Béné, 2006, 2003; Kent, 1997a; Sowman, 2011, 2006). Globally, fish provides about 3.0 billion people with almost 20 percent of their intake of animal protein (FAO, 2012a). In comparison to commercial fisheries, small-scale fisheries directly employ more people, sustain more dependents, catch more tonnes annually for food and have less bycatch (Berkes et al., 2001). Hence, small-scale fisheries contribute to human nutrition, development and poverty alleviation (Andrew et al., 2007; Béné, 2006; FAO, 2012a).

Because of the inherent uncertainty of complex systems such as small-scale fisheries continuous monitoring and evaluation of the system is necessary in order to adapt management approaches and protocols as new information is gained (Folke et al., 2005). Monitoring provides feedback on the state of resources and provides information on how much can be harvested without compromising the future sustainability of the resource. Hence, monitoring of fish stock is essential for effective management of the resource. A further new approach to management recommends rather than applying professional, top down monitoring strategies to encourage the use of locally-based monitors (Danielsen et al., 2005a). To guide the development and expansion of such local monitoring schemes Danielsen et al. (2009a) developed a monitoring protocol that categorises monitoring schemes into categories identified according to the level of local stakeholder and professional scientist involvement. The protocol characterises five different natural resource monitoring schemes according to costs, expertise, accuracy, promptness of decision-making, capacity building and ability to inform national and international monitoring schemes (Danielsen at al. 2009). These schemes offer a basis for developing and applying natural resource monitoring systems at a local, national or international level.

Only recently have small-scale fishers gained national attention in South Africa through the release of the small-scale fishing policy in June 2012 (RSA, 2012). On the West Coast of South Africa there are few small-scale fishing communities that harvest fish from estuaries using gill-nets (Hutchings and Lamberth, 2003; Hutchings et al., 2008a, 2002; Sowman, 2003). Many of these fishers have been engaged in fishing in estuaries as a source of food and livelihood for over 100 years (Williams, 2013). These estuaries are productive systems with high species diversity and abundance and hence provide valuable ecosystem services to society (Van Niekerk and Turpie, 2012). Furthermore, estuaries and associated coastal waters support many essential fisheries such as recreational angling, commercial near shore and subsistence fisheries (Hutchings et al., 2008a). Yet, estuaries are also among the most extensively modified and threatened aquatic ecosystems. As a result, many estuaries are being proposed as protected areas and gill-net fishing, which is considered to be destructive, is being prohibited or phased out (Hutchings et al., 2008a).

The Olifants River estuary on the West Coast of South Africa offers a location where these current issues of resource conservation and livelihood needs are being played out. The surrounding fishing community not only relies on the fishing of *Liza richardsonii* as a means to obtain a livelihood but also consider the practice as a way of life and part of their culture (Huschlak, 2012). Fishers use gill-nets to target *Liza richardsonii,* locally also known as harder, and mostly consume the fish themselves or sell it to the surrounding farming community if there is a surplus. But, as gill-nets are not target specific other fish species are caught. These species are often nationally important angling species and mostly cannot handle high fishing pressure and furthermore use estuaries as nursery grounds. Conservation and fisheries scientists have thus proposed a closure of gill-net fishing in the West Coast estuaries, including the Olifants River estuary to maintain its ecological integrity and provide a refuge for numerous line-fish species (Hutchings and Lamberth, 2002a; Hutchings et al., 2008b). This has caused disputes between the fishing community, marine scientists and management authorities and suggests that an alternative approach to management of the resources is necessary. The new approach to fisheries management, with a strong focus on resource user participation, is being advocated in the recently released small-scale fishing policy (RSA, 2012). Furthermore, as part of effective management, the resource needs to be monitored - preferably with inclusion of the resource users. The small-scale fishing policy proposed the establishment of monitoring programmes where local monitors are appointed to monitor local resources (RSA, 2012 S 4.1.1).

In 1994 the EEU at UCT started a community catch landing monitoring program in the Olifants River estuary. The program aimed at including the resource users for recording catches landed by gill-net fishermen. The recorded data was collected by the EEU/UCT and the stock trends analysed (Carvalho et al., 2009; Fielding et al., 2007; Sowman, 2001). This research aims to revitalise and reintroduce the community-based monitoring system in the Olifants River estuary. For the community monitoring system, monitors record *Liza richardsonii* and bycatch landings in the Olifants River estuary and submit these catch cards to the researcher at the University of Cape Town for analysis. Stock trends of the recent data emanating from this monitoring system and previous monitoring data will be analysed so that a basic understanding of stock trends and fishery indicators may be attained. Furthermore, by employing community members as monitors and by participatory research the monitoring system will be examined and evaluated. Thereby the researcher hopes to contribute to the increased understanding of the strengths and limitations of such community monitoring systems with the aim to develop criteria for robust community monitoring.

1.2 STUDY RATIONALE

Scholars and management practitioners have increasingly recognised the value of involving local communities in natural resource management (Brosius et al., 1998; Cinner et al., 2012;

Danielsen et al., 2005a, 2003; Fraser et al., 2006; Jentoft, 2000; Johannes, 2002; Kellert et al., 2000; Pinkerton et al., 1995; Pomeroy et al., 2001). Cinner et. al. (2012) evaluated 42 co-management arrangements across five countries and showed that, co-management, which included resource users in monitoring was largely successful at meeting social and ecological goals. Fraser et al. (2006) found that the process of engaging people in resource management provided an opportunity for community empowerment that conventional development approaches had failed to provide. Jentoft (2000) argues that although effective resource management is a necessary condition for the viability of communities, viable communities are also an important contribution to the preservation of healthy ecosystems and resources. Hence, he highlights the need to not only manage natural resources regarding only the resource itself but also to incorporate the resource users i.e. the social dimension into resource management. Johannes (2002) highlights the strengths of community-based management and its effectiveness in terms of long term sustainable use. Pinkerton et al. (1995) document success stories of sustainable fisheries from around the world, which apply community-based resources management approaches. Danielsen (2005a; 2003) more closely evaluates the processes of natural resource monitoring and the benefits of involving local resource users and establishes criteria for community involvement in monitoring. Further research highlights that the strength of community monitoring does not lie in detecting trends with a statistical degree of confidence but lies in strengthening local management of land and resources and dealing with threats to resources and ecosystems (Danielsen et al., 2003). This study aims to contribute to knowledge on and application of community natural resource monitoring by focusing on lessons learned from the community monitoring system at the Olifants River estuary in South Africa.

1.3 RESEARCH AIMS AND OBJECTIVE

The overall aim of this research is to assess the strengths and weaknesses of the community monitoring system at the Olifants River estuary. This will be undertaken by analysing the data collected by community monitors at the Olifants River estuary and engaging with the monitors and the fishing-community.

The objectives of this study are to firstly, gather, review and analyse data from the community monitoring system and to evaluate the quality of the data. This research will examine the fishery indicators from data collected by community monitors from 1st September 2012- 31st August 2013. Furthermore, monitoring data from the previous monitoring system intermittently operating from 1994-2010 will be gathered and a continuous database with data from 1994-2013 will be set up. The data will be analysed, fishery indicators will be examined and stock trends will be described. Lastly, using a Participatory Action Research (PAR) approach, the community monitoring system will be assessed. Based on these findings I hope to contribute to improving future implementation procedures and practices of community-based natural resource monitoring programs in the Olifants estuary and elsewhere.

1.4 RESEARCH ETHICS

The researcher ensured that participants in the research had reasonable and sufficient knowledge about the research, the researcher and the research objectives. The project was introduced to the broader fishing community at a fisher workshop and all information relevant to the project was shared and the aim of the research explained. The monitors and researcher were introduced to the fishers and the fishing community by the UCT research team who have been working with the community for the past 20 years and information about the research project was shared with workshop participants. Regular meetings were conducted with the fishing community throughout the research process to keep the fishers informed of the research process and findings. The informed consent of all participants in the research was secured and all participants were given the option to exclude themselves from the study if they so wished. Furthermore, no names of fishermen were recorded on the *Catch Return Cards* (Appendix 1). In view of the participatory nature of this research, the monitors and fishers were considered to be research partners in the research process and information collected from this study was fed back to the broader fishing community. The intention is that information generated from this study may be used to inform the future planning and management of the Olifants River estuary.

CHAPTER 2: LITERATURE REVIEW

2.1. NATURAL RESOURCE MANAGEMENT

2.1.1 Introduction

"The current system of human development, based on increased consumption and reliance on fossil fuel, combined with growing human population and poor overall ***management*** *and* ***governance*** *of natural resources, is* ***unsustainable****."*

WWF Living Planet Report (WWF et al., 2012)

It is well known that the global human population is growing at an exponential rate, and so are its demands on natural resources. This demand on resources is putting pressure on biodiversity, resource sustainability and ecosystem services and hence the future security of human health and well-being is at risk. These demands are not only due to an increased population but are also due to rapid development and hence increased consumption and pressure on resources. People no longer only rely on the natural environment for food and water but have become dependent on other resources such as wood, minerals and extractive fuels. Furthermore, wealthy, developed countries overexploit and grab resources and land of poorer, less developed countries resulting in skewed and unequal distribution of resources (Brookes, 2007; Sowman and Wynberg, 2014). For natural resources to be equally distributed and available for all people of current and future generations they need to be fairly managed.

In an ideal world, access to natural resources needs to be equitable and sustainably managed to avoid Hardin's "tragedy of the commons" (Hardin, 1968). This is the theory that an open access system without adequate management will result in resource overexploitation. It is clear that overexploitation will occur in the absence of management, property rights and ownership. Hence, human actions that impact on the natural environment and lead to overexploitation of natural resources need to be controlled. Therefore, management interventions are required to avoid degradation of natural systems and promote equitable and fair utilisation of resources. Natural resource management approaches vary: on one end of the continuum lies the conventional approach to resource management that adopts a state-centred approach and on the other, a community-based approach to natural resource management (Figure 2). The conventional approach is mostly top-down, technocratic and centralised whereas community-based natural resource management (CBNRM) is a decentralised, bottom up and local approach to management. In between these two ends of the continuum lies co-management, which as the name suggests, is the combined management of resources by state, community and other relevant stakeholders (Carlsson and Berkes, 2005; J. R. Nielsen et al., 2004; Notzke, 1995; Pomeroy, 2001, 1995, 1995; Sowman, 2003).

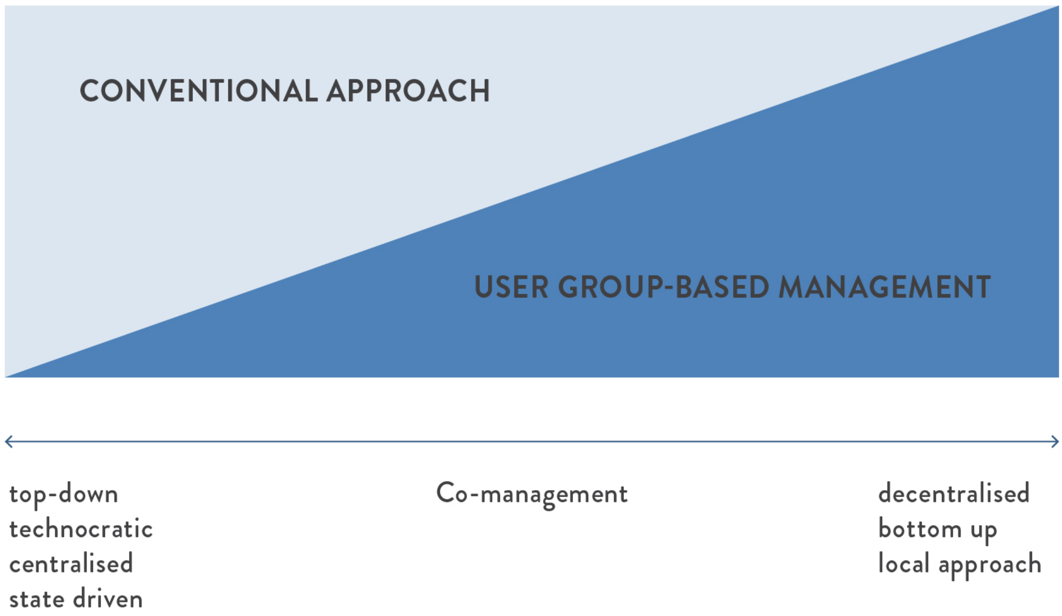

Figure 1: Resource Management Continuum adapted from Hara (2003).

2.1.2. Conventional Approach to Resource Management

A conventional resource management approach is embedded in the utilitarian and exploitive worldview (Berkes et al., 2000; Gill, 1996; Kennedy and Koch, 2004). This management mode is entirely informed by hard science with a mathematical foundation and hence based on the Newtonian reductionist paradigm. This approach to natural resource management seeks to control nature in order to harvest its products, control its threats and establish predictable outcomes for short-term benefits of humanity (Garcia and Charles, 2007; Holling and Meffe, 1996). Hence, the conventional approach to resource management is based on man's domination over nature and assumes the world is predictable and controllable. Control of resources is mostly by central government and hence management is top-down. Furthermore, the state regulates the allocation and use of renewable natural resources by using information from scientists who largely apply Maximum Sustainable Yield (MSY) models to determine sustainable harvesting levels for different species.

The concept of MSY focuses on optimizing benefits of a resource so that maximum yields can be harvested. This approach is a common management practice within the disciplines of silviculture and fisheries (Barber, 1988; Pauly et al., 2002). The idea is to harvest maximum quantities of a species but still maintain biologically sustainable stock levels. However, managing to increase the yield of the most desired product, such as straight growing tree species for wood or single species management of fish, comes first and foremost. The conventional wisdom is that by maximising the yield of the desired goods, exploitation thereof can be increased and hence the good being more profitable. Determining the MSY is based on information derived from stock assessment and is commonly used to determine sustainable harvesting levels of fisheries resource (Berkes et al., 2001). Hence, conventional resource management has largely centred on natural resources, overemphasizing the species in single species models such as MSY (Larkin, 1977; Mace, 2001). Furthermore, the scientific method aims at analysing natural systems objectively and partially in isolation. Based on these analyses scientists inform decision makers on the best management practices to achieve ecologically sustainable resource outcomes.

Critique of the Conventional Approach

The two main criticisms of the conventional approach to natural resource management is the focus on single species and the exclusion of the socio-economic dimensions of natural resource use and management. Ecosystems that are linked to socio-economic systems are extremely complex (Figure 2) and subsequently reducing them to a single species model will not address many of the broader issues. Consideration of natural systems as complex socio-ecological systems requires recognition of the unpredictable and complex nature of these systems and the need to understand the interactions across the many components of the system (Charles, 2004; Holling and Meffe, 1996). Conventional natural science approaches that rely on the predictions from experts and form the basis for much of the advice given to decision-makers, have limited applicability in real world situations (Kay et al., 1999). Socio-ecological systems such as fisheries are in a constant state of flux and subjected to unpredictable external influences, which the conventional approach of resource management does not incorporate. Drawing on other disciplines and knowledge sources thus becomes important for management decisions (Garcia and Charles, 2007)

"Command and control" resource management is limited in a changing and complex setting (Armitage et al., 2008) and many resources are too complex to be governed effectively by a single agency (Berkes et al., 2007). Inclusion of resource users is vital for resource management to be effective and successful. It has been realised that without considering social and economic systems within natural resource management, ecological protection and sustainable resource use is difficult to achieve (Balmford and Cowling, 2006; Holling and Meffe, 1996; Kessler et al., 1992; Rammel et al., 2007). Hence, not only do managers need to be informed by broader ecological processes but should also include social dynamics into their decision-making processes (Berkes et al., 2001, 2000; Kessler et al., 1992). The new approach to natural resource management does not regulate each system in isolation but is open to its complexity and views it as a socio-ecological system (Berkes et al., 2001, 2000).

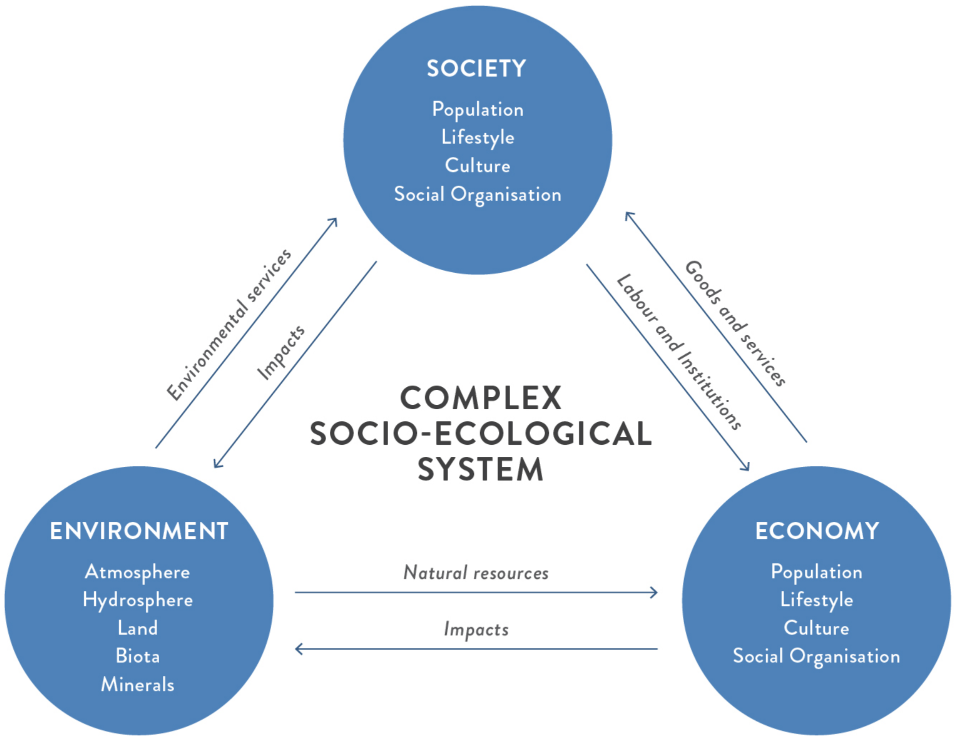

Figure 2: Complex Socio-ecological System.

2.1.3. New Approaches to Resource Management

Increasingly, the use values of natural ecosystems are viewed in a wider context. No longer is an ecosystem only comprised of valuable commodities to support humankind but is also appreciated for its species diversity, aesthetic attributes and its contribution to environmental security for the planet (WWF et al., 2012). Hence, the new approach to natural resource management requires an understanding of the complex, diverse, interlinked and emergent characteristics of socio-ecological systems (Cilliers, 2008; Rammel et al., 2007). The first step towards a more holistic approach is evident in the ecosystem approach to resource management (CBD, 1992; FAO, 2012b; Francis et al., 2007). This management approach is a move away from a single species approach towards incorporating the larger ecosystem. According to the Convention on Biological Diversity (1992) *"The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and* *sustainable use in an equitable way."* Not only does the ecosystem approach focus on levels of biological organisation, which encompass essential processes, functions and interactions among organisms and their environment, but also recognises that humans are an integral component of ecosystems (CBD COP5 decision V/6) and thereby acknowledges linkages between social and ecological systems. The main aim of linking social and ecological systems is for resource managers to include the social needs within ecosystem management. Thereby, the new approach requires consideration of a full array of goods and services supplied by ecosystems and needed by society. Furthermore, within the context of sustainability, management addresses the values and needs of both present and future generations and considers environmental protection in balance with socio-economic development (Charles, 2004; Kessler et al., 1992; Zaccai, 2012). Hence, natural resource management needs to be flexible and adaptive (Armitage et al., 2008; Kessler et al., 1992; Rammel et al., 2007) so that the highest possible array of natural resources is available for current and future generations.

Adaptive management refers to the capability of a system to learn and adapt to changing and uncertain circumstances. For a system to remain resilient it needs to have the capacity to absorb disturbances and reorganize while undergoing changes to still retain essential functions, structures, identity and feedbacks (Walker et al., 2004). The adaptive approach draws explicit attention through experiential and experimental learning to improve the understanding of, and ability to respond to changing socio-ecological systems and foster resilience (Armitage et al., 2009). Overall, in a practical sense achieving sustainable resource use is an interdisciplinary and evolving process that is improved by including wide knowledge, divergent values and needs (Meppem and Bourke, 1999). This new approach to management promotes communication, participation, cooperation and coordination in order to encourage shared responsibility for natural resource management amongst all stakeholders (Fraser et al., 2006; Hauck and Sowman, 2001; Kessler et al., 1992).

In addition the new approach to resource management is a move away from government to governance implying a shared and flexible management arrangement between state, resource users and stakeholders. Governance of resources implies a shared responsibility for devising policy, for preparing management plans, for assessing the likelihood of meeting targets and for auditing performance (O'Riordan and Stoll-Kleemann, 2002). Governance is the interaction among existing structures, processes and traditions that determine how power is exercised, how decisions are taken and how citizens, especially stakeholders are included in decision making and management (Bavinck et al., 2005; Lockwood et al., 2010). The role of government is to encourage interactive problem solving with all stakeholders and allow for co-management of natural resources. Hence, resource users are part of the solution and not the problem (Berkes et al., 2001). Especially important is the inclusion of local resource users in management and monitoring; this arrangement is known as co-management. Co-management is the sharing of power between the state and resource user groups and an integral part of good governance (Pinkerton, 2011).

Co-management lies in between CBNRM and centralised government resource management in the management continuum (Figure 1). Centralised government management approaches have proven inadequate to deal with pressures on resources and hence a partnership between stakeholders is encouraged (Berkes, 2003; Cinner et al., 2012; Hauck and Sowman, 2003). Co-management comes in various forms, depending on the arrangements between the state and other entities such as resource-based communities, individual users and research institutions. The idea of co-management is to move away from a top-down, central management approach to a more bottom-up and inclusive governance approach. The main aim is the inclusion of resource users and other stakeholders in decision-making and sharing of management responsibility. It has been argued that by including resource users in management better compliance and support of regulations will result (Garcia and Charles, 2008; Jentoft et al., 1998; Pomeroy, 1995). The inclusion of resource users subsequently aims at achieving the objectives of sustainable resource use and management as well as empowerment and equitable access to resources and therefore social development. Ultimately, democratic governments should aim at creating societies that are self-sufficient and have little dependence on the state. Especially as communities that are direct resource users, or hence dependant on the resource are often poor and marginalised. Therefore it is important to empower marginalised communities by including them in decision-making and management (Berkes et al., 2007; Colfer, 2005; Zerner C., 1999).

However, there are also questions and criticisms regarding the effectiveness of co-management (Bradshaw, 2003; Jentoft et al., 1998). Firstly, co-management requires trust and partnerships between government agencies and resource users. Where these relationships have been conflicting building these relationships will take time. Another concern regarding the effectiveness of co-management relates to issues of capacity both at the government and community level. Where capacity is limited it may be necessary to involve all partners in capacity development programmes. Furthermore, commitment from government to the co-management process and being willing to devolve certain powers and responsibilities to local resource user groups can also limit the effectiveness of co-management efforts.

At the other end of the continuum lies community-based natural resource management (CBNRM), which is a management approach that devolves decision-making and management to local level (Figure 1). CBNRM is a management effort in response to the resource degradation occurring because centralised management cannot deal with open access regimes and hence vesting local users with rights to manage, use or own resources is a key amendment (Nelson and Agrawal, 2008). Hence, it often is a co-management arrangement that is community led. The idea of CBNRM is through community empowerment and stewardship it is possible to support transnational goals of social justice and environmental health and sustainability (Hulme and Murphree, 2001; Murombedzi, 2001; Murphree, 2004). CBNRM has been advanced as a way of improving social and economic standards of local people with an emphasis on participation (Berkes, 2006; Kellert et al., 2000; Lynch, 1993).

According to Kellert et al. (2000) there are various forms and expressions of CBNRM, yet most share certain characteristics, including:

- Involving community members and local institutions in the monitoring, management and conservation of natural resources;
- Empowerment of local institutions and people by transferring power and authority from central government to communities;
- Capacitate communities so that they can manage resources

- Linking socio-economic development with environmental conservation, protection and sustainable utilisation
- Defending and legitimising local resource use and property rights; and
- Including traditional values and ecological knowledge in resource management.

According to some scholars, one of the main incentives of CBNRM is to revive traditional management practices, which have been eroded as a consequence of economic globalisation and hence market expansion, industrialisation, centralised power and alterations in lifestyles, consumption patterns and rights (Brosius et al., 1998; Cinner et al., 2012; Kellert et al., 2000; Nielsen et al., 2004). The main objective of community resource management is to reconcile rural poverty alleviation with biological diversity conservation and sustainable resource extraction. While CBNRM will be appropriate in certain contexts, increasingly co-management or co-governance is considered as a the most promising mode of governance since it draws on the strengths, knowledge and capacities of government, resource users and other stakeholders (Hauck et al., 2002; Pomeroy, 1995).

2.2 NATURAL RESOURCE MONITORING

Because of the inherent uncertainty of complex systems continuous testing, monitoring and re-evaluation is necessary to advocate adaptive management of social-ecological systems (Folke et al., 2005). The knowledge attained by monitoring feeds into managing practices strengthening the adaptive approach. Monitoring provides feedback and synthesizes the observations into a comprehensible understanding of the situation now and how it might unfold in the future. As social-ecological systems are intricate with many systems within the system (Figure 2) monitoring itself needs to be approached holistically. Hence, monitoring is multifold ranging from monitoring social and economic indicators to monitoring natural resources variables. As the focus of this project is on natural resource monitoring, only this form of monitoring will be elaborated on.

Ecological information collected over extensive periods provides valuable insights into changes in ecosystem structure, ecological processes and the services that ecosystems provide

(Lindenmayer and Likens, 2010). Variables to be monitored can range from direct resource assessments of for example a fish stock, to assessing the impact of a conservation intervention (Danielsen et al., 2005b). Resource monitoring is an integral part of natural resource management and has been defined as the systematic measurement of variables, processes and changes over time and space (Spellerberg, 2005; Yoccoz et al., 2001). In principle, natural resource monitoring provides data that describes the state of a resource at a site at a certain time. Different types of information may be collected and may include data on species composition, distribution and abundance, biology and the surrounding environment. Furthermore, information on how data was sampled or collected is vital as data monitoring should be repeatable and standardised for rigorous results to be obtained. The data may be used for guiding natural resource management and/or as a basis for scientific inquiry. For resource managers the main objective of natural resource monitoring is to evaluate the state of the resource or ecosystem and to determine the levels at which these resources may be sustainably exploited (King, 2013). Governments require monitoring data for management and decision-making and have recognised the need to include stakeholders in these processes (Conrad and Hilchey, 2011). In many countries resource monitoring is a key requirement in natural resource management laws. Without monitoring, resource managers cannot make educated decisions regarding management of resources.

However, mostly the goal of monitoring for management differs from the aim of scientific monitoring (Holck, 2008; Yoccoz et al., 2001). The aim of monitoring for resource management is to evaluate the state of the system and to provide information for decision-makers on appropriate management action whereas the aim of scientific monitoring is to understand the behaviour and dynamics of the ecological systems (Danielsen et al., 2005c). Hence, monitoring efforts and collection approaches will differ depending on the answer monitoring is to provide. According to Holck (2008) conventional biodiversity collection approaches by professional scientists are often considered irrelevant by local managers. Furthermore, professional monitoring is often far more costly and therefore not sustainable for resource managers in developing countries (Danielsen et al., 2009b, 2005b; Holck, 2008; Sheil, 2001). To improve management strategies and sustainable resource use in developing countries local participation of communities and resource users is encouraged (Cinner et al., 2012;

Danielsen et al., 2007; Getz et al., 1999; Jentoft, 2000; McCay and Jentoft, 1996; Pomeroy, 1995). A form of the co-management arrangement is the inclusion of resource users in monitoring, not only to encourage environmental democracy but also to tighten the link between the resource user community and the management of the resource. This requires the development of simple and cost-effective yet reliable and robust monitoring tools that are able to detect trends and can be used by community members without scientific training and most importantly by local and national natural resource managers.

Like natural resource management, natural resource monitoring also comes in various forms and approaches. The monitoring spectrum mirrors the natural resource management continuum: the top down, centralised, professional-research-executed monitoring approach on one end and the decentralised, bottom-up, locally-based monitoring at the other end of the spectrum (Figure 3). The co-management approach usually involves local data collectors but the design of the monitoring system, analysis of data and management of data may be externally driven. In the case of co-management and CBNRM the participation of resource users in all phases from problem identification, data collection and analysis, evaluation of options and decision-making has been identified as a crucial component of the new management approach (Sowman, 2011).

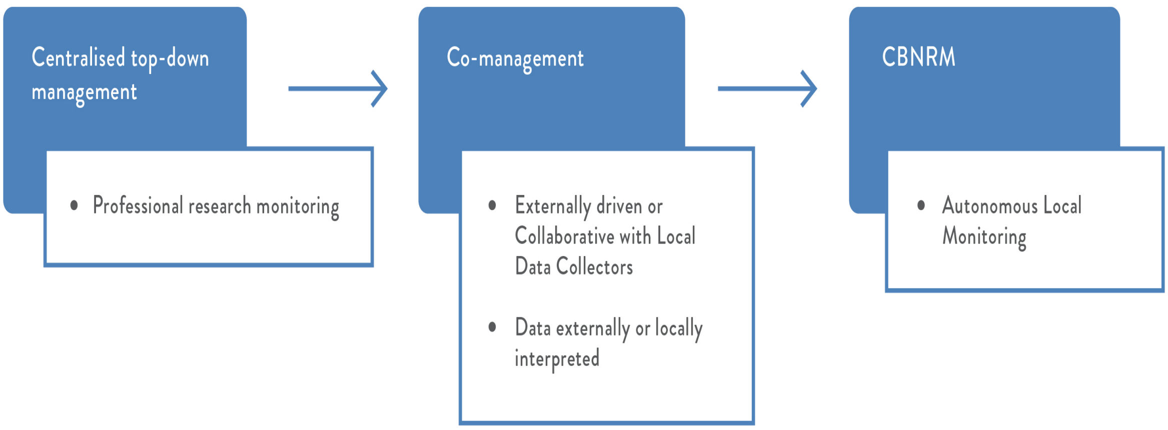

Figure 3: The Monitoring Spectrum adapted from Danielsen et. al. (2008).

Although most widely used, monitoring conducted by professionals can be very costly and exclusive (Caughlan and Oakley, 2001; Danielsen et al., 2005a, 2003). Many developing countries have major problems establishing monitoring schemes as funds are extremely limited and biodiversity and resource monitoring does not have the highest funding priority (Dinesen et al., 2001; Uychiaoco et al., 2005). However, lack of funding and limited professional capacity should not result in lack of monitoring as this information is required to detect, understand and reverse declines in natural resource values (Poulsen and Luanglath, 2005). Especially in countries where state funding is limited and local empowerment encouraged, local stakeholder participation in resource monitoring can be highly beneficial (Holck, 2008). Therefore, involvement of local resource users in natural resource monitoring schemes should be further explored and encouraged.

To guide the development and growth of monitoring schemes Danielsen et al. (2009a) developed a monitoring protocol that categorises monitoring schemes into categories identified according to the level of local stakeholder and professional scientist involvement. The 5 categories span the spectrum of management protocols where *Category 1* is centralised, professionally driven monitoring and *Category 5* is autonomous local monitoring. Furthermore, Danielsen et al. (2009) characterised the 5 categories of monitoring according to criteria ranging from costs, accuracy and precision, promptness of decision-making, potential of enhancing local stakeholder capacity, and capacity to inform national and international monitoring schemes (Table 1). The 5 categories and characteristics are given below.

Table 1: The characteristics of 5 different categories of natural resource monitoring schemes taken from Danielsen et al. (2009).

	Characteristics[a]							
Monitoring Category[b]	*cost to local stakeholders*	*cost to others (outsiders)*	*requirement for local expertise*	*requirement for external expertise*	*accuracy and precision*	*promptness of decision making*	*potential for enhancing local stakeholder capacity*	*capacity to inform national and international monitoring schemes*
Category 1	*	***	*	***	***[c]	*[d]	*	***
Category 2	**	**	**	***	***	*	*	***
Category 3	**	**	**	***	***	*	**	***
Category 4	***	*_***[e]	***	**_***[f]	**	***	***	**
Category 5	***	*	***	*	*	***	***	*

[a] *Key * low, ** intermediate, ***high*
[b] *Monitoring categories are defined in the text*
[c] *Especially in developing countries, local people may be needed for locating and identifying (e.g. tracks of) wildlife species*
[d] *An exception is remote-sensing schemes that detect, for example, forest fires in near real time and potentially may allow for almost immediate decision making*
[e] *Recurrent costs to nonlocals low, set-up and training costs to nonlocals high*
[f] *Recurrent requirements for nonlocal expertise intermediate, during set up/training requirements for local expertise high*

Category 1: Externally Driven Professional Monitoring

Professional monitoring is mainly externally driven and does not involve any local stakeholders. Monitoring is undertaken by professional scientists funded by external agencies such as central government, NGO's or international organisations. This form of monitoring is common in developed nations where funding is more readily available. Professional monitoring is mostly undertaken on a large scale, is complicated and difficult to sustain (Danielsen et al., 2003). External agents carry all the costs. Should funding be terminated then monitoring will cease to be undertaken. Furthermore, external expertise requirements are high and therefore need to be readily available. The information collected by scientists under this model does not result in prompt decision-making as it firstly needs to be analysed, discussed and evaluated by the management authority. This form of monitoring often pertains collecting data to establish MSY and hence is based on the conventional approach to resource management. Examples of this monitoring scheme can easily be found and include national and international monitoring programs such as water-quality monitoring, forest cover monitoring, fish stock monitoring and game counts.

Category 2: Externally Driven with Local Data Collectors

In this category the design of the monitoring program and analyses and interpretation of the data are undertaken by professional researchers. Local stakeholders are involved only in data collection. In developed countries, volunteers often collect the data whereas in developing countries data collectors are paid for their time. Data collectors need to have species identification expertise, must keep records and follow the prescribed methodology with procedural rigour. The scheme is vulnerable to bias due to lack of experience, changing methods and observer perceptions being reflected in the results (Danielsen et al., 2005b). Hence, the degree of accuracy and precision is variable and comparisons of data collection methods should therefore be done if available. As local stakeholders are only involved in data collection, decisions will not be made at speed but have to follow the same chain as for *Category 1*. Capacity building will be limited to the data collectors, but a change in attitude towards environmental management by community members may result depending on the engagement with the community. An example of this form of monitoring scheme is the data collection in the Bangweule Swamps in Zambia where literate professional fishermen were selected to carry out part of a sampling scheme in parallel with an experimental gill-net survey undertaken by scientists (Ticheler et al., 1998).

Category 3: Collaborative Monitoring with External Data Interpretation

In the category, local people are the data collectors and also participate in management-orientated decision-making on the basis of the results of monitoring. Similarly as in *Category 2,* data collectors require significant biological expertise and procedural rigor. Although data is interpreted externally, decision-making regarding appropriate management interventions are faster than *Category 1 and 2* as there is an additional need to make prompt decisions and so potential government bureaucracy is bypassed (Danielsen et al., 2005c). As data collectors are knowledgeable about the resource state they have a role to play as informants to the community and resource managers. An example of a *Category 3* monitoring scheme comes from Madagascar where local communities collected data on key species and natural resources which are then externally analysed and interpreted (Andrianandrasana et al., 2005). Further examples include *Liza richardsonii* and bycatch monitoring by community members in South Africa (Carvalho et al., 2009), fishermen collecting data in Kenya and Tanzania (Obura et al., 2002) and community monitoring in the Philippines (Uychiaoco et al., 2005).

Category 4: Collaborative Monitoring with Local Data Interpretation

Local stakeholders are involved in data collection, interpretation or analysis, and management decision making with optional advice and training from external scientists. The data collected remains in the area of collection and hence creates local ownership of the monitoring scheme and its results. An example of this scheme is provided by community-based monitoring of Philippine Protected Areas (Danielsen et al., 2009a, 2005c). The monitoring was intended to identify trends of important biodiversity assets and use these to guide management action. The data interpretation was undertaken locally and a report compiled by local members was presented to the management council. Local expertise therefore needs to be high due to the need to select relevant methods, interpret data and make management decisions. Although this model requires skilled and educated monitors it does not exclude resource users from participating, as any community member could be trained. External expertise may still be required before the scheme can function independently. Another example of this monitoring scheme is the Event Book System of the CBNRM programme in Namibia, which differs from conventional monitoring in that the community dictates what needs to be monitored, and scientists only facilitate the design process and conservancy members undertake all data analysis (Stuart-Hill et al., 2005). Other examples include the community-based monitoring of the Philippine Protected Areas (Danielsen et al., 2005c) and forest use monitoring in montane forest in Tanzania (Topp-Jørgensen et al., 2005).

Category 5: Autonomous Local Monitoring

This monitoring scheme is at the other end of the spectrum as the whole monitoring process is carried out by local stakeholders. This includes designing the monitoring system, collecting data, analysing and interpreting data and using the information to inform management decisions. These monitoring schemes are typically part of traditional or customary systems of resource management with local stakeholders having full control of resources and hence the monitoring leading to prompt decision-making. Examples of autonomous monitoring schemes include an Inuit customary conservation regime in the Arctic (Ferguson et al., 1998), communal management in Indonesia (Mantjoro, 1996), sustainable harvesting management in Mexico (LaRochelle and Berkes, 2003) and traditional marine conservation practices of the Pacific Islands (Johannes, 1978).

2.2.1 Choosing an Appropriate Monitoring Scheme

It must be realised that different monitoring systems are suitable in particular contexts. Yet, overall experiences and research suggests that the involvement of resource users in monitoring positively contributes to sustainable resource management (Danielsen et al., 2009b, 2007, 2005a; Fraser et al., 2006; Rijsoort and Jinfeng, 2005). Although *Category 1* schemes can be executed anywhere they require a guaranteed source of funding due to the salaries that need to be paid to professional researchers. *Category 2* is useful in a setting where there are skilled volunteers or funds to pay monitors to collect data. *Category 3 and 4* will only be supported if there are benefits to local stakeholders and hence are most appropriate where local communities have an interest in natural resource use and sustainable management. The success of community monitoring highly depends on its context. The ecology, history, politics, institutional arrangements and current socio-economic state of the community each play a role as to whether community monitoring and hence management will thrive or not (Blaikie, 2006). The main strength of community monitoring is the direct link between the outcome of decisions based on monitoring and decision-makers. Hence, within community monitoring the ecological integrity is more directly linked to social choice and therefore the potential for prudent, flexible and sustainable resource management is more attainable (Bradshaw, 2003; Kellert et al., 2000).

Danielsen et al. (2008) created a key to identify the category of a natural resource monitoring scheme, based on the role of local and professional researchers (Figure 4). However, it needs to be highlighted that the goal of community involvement is not purely to attain data but also to achieve broader goals such as seeing the results used in decision-making about natural resource management, participation and empowerment, skills development, and building trust and partnerships between communities and management agents (Sowman, 2003). Furthermore, the nature and quality of data needs to be considered in view of available capacity, and the subsequent monitoring systems designed such that it incorporates local capacities in its design (Sowman, 2011). *Category 5* schemes cannot be influenced from the outside but can be supported by encouraging their continuation. The data emanating from such systems may not be valuable for external agents but may be useful to a localised monitoring system and contributes to local decisions that promote sustainable resource harvesting.

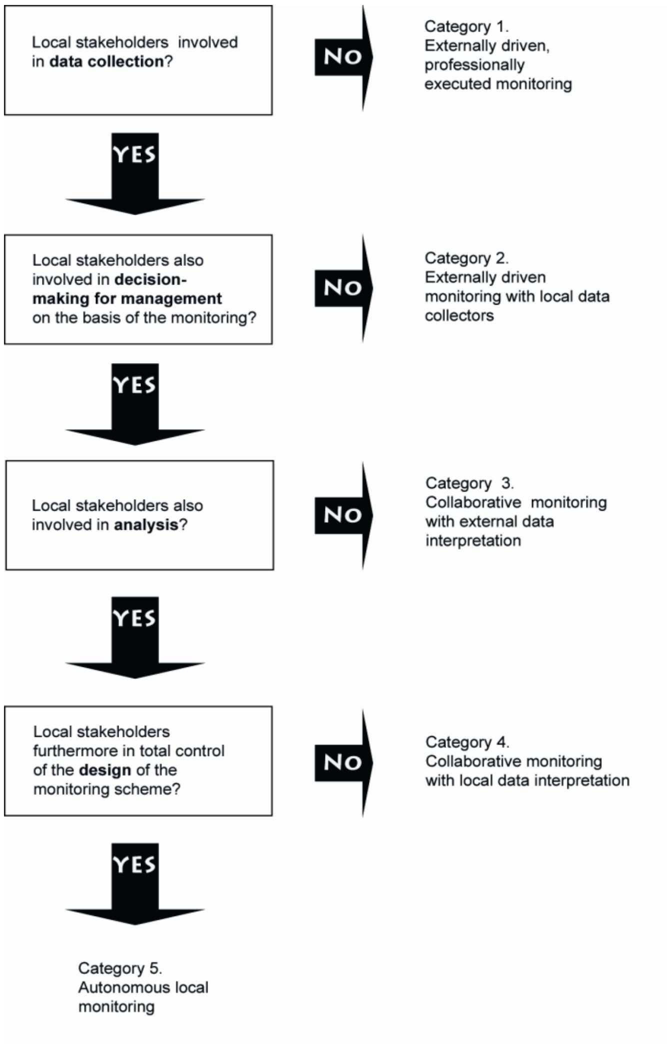

Figure 4: Key from Danielsen et al. (2008) to identify the category of a natural resource monitoring scheme.

2.2.2 What needs Monitoring?

The majority of the world's countries, as parties to the Convention of Biodiversity, are obliged to monitor biodiversity according to article 7 in the convention (CBD 1992). Furthermore, resources that are used but regenerate need to be monitored so that harvesting pressures can be equated with regeneration capacity and ultimately that sustainable resource use be attained. Hence, within natural resource ecosystems functioning and processes, species diversity and abundance and other physical indicators need to be monitored.

In fisheries, monitoring of fish stock abundance is an important part of the fisheries management process. According to the Food and Agricultural Organisation of the United Nation (FAO) monitoring within fisheries is defined as *"the collection, measurement and analysis of fishing activity including, but not limited to: catch, species composition, fishing effort, bycatch, discards, area of operations, etc."* Fisheries managers use the data to arrive at management decisions such as setting quotas. Hence, if the information is unavailable, inaccurate or incomplete then managers are incapacitated to make and implement management measures.

In South Africa, the large scale commercial fishery sector has received adequate management attention with many of the commercial species such as hake, anchovies and sardines being monitored and managed by the state (Cochrane et al., 1998; Johnston and Butterworth, 2005; Payne and Punt, 1995). This management entails professional monitoring procedures, and analyses integration to inform decision-making. However, the small-scale fishing sector in South Africa has largely been ignored by state fisheries management authorities and has only recently received increased attention through the promulgation of a new policy to manage the sector (DAFF, 2012).

2.3. SMALL-SCALE FISHERIES AS A SOCIAL-ECOLOGICAL SYSTEM

Fisheries are often seen as an example of the "tragedy of the commons" due to their characteristic of being a common pool resource (Berkes et al., 1989). Hence, generally marine living resources are considered to belong to all because of the open access nature of the resource. However, due to the blurred boundaries of fisheries their management becomes challenging. Issues being faced by fisheries managers are embedded in economic, ecological and social realms ranging from local to global scales. Recently there has been a shift in the fisheries management approaches that link ecological with social dimensions (Berkes et al., 2001).

Fisheries themselves can broadly be divided into three sectors: commercial large-scale, recreational and the small-scale fisheries. As it is more lucrative, the commercial fishery receives more attention and therefore is more organised, structured and centrally managed. However, more recently the small-scale fishing sector has received increased attention as resource managers and decision-makers realise the importance these resources play in food security and livelihoods (Kent, 1997b; Pauly et al., 2005).

2.3.1 Definition and Scope

No universal definition of small-scale fisheries exists and other terms such as subsistence and artisanal are often used interchangeably (McGoodwin, 1995; Sowman, 2006). As name suggests, small-scale fishers are people who harvest marine resources on a small scale, hence their catch per fishing unit tend to be medium to low. Small-scale fishers includes both fishers who harvest marine resources for their own and their family's consumption and fishers who sell or barter their harvest locally (Berkes et al., 2001). These fishers traditionally employ low technological or passive fishing gear with labour intensive methods and operate in and around near shore fishing grounds (Berkes et al., 2001; DAFF, 2012; Sowman, 2006). Small-scale fishers mostly form a family or community group, especially in a rural setting. However, lone operators can be found in urban areas (Sowman et al., 2011). Small-scale fishing communities are mostly part of the middle to low income sectors of society and often have other occupations.

Small-scale fishers are predominantly found in developing nations, especially in tropical areas (Cinner et al., 2012; King and Lambeth, 2000). They tend to exploit a variety of small stocks distributed over many different management areas and therefore have a wide range of organisational levels. Hence, they target a higher variety of species than commercial fisheries (Berkes et al., 2001). According to Andrew et al. (2007) small-scale fishers make an important but poorly quantified contribution to regional and national economies. The Food and Agriculture Organization, estimates that 90% of the 38 million fishers and fish farmers in the world are small-scale, collectively harvesting half of the world's fish catch for consumption, and that 135 million are directly or indirectly employed in small-scale fisheries and aquaculture (FAO, 2005). Hence, small-scale fishers contribute to human nutrition, development and poverty alleviation (Andrew et al., 2007; Béné, 2006; FAO, 2014). If associated livelihoods such as processing and marketing are taken into account many individuals, including woman and children, depend on small-scale fisheries indirectly. In comparison to commercial fisheries small-scale fisheries directly employ more people, sustain more dependents, catch more tonnes annually for food and have less bycatch (Berkes et al., 2001). Yet, these fisheries have not attracted much attention from scientists and government agencies historically although this is changing as the value of the sector is being acknowledged. Because these fisheries occur in developing nations and contribute to the livelihood of the rural poor, they need attention and organised management. Furthermore, because fishing activities vary between countries and regions each small-scale fishery needs to be defined within each socio-cultural and economic context.

2.3.2 Problems being faced by Small-Scale Fisheries

The most prominent problem being faced by small-scale fisheries is the overexploitation of resources. Fisheries worldwide are in a state of crisis (FAO, 2012a; McGoodwin, 1995; Pauly et al., 2005, 2002). Many coastal fish stocks have been harvested in excess far beyond their sustainable yield, effecting not only people but also ecosystems as a whole. Due to being a common-pool resource the commercial overexploitation of fish stocks affect small-scale fisheries. Small-scale fishers often do not have the option of migrating to further fishing grounds due to their use of non-mechanised equipment and limited capital. This often puts pressure on inshore resources; furthermore, in many countries no formal management system for small-scale fisheries exists. The lack of management within small-scale fisheries themselves can lead to unsustainable resource exploitation. However, there are many examples within small-scale fisheries where common-property regimes do not necessarily result in overexploitation (Dyer and McGoodwin, 1994). These examples are sites where customary systems still operate or where communities are organised and common property is co-managed (Berkes et al., 2001; Cinner et al., 2012; Dyer and McGoodwin, 1994; Michael King and Faasili, 1999). In contrast commercial fisheries are largely top-down, state operated or under private property regimes with few examples of community involvement in management and decision making (Martin, 2001).

Another issue within the small-scale fisheries sector that creates conflict is use and access rights to the resources. Everyone wants a "piece of the pie", which in a formal centralised system gets granted via quotas and hence fishing rights or permits may be issued (King, 2013). The number of permits and/or quota allocated is usually a reflection of the available yield that can be harvested. On a sustainable yield basis this is usually based on stock assessments carried out by scientists. Access to the fishery as an individual, company or community is usually granted via a fishing right, unless it is an open access system. For each resource a total allowable catch (TAC) and/or total allowable effort (TAE) may be established and rights holders are granted their annual TAC or operate under the TAE system. Predominantly rights allocation has focused on allocating rights to the commercial and recreational fisheries sector and omitting the rights and needs of small-scale fishers. Yet, permitting systems vary in different locations, with areas where no official permits are issued being common within traditional fishing communities. Charles (1995) commented that through the creation of local management institutions, the support of government and collective community action resource stewardship and effective compliance can be created. Hence, in those situations a collective rights approach may be more appropriate.

2.3.2 Managing Small-Scale Fisheries as a Social-Ecological System

As mentioned above, in most countries wild marine living resources belong to the people of the country and are managed by the state for the benefit of all citizens. A healthy fishing industry is one in which the primary resource users are able to sustain a decent standard of living and the resource is sustainably exploited (Berkes et al., 2001). Hence, the interest of the resource user needs to be considered while ensuring that the fishery system as a whole is sustainable. Fisheries management needs to incorporate the human dimension by linking the management of social and ecological systems (Sowman, 2011). Fisheries are managed through a variety of arrangements ranging from central management predominantly found in commercial fisheries to co-management and community management found in small-scale fisheries.

Fish Stock Assessment and Sustainable Exploitation

One of the first steps of successful fisheries management is to gain an understanding of the fish stocks (Figure 6) and subsequently determine how much can be sustainably harvested. A well-managed fishery should not lead to human induced resource crashes. However, while the need to control fishery exploitation has been recognised it is only recently that the limitations on what is possible through management have emerged and the "fallacy of controllability" has been realised (Charles, 1995). None the less, in most commercial fisheries control is executed by quota management. To know how much stock and hence total allowable catch (TAC) and total allowable effort (TAE) may be allocated some form of monitoring must be conducted. Conventional approaches have management objectives in the form of maximum sustainable yield (MSY) which will inform catch quotas (King, 2013; Larkin, 1977). Hence, the natural resource trends inform management and in turn can be adapted to respond to changes (Figure 6). However, shortcomings of the single species approach that ignores larger ecosystem processes, and secondly overlooks the human aspect of fisheries has been widely documented (Charles, 1995). Management needs to be adaptive and this requires monitoring on an ongoing basis. Hence, if there are signs that the fish stock are declining then management needs to adjust its quotas to ensure the resource remains sustainable (Figure 5). If changes in the natural system occur, management needs to be responsive enough to adjust to these changes. These are benefits of an ecosystem approach to fisheries management. Furthermore, the system is more responsive if the resource users are included in the monitoring and management of the resource.

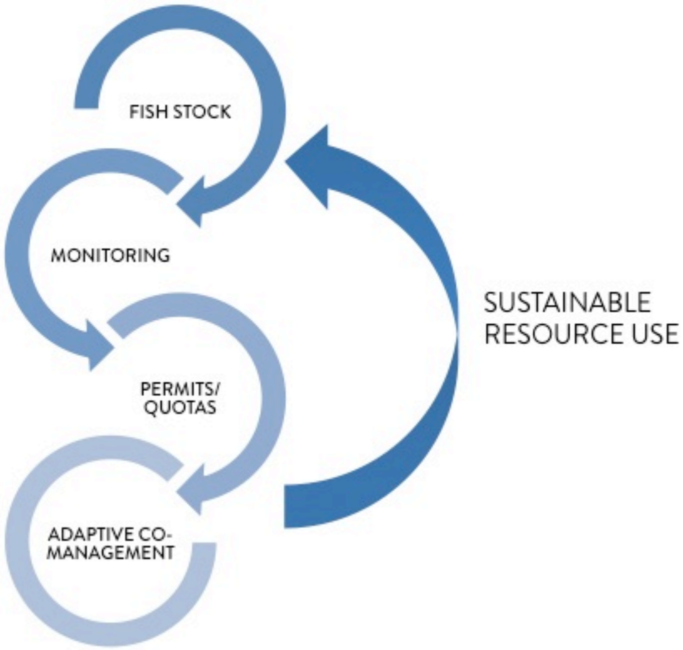

Figure 5: Sustainable resource use is achieved through adaptive management. Management is adaptive if monitoring of fish stock takes place.

Inclusion of Resource Users in Fisheries Management

As highlighted in Section 1.2 "New approach to resource management" the new trends in resource management promote a move away from conventional, top-down and technocratic approach to a more holistic, integrated approach and participatory approach. This approach is to include the social or the human dimensions and create integration between human and ecological systems within the fisheries context. Co-management and community-based resource management are both forms in which the participation of resource users and stakeholders is integrated within fisheries management. The ultimate goal of user participation within small-scale fisheries is community empowerment through decision-making and sustainable resource use (Berkes et al., 2001; Charles, 1995). 2.2.3 Small-Scale Fisheries in South Africa

History of Small-Scale fisheries

South Africa's coastline is very diverse, stretching from the cold west coast bordering Namibia to the warm east coast of Mozambique. This dynamic biophysical environment has generated complex socio-ecological relations along the South African shoreline for millennia. The socio-ecological resource management systems that have been developed differ along the coastal regions. The past political system, the transition to democracy, the drive for economic growth and customary histories has shaped current small-scale fisheries management or lack thereof.

The period 1890-1939 marked the onset of industrial fishing in South Africa. A demand for canned crustaceans in Europe created a boom of canned rock lobster export but after 1920 the industry was crippled by a shortage of raw material caused by profligate fishing practices (van Sittert, 2003). This prompted the relocation of factories from the Cape to the West Coast and the motorisation of fishing fleets. Road improvements and hence better transportation resulted in the integration of the fishing industry into a single market and hence the start of an industrialised, central market of a fast growing and potentially lucrative industry. In the early 1930's the State introduced the individual quota system as a way of allocating rights to high value species mainly found in the productive Benguela current in the west coast of South Africa. A few commercial companies gained access to these resources, which resulted in the "privatisation" of the marine commons (Sowman et al., 2011). In 1935 the Sea Shore Act was promulgated which recognised the President as the custodian of the shore and sea. This further ensured state control of marine resources (Bavinck et al., 2014). Furthermore, the Sea Fisheries Act aimed to fully industrialize the fisheries and increase the competitiveness of “white” fishers in the global market[1]. Hence, during apartheid small-scale fishers had no rights as these rights were mainly allocated to white fishers (van Sittert, 2002) . In the Western and Northern Cape increased restrictions on traditional fishers’ steadily eroded customary systems of access and use rights (van Sittert, 2003). The government’s aim was to bring traditional fisher communities under the control of the industrial sector, which dominated the fisheries sector in the North and Western Cape (van Sittert, 2003). The individual quota system was introduced with the state

[1] “White” refers to an ethnic group whose ancestors are of European origin

providing funding for infrastructure development and the Fisheries Development Corporation supporting modernisation efforts (van Sittert, 2002). During this period the international interest in the fisheries sector increased, which led to the proclamation of the Economic Exclusive Zone (EEZ) in 1977. This fisheries management system relied on the conventional top-down approach to managing marine resources and hence the local, on the ground system of decision-making and accountability was lost (van Sittert, 2003).

In 1998 the Marine Living Resource Act (MLRA) was promulgated, which for the first time in South Africa gave subsistence fishers legal recognition (Sowman, 2006). The objective of the Act was to balance economic stability, ecological sustainability and social equity (MLRA S2). Equity was to be achieved through redistribution of access rights, internal transformation of industry and recognition of subsistence fishers (MLRA S2(f) and S19). The MLRA aimed to "restructure the fishing industry to address historical imbalances and to achieve equity within all branches of the fishing industry" (DEAT 1998). The Act assured the previously disadvantaged and marginalised groups equitable access to marine resources by declaring coastal areas for their exclusive use (MLRA S19) and creating a sector limited to subsistence fishers (DEAT, 1998). However, no official management strategy was in place, which resulted in government recognising the need to appoint a Subsistence Fisheries Task Group (SFTG) to advise on future management of small-scale fisheries (Sowman, 2006).

The SFTG firstly defined and identified subsistence fishers, including their activities and the resources they gathered, and were able to document their socio-economic profile (Clark et al., 2002). They also recommended the creation of a new sector-a limited commercial sector. However, ultimately resource suitability and sustainability determined whether subsistence fishers gained access to resources (Cockcroft et al., 2002; Sowman, 2006). The SFTG compiled a recommended list of resources suitable for the four fishing sectors: subsistence, small-scale commercial, commercial and recreational. The identification of the small-scale commercial sector was based on the work of the SFTG, since their research highlighted that the category 'subsistence' as defined in the MLRA (1998) was too restricted and failed to recognise the thousands of resource users that were operating along the coast as small-scale fishers. According to the SFTG the extent to which access would be broadened depended on what resources would be made available and how rights were going to be allocated. A further important recommendation was in regard to management approaches. Communication and consultation with fishers and managers was promoted, as this approach would address the aspirations and needs of the fishers and the experiences of managers would be incorporated into management recommendations (Harris et al., 2002; Hauck et al., 2002). However, by the mid 2000's many traditional small-scale fishers had not benefitted from the new fisheries dispensation under the MLRA.

In the early 2000's, the state fisheries management branch Marine and Coastal Management (MCM), introduced various policies in order to allocate user rights to both offshore and inshore fisheries on a long-term basis (DEAT; 2005). This included issuing of individual permits to commercial fishers and the allocation of resources to a new category of fishers labelled 'limited commercial' which targeted small-scale fishers and focused on resources such as West Coast Rock Lobster, line fish and rocky-shore and intertidal invertebrates (Cockcroft et al., 2002). The limited commercial right was allocated for four years to selected or registered associations through an application process where rights had to be verified. This application process was complex and hence largely excluded many of the traditional small-scale fishers (Isaacs, 2006). Therefore, many small-scale fishers did not gain access to their traditional fishing grounds and hence the application and verification process was regarded as illegitimate by several fishers.

After ten-years of democracy small-scale fishers were still mostly marginalised and poor (Sowman, 2006). Sowman (2006) identified some of the key problems of South Africa's approach to small-scale fisheries management. Firstly, the definition or classification of small-scale fishers needed to be more inclusive and the implementation more consistent. Secondly, the small-scale fisheries sector should be prioritised over the commercial and recreational sector as small-scale fishers depend on resources for their livelihoods. Access to fisheries resources also needs to be in-line with the South African Constitution (such as equality S9, right to food S27 and freedom of trade S22) and international obligations relevant to fisheries management such as the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). A further major problem has been the allocation of individual rights and failure to recognise the communal nature of many traditional fishing communities. However, Sowman (2006) cautioned that communal rights allocation would only work if there is geographic and social clarity of the community and if the level of organisation amongst the fishers is cohesive. Lastly, a major problem facing small-scale is the sectorial nature of its management. Sowman (2006) argued that management needed to recognise the complexity and diversity of the sector and for its management to involve other government departments. This is supported in international literature that calls for a move away from a resource centred approach to a more holistic livelihoods approach (Allison and Ellis, 2001; Charles, 1995; Sowman, 2006).

When the NGO Masifundise began working with small-scale fishers in the Western Cape in 1999, there were high levels of frustration due to difficulty in accessing the sea and its resources. This was despite the introduction of the MLRA which aimed to address injustices of the past and promoting transformation in the industry. Furthermore, it appeared that the fishing rights allocation policy (DEAT; 2005) was prioritising the rights of commercial fishers at the expense of small-scale fishers. It was only in 2007 that small-scale fishers began agitating and demanding their right to marine resources. Their agitation was further fuelled when due to the collapse of many linefish species (Griffiths, 2000), government reduced the numbers of permits allocated to traditional line fishers. The exclusion that was felt by small-scale fishers led to a class action by traditional fishers against the Minister responsible for fisheries (SCA Case no: 437/2005 Equality Court no: EC1/2005f). Based on evidence presented, the high court ordered the Minister to prepare a policy that would develop "*a new legislative and policy framework to accommodate traditional fishers more effectively" (*Kenneth and others v. Minister). Furthermore, it was ordered that the framework must take the socio-economic rights of fishers into account and ensure equitable access to marine resources for them (Kenneth & others v. Minister Paragraph 8). The judge also ordered that while the policy was being developed, interim relief must be given to *bona fide* traditional artisanal fishers in South Africa.

The procedure of preparing the policy for the small-scale fisheries sector was slow but meaningful process as it included the voice of the traditional fishers and therefore was culminated in a policy that was broadly supported (Sowman et. al.; 2014). In June 2012 the 'Policy for the Small Scale Fisheries Sector in South Africa' was released (RSA, 2012). This policy "*recognizes that traditional/artisanal fishers were excluded from the long term rights* *allocation process under the General Policy on the Allocation of Long term Fishing Rights, 2005, and the effect that this had on Small Scale fishing communities. It provides a mechanism for allocating fishing rights to Small Scale fishing communities and ensures equitable access to marine living resources for these communities*" (SSF Policy S2).

Current Management of Small-Scale Fisheries Sector

Marine resources are identified under the Constitution as a national competence (S24) and fall under the responsibility of the Department of Agriculture, Forestry and Fisheries (DAFF). Marine resources are regulated in terms of the Marine Living Resources Act (Act No. 18 of 1998). This Act brings the Constitutional imperative to "*protect the environment and secure the ecologically sustainable development and use of natural resources while promoting justifiable economic and social development*" into reality since it needs to balance redress and stability in the industry with resource sustainability. To provide a legal framework for the implementation of the Small-Scale Fishing Policy (2012) and the measures it introduces, the Marine Living Resources Amendment Bill of 2013 was made public. However, according to the Amendment Bill "*the development of the Small Scale Fishing Policy has taken place within a very challenging and complex context".* The challenge arises as long-term fishing rights have already been allocated and as a result there are limited resources available for allocation to small-scale fishing communities. The State realises that small-scale fishing communities are faced with high levels of poverty, unemployment and food insecurity (MLRA Memorandum on Amendment Bill 2013) yet must be catered for. Thus, the State has an obligation to give effect to the court ruling and to therefore implement the small-scale fishing Policy (Kenneth & others v. Minister). Through the adoptation of the MLRA Amendment Bill of 2013 by the South African Parliament, the state recognised the rights of small-scale fishing communities and provided a legal framework to address their rights and needs. The critical issue now is how to redistribute resources to the small-scale sector in a manner that is equitable and fair and does not result in legal action from current commercial rights holders. Although the small-scale fishing Policy requires a radical shift in management to a more holistic approach there are still many challenges that need to be addressed.

Importantly there is a need to adopt an interdisciplinary approach to fisheries management and recognise the value of local and indigenous knowledge. Furthermore, participation of fishers in all aspects of policy-making and management are seen as key principles of this new approach. In certain situations the application of community-based monitoring systems can play an important role in informing management decisions and promoting support of management systems. The key challenge is how to proceed with implementation of the Policy in a manner that reflects the intention of the policy.

Participation and Monitoring

A general principle of the small-scale fishery Policy is to "*promote the effective participation in policy development, management and decision-making"* (DAFF; 2013 S 3.1 (j)). Further, the small-scale fisheries Policy proposed a shift away from past management approaches to one that emphasises the involvement of the fishers in decision-making and management of marine resources. To achieve this objective the policy establishes mechanisms and structures for a community-based approach to harvesting and managing marine resources (DAFF; 2013 S 4.1.1). Hence, the policy calls for the shared responsibility or co-management of marine living resources between government and small-scale fishers.

The Policy proposes the establishment of monitoring programmes where local monitors are appointed and integrally involved in the process. The information captured by the monitors will facilitate the continuous re-assessment of resource management plans and allow for appropriate responses to changes in resource trends (DAFF; 2013 S 4.3.2). DAFF is aware that training for monitoring and recording of catches must be provided and further proposes the identification of designated landing sites where strict measures for local community-based monitoring and catch recording can be instituted (DAFF; 2013 S 5.1.2.). According to the policy, monitoring and recording of fisheries data will form part of technical control measures so that appropriate management measures can be identified. Implementation of these requirements of the policy is still being worked out.

Small-Scale Fishers of the Olifants River Estuary

On the west coast of South Africa the Olifants River forms a productive estuary where currently a community of small-scale fishers harvest marine resources using gill-nets. Management authorities have largely ignored the community and their fishing practice with only recently DAFF opening communication and including the community in decision-making and management. However, in the late 1990's a monitoring project was initiated through a research initiative of the EEU/UCT. It was realised then that it is important to have data available in terms of the information about the state of the resource. Monitoring and management of resources is especially important in a highly contested and crucial ecosystem as estuaries.

2.4. ESTUARIES AS A COMMUNAL NATURAL RESOURCE

2.4.1 Biophysical Characteristics and Ecological Importance

Estuaries are formed at river mouths, in the narrow boundary zone between land and sea. They form a gateway between ocean and rivers and therefore shape a dynamic physical environment. The oceanic water input is primarily driven by the tides, while the freshwater input is dependent on the rainfall catchment areas of the rivers. Although estuaries are largely physically dominated ecosystems they are known for being highly productive and performing important ecological functions. Estuaries and their many habitats provide a home for a great diversity and abundance of wildlife species, supporting high levels of biodiversity both locally and seasonally (Day et al., 2013). Estuaries support a variety of residential as well as migratory bird, fish and invertebrate species and provide nursery and feeding grounds for marine and freshwater fish (Coetzee et al., 1997; Lamberth and Turpie, 2003; Maree et al., 2003). Many species are dependent on estuaries as they utilise the unique habitats for parts of their life-cycle, as foraging grounds and for protection.

Sea grasses, salt marshes and mangroves are vegetation types commonly found in estuarine habitats (Barbier et al., 2010; Day et al., 2013). As primary producers they provide food and protection to species such as scallops, shrimp, crabs and juvenile fish. Due to tightly packed plant structure these habitats become inaccessible to larger fish and hence provide ground for increased growth and survival of young fishes, shrimp and shellfish. Because estuaries act as nursery grounds for many juvenile fish species they are an integral part of many fishes life cycle, including pelagic marine species. Therefore, estuaries make an important contribution to productive fisheries (Day et al., 2013;Lamberth and Turpie, 2003). Estuaries play a key role in productive fisheries not only by providing safety to juveniles but also by providing feeding grounds. Coastal lagoons and estuaries are overall more plentiful than other ecosystems in terms of fisheries yield due to high primary production (Day et al., 2013). Primary production in estuaries is high due to availability of organic matter from river input and vegetation and fast remobilisation of nutrients due to shallow water. Furthermore, velocity and volume of water exchange between the sea and estuarine system directly affects fish production via fish recruitment. However, estuarine fish stocks tend to be highly varied due to seasonality, fresh water input, shallow sills preventing recruitment and predation.

2.4.2 Human Utilisation and Impact

Human habitation along estuaries dates back tens of thousands of years. Since early ages humans have utilised and prospered from estuarine environments. Initially the abundance of food attracted settlements to estuarine sites (Barbier et al., 2010; Day et al., 2013; Lotze et al., 2006; Worm et al., 2006). Later, protected river mouths offered favourable locations for commerce and transportation. Presently, many large cities such as New York, London, Cairo and Calcutta border estuarine systems (Day et al., 2013). Human activities include water extraction, habitat transformation, pollution and overexploitation are threatening the integrity of estuarine systems. Globally, many estuarine and coastal ecosystems are functionally degraded or being degraded at an accelerated pace (Barbier et al., 2010; Worm et al., 2006). This degradation has been accompanied by a loss of species or a reduction in estuarine dependant populations (e.g. (Whitfield, 1998). According to Day et al., (2013) and Lotze et al., (2006) human impacts have destroyed over 95% of sea grasses and wetland habitats worldwide, degraded water quality and accelerated species invasion. Furthermore, the study found that 90% of formerly important species, which are species selected on their economic, structural or functional significance, have been depleted (Lotze et al., 2006). However, the deterioration of estuarine systems does not only compromise its ecological integrity but also the services estuaries deliver to the human population.

Estuaries provide valuable benefits, goods and service to society. The broad definition that has been adopted for identifying the ecosystem services provided by natural environments is from the Millennium Ecosystem Assessment (MEA, 2005) that states "ecosystem services are the benefits people obtain from ecosystems". This implies the contribution of nature to human kind via a variety of goods and services, which can be classified under three different categories: (1) Direct "goods" such as wood, food, water and genetic material (2) "Services" which can be regulatory services such as water purification and erosion control and indirect services such as recreation and tourism benefits and (3) cultural benefits such as education, spiritual revitalisation and heritage values (Barbier et al., 2010; Worm et al., 2006).

Regulatory services of estuaries include protecting the coast from erosion, wave and storm surge and acting as water filters and direct services include supplying people with food such as fish, crabs, scallop and oysters (Barbier et al., 2010). Estuaries contribute towards fisheries in both coastal and estuarine zones (Lamberth and Turpie, 2003). As mentioned above estuaries provide nursery grounds for fish species, which are later harvested by people. Therefore, commercial, recreational and subsistence fisheries gain from a healthy estuarine environment. In addition, numerous subsistence or small-scale fishers rely on estuaries as a major source of food, income and contribution to their livelihoods.

Further, benefits to people include recreation, tourism, transportation, education and research. Because estuaries deliver an array of services to a diversity of people and nature, it is important to realise that estuarine management should be multifarious. Although it is important to protect estuaries due to their ecological importance, its management needs to not only consider the estuarine ecological integrity but also socio-economic dependencies (Barbier et al., 2010). Although estuarine protection is important and of national and global concern it needs to be balanced with local rights and needs as many estuaries provide many people with food and an income. Local communities should not bear the brunt of conservation efforts but should benefit from such efforts. Hence, livelihood dependence on estuaries needs to be addressed alongside consideration of protection and conservation of estuaries. The greater societal benefits associated with ecosystem protection needs to be balanced with local community benefits.

2.4.3 Estuaries in South Africa

The South African coast can roughly be divided into three climatological regions into which estuarine features are placed (Allanson and Baird, 2008). The subtropical region spans the area from Mozambique until the Mbashe River in the Eastern Cape, the warm temperate region stretches from the Mbashe River to Cape Point in the Western Cape and the cool temperate region comprises the west coast. According to an analysis by Whitfield (2000) there are about 258 functioning estuarine systems found in South Africa. In the recent National Spatial Biodiversity Assessment, (Van Niekerk and Turpie, 2012) concluded that the overall health of South African estuaries is relatively good. A total of 28% of estuaries are in excellent condition and 31% are in a good condition. However, 43% of estuarine ecosystems are threatened, which represents 79% of total estuarine area. Furthermore, only 33% of South African estuaries are well protected and 59% have no protection at all with 83% of the area of ecosystem types not protected (Van Niekerk and Turpie, 2012).

Much like the rest of the world, South Africa is developing at a fast pace. Development has its accompanying challenges of which environmental degradation is high on the list. In general, the condition of South African estuaries is deteriorating due to human activities (Allanson and Baird, 2008; Turpie, 2004). Habitat alteration, resource overexploitation, changes in water quality and quantity and other factors are compromising the integrity of estuarine systems. As most of the country is semi-arid, to keep up with population demands many inter-basin water transfer schemes and large dams have been implemented. These dams have consequences on river systems and hence effect the ecological integrity of estuaries. According to the Water Act, a reserve, which consists of the basic human needs reserve and ecological reserve, must be determined (NWA 36 of 1998 S 16). The ecological reserve relates to the water required to protect the aquatic ecosystem of the water resource (NWA 36 of 1998 Part 3). Yet, freshwater flow requirements have only been established for 12% of estuaries (Van Niekerk and Turpie, 2012). As estuaries are the last to receive water from rivers it has serious implications for their well-being. Furthermore, most of South Africa's coastline is rugged and has very few sheltered embayments. Therefore, direct pressure on estuaries is increasing due to their favourable location for human habitation and development. Therefore, for estuarine ecosystems to be conserved and sustainably used, human impacts and activities need to be managed and regulated.

Estuarine management is complex and governed by a variety of departments, from national to local level. At a national level the management of the estuaries falls within the Department of Environmental Affairs (DEA) mandate but the Department of Water Affairs (DWA) and the Department of Agriculture Forestry and Fisheries (DAFF) also have responsibilities in terms of water quality management and fisheries management. However, this poses certain difficulties as management functions are split across numerous departments. The range of governance actors has led to confusion in terms of roles, responsibilities and mandates and has subsequently led to poor management of coastal and estuarine resources (Glavovic, 2006). Hence, cooperative governance with an integrated approach is essential for management to be effective. Only recently has the adequate management of estuaries in South Africa been prioritised (DWEA, 2013; Lamberth and Turpie, 2003; Turpie, 1995; Turpie et al., 2004). The National Environmental Management: Integrated Coastal Management Act (Act No 24 of 2008) requires integrated planning and management of South African estuaries in accordance with a National Estuarine Management Protocol (NEMP; GZ 36432). This Protocol has only been gazetted on 10 May 2013, and aims to provide guidance for the adequate management of individual estuaries through the development and implementation of environmental management plans (EMP's) (DWEA, 2013). The NEMP framework follows an adaptive management approach, which requires the setting of a vision and resource objectives, the development of strategies, implementation, monitoring and an assessment of the results.

South African government agencies realise that estuarine management is complex not only because estuaries are part of marine, riverine and terrestrial ecosystems but also because they provide a vast array of socio-economic services. It has been realised that estuaries need to be managed holistically with considerations to both ecology and socio-economic dimensions. Therefore, vertical and horizontal governance plays an important role. For successful protection and conservation all disciplines and stakeholders need to be considered and integrated into management decisions. Hence, due to estuaries supporting livelihoods of many South African citizens, decision-makers need to broaden and incorporate human needs and rights into management plans, policies and programs. Furthermore, to balance ecological and socio-economic objectives the plans, policies and programmes need to be equitable, fair and all-inclusive. In South Africa many small-scale fishers are reliant on estuarine resources for food as part of their livelihood and hence form an integral part of estuarine systems. Therefore, they too need to be included into estuarine management plans.

The Olifants River Estuary

The Olifants River estuary holds a high conservation status due to its biological importance (Van Niekerk and Turpie, 2012). Like many estuaries worldwide and in South Africa the Olifants River estuary is being utilised extensively by people. Water is extracted for agriculture and human needs, recreational and small-scale fishing takes place, water is potentially polluted by human activities and the estuary is used for recreational purposes such as bird watching. Hence, environmental monitoring of the Olifants River estuary is essential for management to be effective and hence was chosen as a study site. The Olifants River estuary is further discussed in Chapter 3

2.5 CONCLUSION

For natural resources to be available for current and future generations they need to be actively managed. It is especially important to sustainably manage resources that people depend on directly for their survival and livelihood. Fish is a widely harvested natural food source that many poor and marginalised people depend on (FAO, 2012a; Pauly et al., 2005). Yet, many fish resources are overexploited and the people and communities that depend on them threatened. Hence, management of the resource is essential not only to ensure the survival of the natural resource but also the survival of the people that depend on it. Conventionally natural resources have been managed with a top-down, state and science driven approach. This approach does not seek to include the wider needs of the resource users and hence fails to address the social and ecological sustainability of the resource together with its users (Berkes et al., 2001). The new approach to natural resource management is holistic and calls for the inclusion and involvement of resource users in all management aspects. Co-management of natural resources is a management arrangement between state and local users (Armitage et al., 2009; Hara, 2003; Hauck and Sowman, 2003). Resource monitoring is an integral part of resource management and participation of resource users in monitoring a co-management arrangement which allows for the involvement of resource users in management and decision-making.

In South Africa resources such as wood, water and fish are managed by state departments such as DAFF and DWA. However, many departments are under capacitated to fully manage all resources successfully. Especially within the small-scale fishing sector there is a need to include resource users in management. This need has been addressed by the recently released small-scale fishing Policy (DAFF, 2012). Furthermore, for resources to be sustainable now and in the future they need to be monitored and the monitoring linked to decision-making (Danielsen et al., 2007). Human impact on estuaries is apparent and ranges from direct impacts such as fishing and indirect impacts such as water abstraction and pollution. Fishing in the estuarine and nearshore environment has clear impacts on the structure and functioning of estuarine ecosystems (Blaber et al., 2000). Hence, estuaries are important ecosystems that need to be monitored to ensure their continued ecological functioning. The fishing communities living along the Olifants River have fished with gill- nets in the estuary for many years. As their current livelihood is threatened due to changes in the ecological and social systems, integrated management of the socio-ecological system is needed. One of the first steps for successful management is an understanding of the system by ongoing monitoring. This research explores the limitations and strengths of community resource monitoring by introducing a monitoring project in the Olifants River estuary of South Africa and analysing the fishery indicators that emanate from it.

CHAPTER 3: OLIFANTS ESTUARY STUDY AREA

3.1. BACKGROUND

The Olifants River rises in the Cederberg Mountains in the Western Cape and is the second largest river system in South Africa. The river is approximately 285 km long with a catchment area of 46,220 km^2 and flows into the Atlantic Ocean on the west coast (Figure 6). Most of the catchment area lies in a winter rainfall area and there are numerous dams along the river supplying water to the surrounding agricultural lands and towns. The biggest dam along the Olifants River is the Clanwilliam Dam located approximately 140 km upstream from the river mouth. Due to increasing demand for water in the Western Cape, raising of the dam wall has been proposed and approved by government (GG 35667 in GN 741 of 2012). The upper reaches of the river are very fertile and support numerous productive farmlands such as vineyards. The estuary lies in an area of low rainfall and less fertile land, yet it is ecologically rich and therefore an important system to conserve (Turpie et al., 2004). The upper regions of the river are regarded as being relatively stable, whereas the lower regions are dynamic with channels changing their course during a flood (Morant, 1984; Turpie, 2004). The estuary is experiencing increased pressure from human activities such as water pollution and abstraction (Lamberth and Whitfield, 1997), potentially unsustainable fishing practices (Hutchings and Lamberth, 2002a, 2002b) and threat from invasive fish species and development.

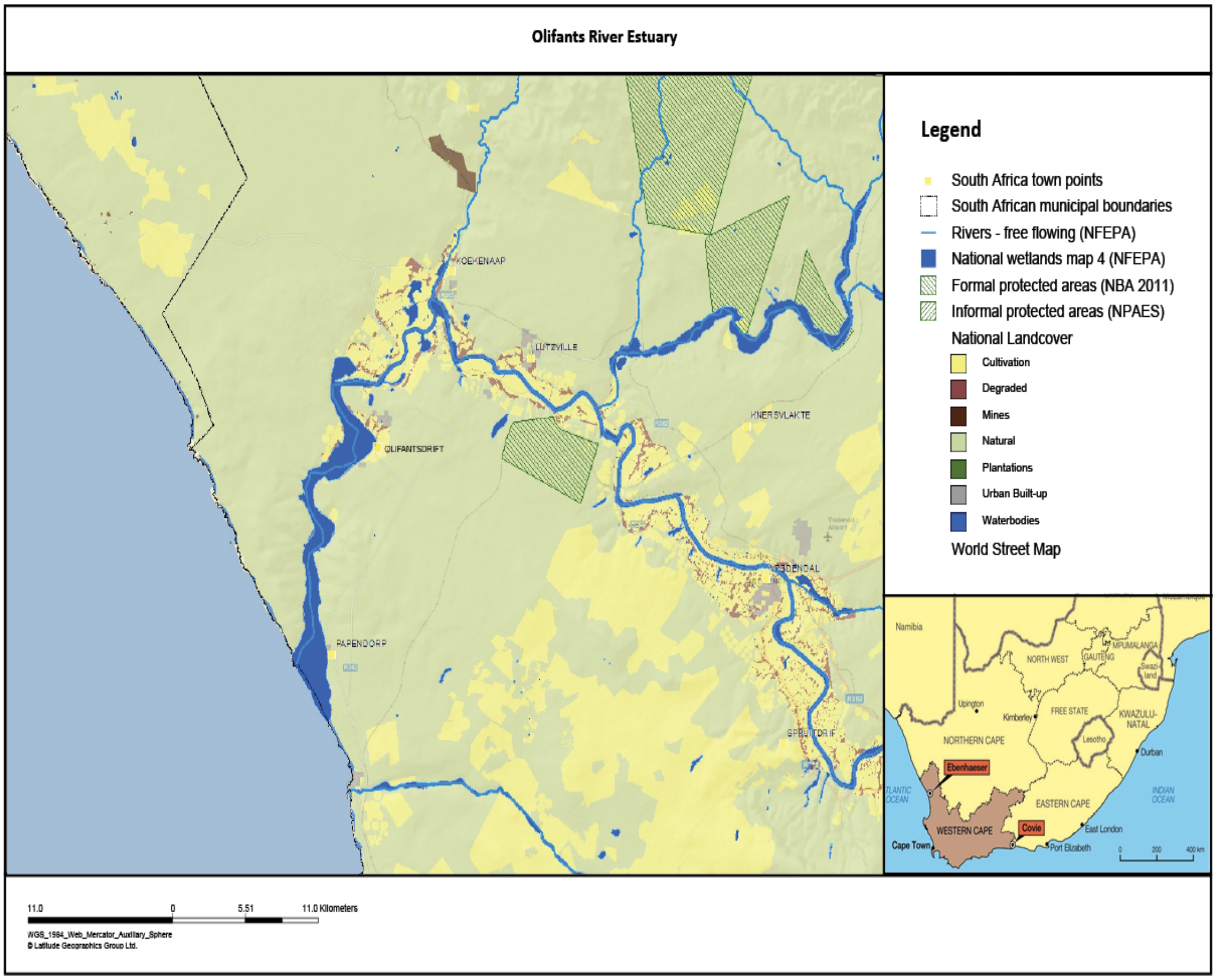

Figure 6: Map of the Olifants River Estuary.

3.2. BIOPHYSICAL AND SOCIAL OVERVIEW

3.2.1 Ecological Significance of Olifants River Estuary

The Olifants estuary holds a high conservation ranking due to its size, rarity, habitat and biodiversity importance (Turpie et al., 2004). It is one of two permanently open estuaries in the cool temperate west coast zone, feeding into the productive Benguela Current, and is still mostly pristine and undeveloped. The estuary has strong tidal and salinity fluctuations which influences the ecology of the river. It is an important nesting and feeding site for many bird populations, and used as a watercourse for both freshwater and marine species. The estuary acts as a sheltered, protected environment which many fish species use as nursery grounds (Lamberth and Turpie, 2003). Important linefish species such as elf (*Pomattomus saltatrix)*, west-coast and white steenbras (*Lithognathus aureti, Lithognathus lithognathus)* and stumpnose (*Rhabdosargus globiceps)* use estuaries, such as the Olifants Estuary, as part of their life-cycle.

Other important species such as *Liza richardsonii,* breed in the sea but a large number of juveniles enter the protective environment of estuaries along the South African coastline (De Villiers, 1987). Although, *Liza richardsonii* does not depend on the estuary for its survival, they benefit from the favourable conditions that estuaries offer. *Liza richardsonii* locally known as "harder", feed mainly during the daylight on highly nutritious particles but seem to feed on whatever is available (De Villiers, 1987; Marais, 1980). Female harder dominate the larger size classes, although no evidence has shown that females grow faster (De Villiers, 1987). Harder reach sexual maturity at just over three years or around a fork length of 220mm, although 50% reach maturity level at 210mm. On the West Coast harder spawn mostly in summer and are sexually inactive in winter (De Villiers, 1987). *Liza richardsonii* are most abundant in estuaries of the west and south coast during spring through to autumn. This is most likely a response to rainfall pattern as harder tend to leave estuaries when salinity is decreased. As estuaries play a vital role in the life cycle of many fish species they ultimately influence the fish stock in the adjacent coast and ocean. Because the Olifants River estuary contributes significantly to the fishery productivity of the region it is of not only regional but also of national significance.

3.2.2 Socio-Economic Context

The first people to permanently settle in the Olifants River estuary area in the 17th century were the descendants of the indigenous 'Khoi-San' people (Parkington, 1977) . During the 1800s many missionary parties came to South Africa to establish missionary stations and in 1837 the Rhenish Missionary Society established a mission in Ebenhaeser (Williams, 2013). The idea of the station was that people living there should be involved in farming and fishing and therefore become self-sufficient.

In the year 1925, the Ebenhaeser community was resettled from fertile land along the Olifants River (then called Ebenezer near present day Lutzville) to land located along lower reaches of the river. The land downstream is less fertile and the water from the river largely saline, which resulted in a substantial part of the community changing their subsistence activities from farming to fishing (Sowman, 2004). The current community consists of descendants of the families that were evicted from original Ebenezer and of additional people that have since settled on the land. The greater Ebenhaeser consists of five different settlements along the Olifants River. It is an Afrikaans-speaking rural community and the population for the greater Ebenhaeser comprises of 1723 people (Williams, 2013). Papendorp (Figure 7), which is located near the river mouth, and Olifantsdrift (Figure 7) are villages from where most fishing activity takes place. Infrastructure, shopping, banking, health and education facilities in Ebenhaeser are limited and economic centres are located in larger towns. Hence, people residing in Ebenheaser have to travel at least 20km to obtain various goods and services.

The fishing community comprises approximately 100 families and is largely poor and dependent on the fish resource for their food and livelihood (Carvalho et al., 2009; Sowman, 2003). Members of the community that are not involved in fishing rely on other employment such as seasonal farm work, factory work, tourism, subsistence farming and government grants. However, fishing forms an important part of the communities' heritage and cultural practices (Huschlak, 2012). Furthermore, currently the community is involved in a land claim process. Due to their unjust relocation in the mid-1920s, they are laying claim to land and/or compensation in terms of the Restitution of Land Rights Act 22 of 1994.

3.2.3 The Harder Fishery: an Ecological-Social Interaction

Small-scale fishers of the Olifants River target *Liza richardsonii,* also known as southern mullet or 'harder', using gill-nets (Lamberth et al., 1997). The fish is mainly caught for their own consumption but when catches are good, the fish is sold locally; hence it is categorised by government as a small-scale fishery. Currently, DAFF issues 45 permits for gill-net fishers each year. Each permit holder is allowed one crew member, which raises the number of legal fishermen to 90 (Carvalho et al., 2009). However, the crew member is only allowed to catch fish if accompanied by a permit holder. Fishing predominantly takes place at night, to decrease the visibility of the nets. However, fishing is prohibited from the river mouth to 1 km upstream at a location locally known as 'die Baken' (NCO of 1972 P 357). The harders are caught using gill-nets that are set out from small wooden rowing boats. These nets either drift downstream or are set and are checked every few hours. If catches are good the nets remain in place and if no fish are caught they are re-set to another location. Total allowable effort (TAE) is controlled by gear restrictions. One net is allowed per boat with a maximum length of 45m and depth of 5m with stretched mesh size of 48-64mm (Permit condition, 2007). There are no restrictions on numbers of harders caught, i.e. no total allowable catch (TAC) restrictions. As part of the permit condition the permit holder must record all catches of the day in so called 'blue books'. Although other species are not directly targeted, they do end up in the nets as bycatch. According to permit conditions bycatch, which is all other species besides harder, must be thrown back if unharmed or surrendered to the DAFF official, who confiscates the catch. However, most of the fishers do not relinquish bycatch as it is mostly already dead and regarded as an important food source. This causes conflict among recreational anglers and gill-net fishers because many important linefish species are caught as bycatch (Hutchings and Lamberth, 2002a).

As fishermen mainly fish at night they land their catches in the early hours of the morning, often before sunrise. If catch yield is high, the fish is salted (sometimes on the boat) and dried. This product is locally known as 'bokkoms'. Fish are mainly consumed by the household or sold within the fishing community. Hence, fishing is primarily for food and forms a key livelihood of this community. If yield is exceptionally good fish is sold to local farmers or taken to surrounding towns such as Vredendal or Lutzville to be sold.

Picture 1: Fishermen from the Olifants River estuary community with their catch and the rowing boats they use on the estuary (photos by J. Miller).

3.3. MANAGEMENT AND MONITORING

The management of the Olifants Estuary has gone through many changes since the 1990's. Many of these changes are concurrent with the political transformation and reordering of democratic South Africa. These changes are evident in the past and current management arrangements as well as future management proposals for the estuary.

3.3.1 Past Management

Prior to 1995 the management of the estuary was under the control of the provincial administration, which in the Cape Province was under the provincial Department of Cape Nature Conservation (CNC) (Sowman, 2003). The rules for managing the Olifants Estuary during those times were set out in the Cape Nature Conservation Ordinance of 1965. However, most of the regulations were decided by CNC and were not always based on sound scientific evidence nor input from fishers. Rules and regulations such as permit numbers and net dimensions were often made *ad hoc* with no explanation given to resource users. For example mesh size and number of permits issued were changed without linking biological conditions such as status of fish stock to these changes (Sowman, 2003). Law enforcement was carried out by officials of CNC. Fishers who were undertaking any illegal activity were fined or taken to court or imprisoned (Sowman, 2003).

In 1993, the fishers from the Ebenhaeser community approached the Environmental Evaluation Unit (EEU) at the University of Cape Town (UCT) asking for assistance in deteriming the possible reasons for the perceived decline in harder stocks in the estuary. After an initial site visit and dicussion with fishers and CNC officials, it appeared as though the decline in fish catches could be attributed to the increase in legal mesh size introduces two years before. In view of the lack of catch data it was agreed that information on the catches was useful (Sowman, 2003). Consequently, together with the managing authority at the time CNC, a co-managment project was inititated (Sowman, 2003). The objectves of the project, which were supported by the community were to: (1) develop a community-based catch monitoring system in order to obtain reliable information of fish catches and hence status of the stock, and (2) to facilitate the development of a co-management system that included the resource users in decision-making and managment of the resource (Sowman, 2003). This project lead to the establishment of a community monitoring system in 1996 (see section 3.3.3)

In 1995, the management of estuaries was transferred from provinicial to national government under the MLRA. Marine resources were declared a national competence under the South African Constituition (Act 108 of 1996) and the Department of Environmental Affairs and Tourism were charged with management of marine resources in terms of the Marine Living Resource Act (MLRA) 18 of 1998. During the transition phase management was left to CNC until 1999 when its responsibilities and powers ceased with respect to management of marine resources in estuaries. The change in government management structure left an institutional vacuum as the new managment authority, namely Marine and Coastal Managment (MCM) of the Department of Environmental Affairs and Tourism (DEAT), had no clear system to manage estuarine resources or strategy to engage with resource users. Consequently the co-managment arrangements that had been developed in the mid 1990s collapsed and the top-down management continued. After MCM too over the management of the estuary, the monitoring project managed by the EEU continued for set periods 1994-1997, 2000-2001 and 2004-2006 when funding for monitors was secure. During the period 1999 to 2012, MCM had little engangement with the fishing community with approximately one meeting per annum. In 2012 fisheries management was transferred to the newly created Department of Agriculture, Forestry and Fisheries (DAFF).

3.3.2 Current Management

As with all estuaries in South Africa, the management of the Olifants River estuary falls within the competence of the Department of Environmental Affairs (DEA), the Department of Water Affairs (DWA), the Department of Agriculture, Fisheries and Forestry (DAFF) as well as provincial and local governing departments. DEA is responsible for general environmental matters especially drafting and implementation of Environmental Management Plans (EMP) with the provincial agency Cape Nature being responsible for the implementation of the plan. DWA deals with the water issues and DAFF with fisheries in estuaries. However, because of the division of functions is amongst several authorities, the management of the Olifants River estuary is complex

Currently, DAFF is responsible for management and law enforcement of fishing activities in the estuary. However, due to being understaffed and underfunded, on ground management and monitoring is limited (DAFF compliance officer, May 2013, pers. comm.). Transgressions can be reported to the DAFF law enforcement official but they are rarely done. An issue that has created tension amongst stakeholders at the estuary has been government's proposal to phase out gill-net fishing in the Olifants estuary. Government scientists comment that gill-net fishing is unsustainable and impacts negatively on a wide range of non-target species favoured by linefishers (Hutchings and Lamberth, 2002a, 2002b). However, the closure of the fishery has been challenged by the fishing community on grounds that the stock is not being overexploited by them and that they have historical rights to fish.

In 2004, the Cape Action Plan for the Environment (C.A.P.E) was funded by a programme of the World Bank to improve the management of estuaries in the Cape Floristic Region by developing estuary management plans and the capacity to implement them. C.A.P.E is a partnership with government and civil society aimed at conserving and restoring the biodiversity of the Cape Floristic Region and its adjacent marine environment, whilst delivering significant benefits to the people of the region. The main partnership it forms is with the South African National Biodiversity Institute (SANBI), which is a statutory authority with regards to biodiversity conservation. Hence, C.A.P.E has indirect legal obligations with a strong conservation interests. The Olifants River estuary was identified as one of the estuaries of significant conservation value that required better management and hence in need of a management plan. Because the C.A.P.E has a strong conservation focus, the main focus of the proposed Estuary Management Plan (EMP) was to on conservation issues. Marine and Coastal Management (MCM) designated Cape Nature as the implementing agent once the EMP was finalised. In 2008, an environmental consulting company produced a draft Olifants Estuary Management Plan (OEMP). The draft EMP neglected to engage with the local resource users of the area and did not address the rights and livelihood needs of the fishing community and hence is currently being reviewed. This shows that all stakeholders, resource users, interested and affected parties and government departments must be involved in the decision-making and management of the estuary and surrounding areas. Subsequently to fulfil this need the Olifants River Estuary Management Forum (OEMF) has been established. The Forum deals with management of the estuary and is made up of all affected and interested parties as well as various government departments such as DWA, DAFF, DEA as well as provincial and municipal departments.

3.3.3 Catch Monitoring

The fishing community has never organised autonomous monitoring of fish catches in the past. Prior to commencement of this study recording of fish catches was done by fishers themselves via blue books provided for by DAFF and in some years by monitors contracted by the EEU/UCT (Carvalho et al., 2009). More recently the DAFF has contracted an external consultant to organise and monitor fish catches of the Olifants River estuary.

EEU Monitoring

Being approached by the fishermen of the estuary due to dwindling catch, the EEU initially supported the implantation of a community monitoring system where fishermen themselves recorded fish catches on catch cards after each fishing trip. The monitoring system based on fisher's catch reports was implemented between 1994 and 1997 and the results showed that resource harvesting was at a sustainable level (Sowman, 2001). However, this system had various shortcomings including limited numeracy and literacy skills of fishers and the attitude to completing the catch return sheets after a long night fishing being too onerous (Carvalho et al., 2009). The system was revised in 2004 by identifying and training four literate local female community members (known as 'walskippers') to record catch data. This monitoring program was implemented from mid-2004 until December 2006 (Carvalho et al., 2009) but had to be terminated due to lack of resource funds. The monitors were living in the fishing communities of Papendorp and Olifantsdrift. They underwent a two week training course which included theoretical and practical components. Theory included explaining the need and importance of monitoring the fish resource, the concept of co-management, the importance of the research and recording accurate data. Monitors were made aware of their responsibilities and the role they were expected to play in the assessment of the state of the fish resource (Carvalho et al., 2009). For the practical component of the training, the monitors were trained in fish identification, measuring fish weight and length (both total and fork lengths) and filling out the catch return data cards. They were required to fill out a catch return card for each observed landing at Olifantsdrift and Papendorp. The catch return card can roughly be divided into three sections: the time spent fishing, the gear used and the landed catch. Recordings for each card included date and time of recording, fishing trip code, the origin of the fisher, the fishing site/s, detail of gear used, the duration of the trip, the actual time spent fishing, the total number of harder caught, the number of salted fish, the total weight of the entire catch, the fork length, the total length and weight of a sample of 50 harder and details of the bycatch (Carvalho et al., 2009). The fisher identification remained anonymous. The actual time spent fishing was categorised into four hour segments and fishermen would inform on their actual time spent fishing. Hence, this time is an estimate. The information on gear used was given to monitors by fishermen. Monitors did not measure the net dimensions themselves. Catch was recorded in total numbers and weight. Furthermore, the subsample of 50 *Liza richardsonii* were measured and weighed using a fish measuring board (Figure 7) and a spring balance (Super Samson), respectively. Lastly, bycatch numbers and weights were recorded. A fish identification guide was designed for reference, which contained an image of the fish found in the estuary and biological information.

The purpose of the monitoring proramme as well as the monitors and the nature of their work were introduced to the fishing community. The monitors worked in the same pairs and altered their monitoring days from Olifantsdrift to Papendorp, which are the two main landing sites. They received a small salary for the data collection and were required to work 15 days a month. The research team visitied monthly to supply blank data sheets, to collect the completed forms, to check the data collection process and to support the monitors.

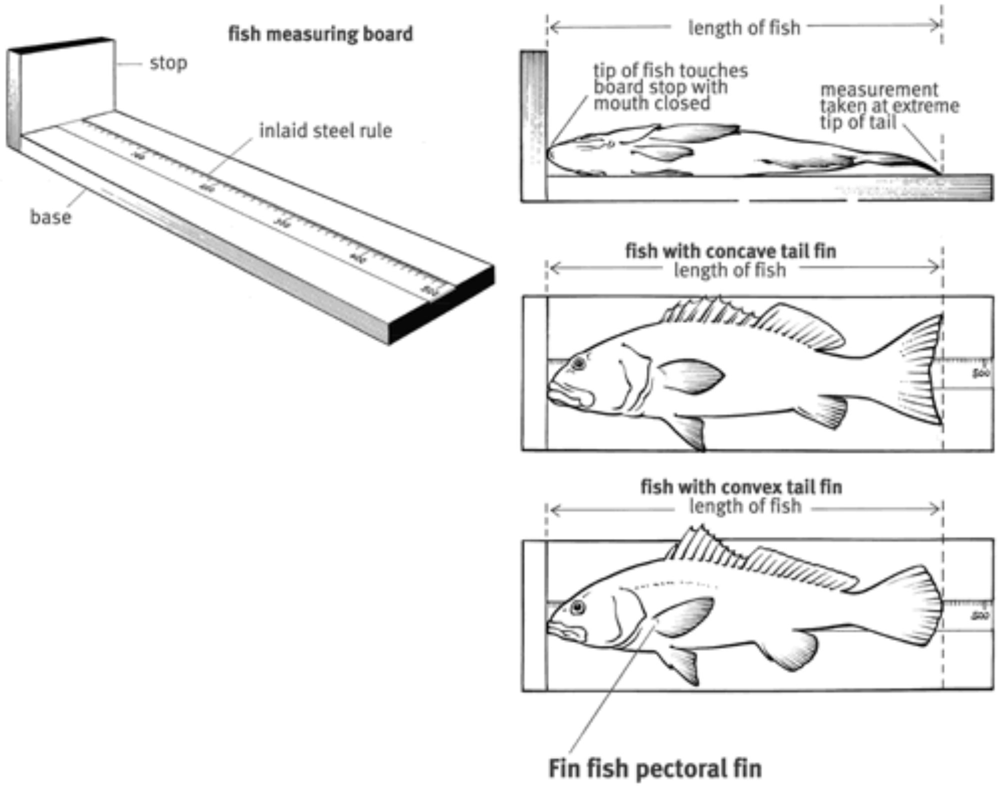

Figure 7: Procedure for measuring total fish length using a measuring board.

Picture 2: Fisherman with a Kabeljou and community monitors recording catch (photos by N. Soutschka).

DAFF Monitoring System

In 2003 the fisheries management authorities introduced a requirement to record fish catches after each fishing trip in a 'blue book'. These blue books are handed out to fishers together with their fishing permit and collected and returned to the research division of DAFF. The department uses this information to analyse stock trends and inform management decisions (Hutchings and Lamberth, 2002a, 2002b). According to the permit conditions of 2007 (6.1)"The exemption Holder shall render statistics as prescribed *in the "Commercial catch returns for gill and drift beach-seine nets" Landing Book Before the 15th of each month in respect of the previous month fished, the Exemption Holder must complete one catch-return sheet and deliver it, still attached to the Landing Book, by hand to the regional Marine and Coastal Management office."*

However, the enforcement officer of the area mentioned that the collection of the blue books started to dwindle (from approximately 2008/2009) and ceased in recent years (from approximately 2010) (DAFF compliance officer, May 2013, pers. comm.). However, it is not known exactly when this system stopped recording and what information is available and has been analysed. Fielding et al. (2007) compared data from the EEU monitoring system to that collected from fisheries management authority. The DAFF monitoring system was revitalised in March 2013 through the appointment of an external consultant (Jaymat Environ solutions cc). The consultants trained community members to collect fish landing information on the Olifants River estuary similar to the EEU monitoring program. However, these monitors only recorded total catch (no weights), were not monitoring in Papendorp and only worked from 9am to 5pm. According to the fishers the monitors were not at the shore when they returned from a fishing trip and therefore did not record most of the catches. Furthermore, the monitors were then found "sitting around" on the shore (as there were no fishermen returning) until 5pm when their work day was officially over. This monitoring system further caused confusion as fishers were now giving catch return information to both the DAFF monitors and the EEU/UCT monitors and highlights that DAFF was not engaging with local resource users and community or current EEU/UCT monitors.

Picture 3: UCT monitors weighing a harder; fishing boats on the river and a fisherman pulling in his gill-net (photos by N. Soutschka)

Data analysis

It becomes clear that data has been collected in various intensities and methods. Analysis of most of the EEU data has been done and compared to data recorded by MCM (blue books) when available (Carvalho et al., 2009; Fielding et al., 2007; Sowman, 2001). Data collected by EEU/UCT monitors between 2003 and 2006 was analysed by Fielding et al., (2007).

Furthermore, Carvalho et al. (2009) tested the realibility of the monitoring system. Currently no published report by DAFF about the state of the fishery of the Olifants River estuary is available. The EEU data was used to inform DAFF that the resource and the bycatch is not overexploitet and therefore the closure of the fishery not neccessary. However, ideally the information obtained from monitoring should be used to inform a collaborative management process.

CHAPTER 4: RESEARCH APPROACH AND METHODS

4.1. RESEARCH APPROACH

The overarching methodology adopted in this research falls within Participatory Action Research (PAR) and both qualitative and quantitative data were collected as part of this process. Therefore the monitoring system could be categorised as a *Category 3* monitoring scheme (see section 2.1.4) (Danielsen et al., 2009a). This implies that the local people are the data collectors and also participate in management-orientated decision-making on the basis of the results of monitoring. The data collected through the monitoring scheme were reviewed and analysed and this information together with participant observation and interviews with monitors enabled the researcher to assess the effectiveness of the monitoring system. Furthermore, the researcher worked closely with the community monitors and used their insights to gain a better understanding of the monitoring system as well as the general management of the fishery. To gain a closer familiarity with the fishing community and fishing activities and procedures, the researcher engaged in participant observations. Qualitative information was gathered via informal interviews and attendance at various workshops held with the fishing communities to discuss fisheries management issues and concerns. Hence, evaluation of the monitoring program was both qualitative and quantitative. Due to past involvement of the EEU and past research interactions of fellow researchers, access to the community by the author was easily facilitated.

4.1.1 Community Engagement

The Olifants River fishing community was engaged in this research process using methods commonly used in Participatory Action Research (PAR). PAR is research by, with and for people affected by a particular problem. It is a way of collecting information that centres on and reflects the experience of the people most directly affected by issues in the community (Greenwood, 2007). According to Selener (1997), PAR is a process through which members of an oppressed group or community identify a problem, collect and analyse information, and act upon the problem in order to find solutions and promote social and political transformation. PAR is only possible with, for and by communities, ideally involving all stakeholders both in the questioning and sense making that informs the research, and in the action which is its focus (Minkler, 2000). The problem of reduced catches was identified by the Olifants River Estuary community long before the initiation of the current project. In 1993 fishers from the Ebenhaeser community requested assistance from the EEU at UCT to investigate reasons for a perceived decline in fish catches (Sowman, 2003). Furthermore, interaction with the community was facilitated through regular field visits, informal interviews with monitors, fishermen and other community members and by attending workshops held with the fishing community.

Field Visits

In March 2012 the author joined a meeting in Ebenhaeser regarding the management of the estuary attended by fishermen from the greater Ebenhaeser area (Papendorp, Olifantsdrift, Hopland and Nuwerus). At this meeting the fishermen raised the need of the reintroduction of a monitoring system. In September 2012 the monitoring project and the researcher were introduced to the fishing community of Papendorp and Olifantsdrift. This visit focused on the introduction of the research, the community monitors and the data collection procedure that the monitors would follow. Approximately once a month from September 2012 to August 2013 the study site was visited by the author. These visits focused on discussing the monitoring process with the fishers and monitors and their concerns and comments were accommodated by adjusting the monitoring system accordingly and noting their remarks for better understanding and developing a community monitoring project. Further discussions with fishers and monitors included the general management of the fishery.

Informal Interviews

Informal interviews were conducted with community monitors, community members, (especially with fishers) and the official fisheries management authority of the area. Questions asked related to the general management of the estuary, the data collection procedure conducted by community monitors and other monitoring programs as well as people perceptions of the monitoring scheme.

Workshops with Fishers, Monitors and other Fishing Community Members

During this research workshops and meetings were held between researchers, NGOs, fishers and monitors to discuss the draft OEMP and what changes to the document were required. Generally, in these workshops the future management of the estuary from the perspective of the fisher community was discussed. The author attended all 4 Workshops within period February 2013- December 2013, required information especially focused on the monitoring aspects of management. Furthermore, all information regarding the OEMP workshops is available on an internally shared database.

4.1.2 Design of the Community Resource Monitoring System

The success of a monitoring system is highly dependent on the design of the project. Substantial thought should be given to the questions of design and what aims and objectives are desired to be achieved (Danielsen et al., 2003). Monitoring designers need to consider 'how', 'what' and 'why' to monitor. Danielsen et al. (2005b) proposes six steps for developing robust locally-based monitoring for biodiversity and resource use. The development of the revised Olifants River monitoring system was informed by these steps (Table 2).

Table 2: Steps for developing locally-based monitoring of biodiversity and resource use taken from Danielsen et al. (2005b)

Box 1. Six steps for developing locally-based monitoring of biodiversity and resource use (modified from Royal Society 2003; Green et al. 2005).

1. Discuss within the responsible institutions and with interested stakeholders the need for, and the aims of, management-oriented monitoring. In particular, discuss:
   - Which aspects of biodiversity and resource use are you interested in?
   - What questions do you want the monitoring to answer?
   - What are you likely to do with the results?
   - When are the results of monitoring needed?
   - What level of precision and accuracy is required?
   - What incentives are required to ensure community, ranger or volunteer engagement?
2. Use existing knowledge, including that of villagers and local staff, to develop a model of the system, even if it is only conceptual. For example, the topic of interest may be the number of turtles than can be harvested sustainably from an area. This cannot be measured directly, but developing a simple model of how this relates to measurements that are feasible and realistic for community members, rangers or volunteers to conduct (such as the number of nesting females on a communal beach) makes the limitations of the assessment explicit.
3. Agree on an institutional framework for using the results of monitoring for adaptive management.
   - Agree on who takes decisions, and how monitoring results reach this body
   - Develop and agree on mandates and responsibilities of the involved parties
   - Wherever appropriate, the monitoring should be embedded within existing institutions
4. Develop a sampling strategy that specifies who measures what, how, where and when.
   - Discuss the usefulness, costs and difficulty of alternative measures, including any existing schemes underway
   - Identify which species, areas, or resource uses are to be monitored
   - Design a sampling strategy which pays explicit attention to potential sources of bias and in which the spatial and temporal deployment of sampling effort is appropriately stratified to maximise precision given available resources
   - Train data gatherers to follow a common protocol which is written down; if guidelines and training materials from other monitoring schemes are relevant, ask to use them, and adapt the materials to the local context
   - Agree on how and where to store data
   - Conduct a pilot study to test feasibility of data collection protocols; check with stakeholders whether the resulting data address their needs
5. Begin implementation on-the-ground. Important steps include:
   - Store data in its most disaggregated form and with details of exactly how it was collected
   - Record sampling effort, who collected the data, and precise locations of field study areas
   - Keep raw data for checking and re-interpretation
   - Ensure that checks are carried out to keep errors in recording and data storage at an acceptable level
   - Analyse the data, and feed results back to data gatherers
   - Wherever possible compare results with those of other locally-based or professional approaches
   - Provide results to decision-making body, and check they are fit-for-purpose
   - Ensure that data gatherers are aware of management decisions arising from their data
6. Discuss the results with the local/national stakeholders and revise the strategy for the monitoring accordingly.
   - Address sustainability issues such as post-project funding and recurrent training needs
   - Keep track of management interventions resulting from the monitoring
   - Make data available on open access database, if possible
   - Facilitate the development of national policy, guidelines or tools for monitoring.

The first step is to discuss the aim and need of management orientated monitoring with stakeholders. All stakeholders need to firstly be identified and should include interested and affected parties, management bodies and authority (for example in the case of the Olifants River estuarine fishery government departments such as DAFF, DEA and DWA) and resource users. In particular early engagement with the resource-user community is important, so that the monitoring system will receive support from the community. Engagement with all stakeholders involves jointly discussing the aim and objectives of monitoring. Consideration must be given to which aspect of resource use and what questions the monitoring should focus on and seek to answer. Further, all involved need to discuss what must be done with the results, when they are needed, and what level of accuracy and training is required. It is important for the results to reach decision-makers and managers so that management can be adaptive (Armitage et al., 2008; Berkes et al., 2007; Folke et al., 2005; Lal et al., 2002). For decisions made to be most effective, a committee or body should be set up that channel the results of the monitoring process to decision-makers. The monitoring system at the Olifants River has been set up and revitalised at various stages over an 18-year period. The initial need for monitoring dates back to 1994 when fishers perceived a decline in fish catches and together with the EEU at UCT initiated a community-based monitoring system during 1996-1998 and has progressed until now. Due to the nature of research projects and funding constraints, the monitoring system was operational for certain years when funding was available.

As this one year monitoring project came in at a late stage of the already established, although ad hoc monitoring system, it seemed unnecessary to redesign the monitoring as it already had been through many readjustments together with input from scientists and the community (Carvalho et al., 2009; Fielding et al., 2007; S. William, pers. comm, 2013). However, throughout the current project minor changes were made to the monitoring system as improvements were identified. The second step of the development phase is the inclusion of existing knowledge of community and local staff to develop a model of the system and how it relates to feasible and realistic measurements for community monitors to conduct. As mentioned previously, the fishers and monitors of the Olifants River estuary were engaged in the design of the monitoring system with due consideration given to the fishing practices. Furthermore, fisheries scientists were consulted to improve to the design of the data collection procedure. For the monitoring system to be accepted by professionals it was important to include them in the design phase. Whilst input from professional and government scientists was obtained during the redesign of the monitoring programme and catch cards, the government scientists remained cautious about the reliability of the monitoring process in terms of how and when data was collected.

The third step in developing a monitoring system is to agree on an institutional framework for using the results of monitoring for adaptive management (Danielsen et al., 2007; Rijsoort and Jinfeng, 2005; Stuart-Hill et al., 2005). This includes agreeing on who takes decisions, and how monitoring results reach this body, to develop and agree on mandates and responsibilities of the involved parties and wherever appropriate, to embed the monitoring within existing institutions. Consideration and incorporation of these principles and activities in the development of the monitoring system is part of good governance.

The fourth step in developing local monitoring focuses on designing the sampling strategy. The sampling strategy in the case of the Olifants River monitoring system was designed to be relatively simple. Decisions regarding the species, areas, and resource users that will be monitored were agreed upon with the Olifants River fishing community during previous monitoring projects (Carvalho et al., 2009). Potential bias was avoided as the catch cards are anonymous and resource monitoring is kept separate from compliance monitoring. This is especially important as it is illegal to catch and keep bycatch species and linking catch to user could influence abundance monitoring. Furthermore, the sampling strategy specified who measures what, how, where and when. Spatial and temporal positions of sampling effort is maximised by involving two monitors working at two landing sites five days a week.

Step number five is on ground implementation (Danielsen et al. 2005b) and suggests that the storage of data should be universally and easily accessible. Therefore, the data was stored on dropbox a cloud filing system accessible from any computer connected to the internet.

Revising the Catch Card

The previous community monitoring system implemented on the Olifants River estuary was revisited so as not to deviate from the previous approach and to maintain consistency but also to address gaps and shortcomings of the monitoring done in the past. Modification of the monitoring system was informed by the research undertaken by Carvalho et al. (2009), from archival records found in the EEU and by questioning researchers who had previously facilitated the monitoring programme (see section 3.3.3). A draft catch card was designed and sent to DAFF and a UCT fisheries scientist for their input and comments and was then finalised. With the information obtained a catch return card was designed (Appendix 1).

Selection of Community Catch Monitors

The position for monitors was advertised in English and Afrikaans both in Olifantsdrift and Papendorp via the Ebenhaeser community information and development centre (Appendix 2). Two community members from Olifantsdrift and two community members from Papendorp were employed as data collectors or as it is locally know 'walskippers'. Four young female members of the community were chosen as it presented an opportunity for female members of the fishing community to become more involved in the male-dominated fishing activity. They were expected to monitor catches every morning expect weekends.

Training of Community Monitors

At the end of August 2012 the four monitors attended a training workshop at the University of Cape Town together with staff from EEU who had worked on the monitoring project in Olifants Estuary previously. Monitors were trained on how to fill out the catch sheets, how to measure and weigh fish, bycatch identification and the importance of collecting accurate information. To assist them in fish identification, they were given an Olifants Estuary fish identification guide. Initially the fish fork length and total length had to be recorded using a measuring board. However it was later agreed that only the total length would be recorded (Figure 8). In September 2012 the monitors and the data collection procedure was introduced to the fishing community. Whenever fishermen returned from a fishing trip the monitors were expected to record relevant information on the 'catch return cards'. Further recordings included no fishing activity and reasons thereof also needed to be recorded. Monthly visits by the author were conducted to obtain feedback and discuss possible improvements to the data collection. Adjustments to the monitoring system were made when necessary. Monitoring started on the 1st

September 2012 and was terminated at the end of August 2013 due to the end of a funding cycle.

Database

Historic catch data of previous monitoring years from 2004-2006 was gathered and digitised using Microsoft Access®. A digital version of data from 1994-2001 (excluding 1998 and 1999) was not available but analysis thereof can be found in Sowman (2001). The data obtained from the community monitors from 1st September 2012 until 31st August 2013 was added to the digital database therefore forming a digitally available database from 2004-2013. However, it needs to be noted that data monitoring and collection efforts varied throughout this time (Appendix 4). The years 2004-2006 were entirely monitored, 2008-2010 was intermittently monitored and 2012-2013 was again entirely monitored.

4.2. DATA ANALYSIS

In order to analyse the data gathered over this research period, examine fishery indicators and stock trends of the Olifants River estuarine fishery, previous reports (Fielding et al., 2007; Sowman, 2001) were consulted to decide which analyses needed to be done to determine resource trends. Specific questions about the data (queries) were designed and set up in Microsoft Access and run in Micosoft Excel. Through these queries various comparisons could be made and subsequent analysis and graphs created. Quantitative analyses for the year 2012-2013 included analysing the data provided by the monitors by categorising each day of the month into 1) monitoring with catches, 2) monitoring with no catches, 3) monitoring with no fishing taking place, and 4) no monitoring taking place e.g. on weekends. Monitoring of the gear used by fishermen included the net depth, length and mesh size and was compared to previous years. Further analysis was on the total recorded catch (number and kg's) both in summer and winter. Weights were calculated by dividing the actual number of fish caught by 8.5, a ratio obtained from Fielding et al. (2007). Further actual fishing effort and Catch per Unit Effort (CPUE) were analysed. CPUE is measured per fishing trip per boat and calculated into daily CPUE and monthly CPUE. Regression analysis on average number and weight per boat per fishing trip for each month was run and significance tested. Furthermore, the CPUE was also compared to previous years. The size distribution was established using the 50 sampled harders from each returning boat (if available) and compared to previous analyses. The percentage of boats returning with a license was evaluated, however as this was only added to the catch cards in mid-May information is only available for June and July. Furthermore, the percentage of fishing activity at each site was quantified and presented on a map. Lastly, recorded bycatch in numbers and percentage of total catch was quantified. Most importantly however, it needs to be noted that quantitative data was analysed to evaluate the fishery in terms of indicators. Hence, comprehensive statistical analysis was avoided to keep the analysis simple so that in the future local community members can conduct data analysis. The qualitative information gathered through interviews and workshop attendance was added to substantiate or explain a finding.

4.3. LIMITATIONS

4.3.1 Presence of Researcher

In order to obtain an understanding of the shortcomings, strengths and required improvements of the community monitoring system the researcher sought to spend as much time as possible with the community and with the catch monitors. The 400 km distance to the field site made regular field visits difficult and a total number 30 days were spent in the field. Although every attempt was made to explain the purpose of the research, there seemed to be an expectation from the interviewees that the researcher could bring opportunities and expedite change. The researcher was not seen as a neutral entity with a passive presence but one with influence over current and future management decisions.

4.3.2 Community Monitoring

Limitations on the catch monitoring include that some of the information collected by the catch monitors was not accurately measured but was taken in good faith by the catch monitors from the fishers. For example, the monitors did not measure the net length and mesh size of each net but were given that information by the fishermen. The time fishers spent fishing is difficult to quantify, as most fishermen do not keep strict records of their actual fishing duration. This is made more difficult as fishers often allow their nets to drift with the tide and may leave them or reset them several times on any one trip. Both the gear used and effort applied influenced catch per unit effort (CPUE) and as these measurements were slightly subjective it will influence the accuracy of the data. Furthermore, the catch monitors work without supervision and as employment in the area is low and monitoring itself pays little the monitors seek out other employment opportunities from time to time that could impact the monitoring activities. Lastly, the fishermen often return at random times mostly in the early hours of the morning and the monitors may only record catches later in the morning. These factors may have influenced the regularity of data collected.

4.3.3 Data Analysis

To be able to analyse and interpret past and current data collectively the methods of data collection and analysis need to be comparable. However, given some of the shortcomings in the catch cards and data collection methods, certain changes were made to the monitoring system and hence the data captured and methods employed in this one year study were slightly changed from previous methods. This poses a problem for analysing the full record.

CHAPTER 5: FINDINGS

This chapter presents results from the community-based monitoring process and actual data recorded by the monitors. Firstly, indicators related to the quality of the monitoring process are presented and complemented with qualitative data gathered during participant observations, interviews and workshops. Secondly, indicators related to the actual fishery are presented in order to evaluate the quality of the data and the merit of community-based catch monitoring and its contribution to fisheries management. The following fishery indicators are presented: the gear used by fishermen, the total catches, fishing effort, catch per unit effort, size of fish caught, the areas where fishing took place and the recorded bycatch.

5.1. MONITORING ACTIVITY AND QUALITY OF THE MONITORING PROCESS

The community monitors were expected to be at their designated landing sites (Olifantsdrift or Papanedorp) to record catch landings 5 days a week from 1st August 2012- 31st September 2013. Each day of the month can be categorised according to a monitoring scenario (Table 3; Figure 8). Scenario 1 is used for the days when monitors were active and recorded catches. Scenario 0 are the days that were monitored but fishermen returned with no catches. It needs to be noted that one day of monitoring could be for more than one day of fishing as often fishermen are out for more than one night, but this still only accounts for one fishing trip. Hence, one fishing trip is one recorded catch landing of one boat returning to a landing site. Scenario 2 are the days that were monitored but no fishing took place. The last scenario is where no monitoring took place at all for varying reasons including over the weekends when monitors did not work and thus no data was recorded. When monitors were not active, fishing could have taken place, with or without catches, or no fishing took place. Furthermore, Scenario 2 may include several days for example when monitors said no fishing took place for the first two weeks of September due to bad weather. Hence, it was difficult to tease out the days when no fishing took place and days of no catch as the monitors did not always clarify this on the catch cards.

Table 3: Monitored days categorised into monitoring with catches (Scenario 1), monitoring with no catches (Scenario 0), monitoring with no fishing taking place (Scenario 2) and no monitoring

	Days of monitoring with catches (Scenario 1)	Days of monitoring with no catch (Scenario 0)	Days of monitoring with no fishing (Scenario 2)	No monitoring
Sep-12	5	3	8	14
Oct-12	13	3	2	13
Nov-12	14	1	6	9
Dec-12	0	0	21-according to monitors not much fishing took place due to bad conditions.	10
Jan-13	4	1	Data lost. Monitoring took place (according to monitors there were about 200-300 fish caught in Jan, and Feb).	8
Feb-13	-	-		8
Mar-13	3	1	17-according to monitors not much fishing took place.	10
Apr-13	6	0	first 14 days were cold, windy, wet therefore no fishing. In Papendorp road laying work or interim relief keeping fishers busy.	10
May-13	13	1	0	17
Jun-13	12	0	0	18
Jul-13	6	0	0	25
Aug-13	0	0	23-Due to bad weather no fishing took place.	8
Total days and % of year	76; 21%	10; 3%	91; 24%	142; 39%

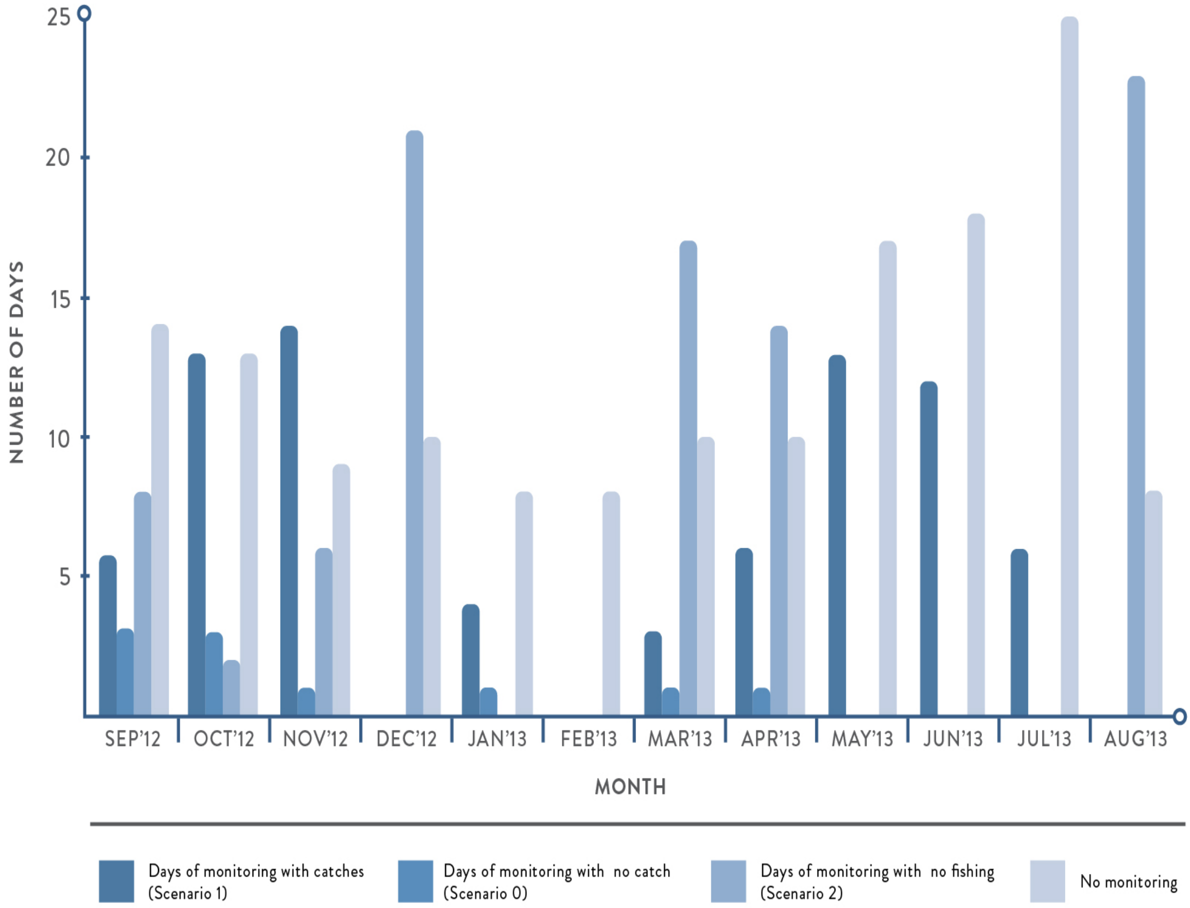

Figure 8: Monitored days categorised into monitoring with catches (Scenario 1), monitoring with no catches (Scenario 0), monitoring with no fishing taking place (Scenario 2) and no monitoring. With data for January and February lost by monitors.

Fishing activity was measured by looking at all recordings made by the monitors. This included records of fishermen returning with catches, records of no catches and records of no fishing activity. Olifantsdrift is a slightly larger settlement and more fishermen reside here, therefore the fishing activity in general is higher than in Papendorp. The monitors from Olifantsdrift generally were more active than the monitors from Papendorp (Figure 9). This is due to the fact that there are more active fishermen residing in Olifantsdrift and monitors would easily find out if fishers had been out fishing and meet them at the landing site or go to their homes. In the case of Papendorp there were only a few active fishermen and although the monitors were paid for their monitoring work they took up other employment in the village when it was available. According to the monitors in Papendorp many of the older fishermen are not active anymore and only very occasionally go out to fish. *Catch Cards* were lost in Olifantsdrift for January and half of February during this study. The monitors that lost the catch cards said they had gathered all the records so that they could be handed to the researcher at a community meeting. However, the catch card records were left behind and were never found nor returned. According to the monitors catches were average in January with approximately 200-300 fish caught in addition to recorded catches from Papendorp and conditions in December and August were not ideal for fishing. Bad conditions include wind, rain and excessive freshwater flow especially in August. In Papendorp, a government funded bricklaying project employed many of the fishermen and both of the monitors. This resulted in the monitors often not being available to monitor catches. Thus appeared that other work opportunities kept the monitors from fulfilling their monitoring duties adequately. Furthermore, fishermen often return in the early hours of the morning (before 6 am). In group discussions and personal interviews, fishermen mentioned that monitors are often not at the shore to record their catches when they return. However, the monitors mostly know who went out the previous evening and record the catches at the fishermen's houses the following morning. Yet, this situation is not ideal as many fishermen have already sold or frozen their catches by the time the monitors visit their homes.

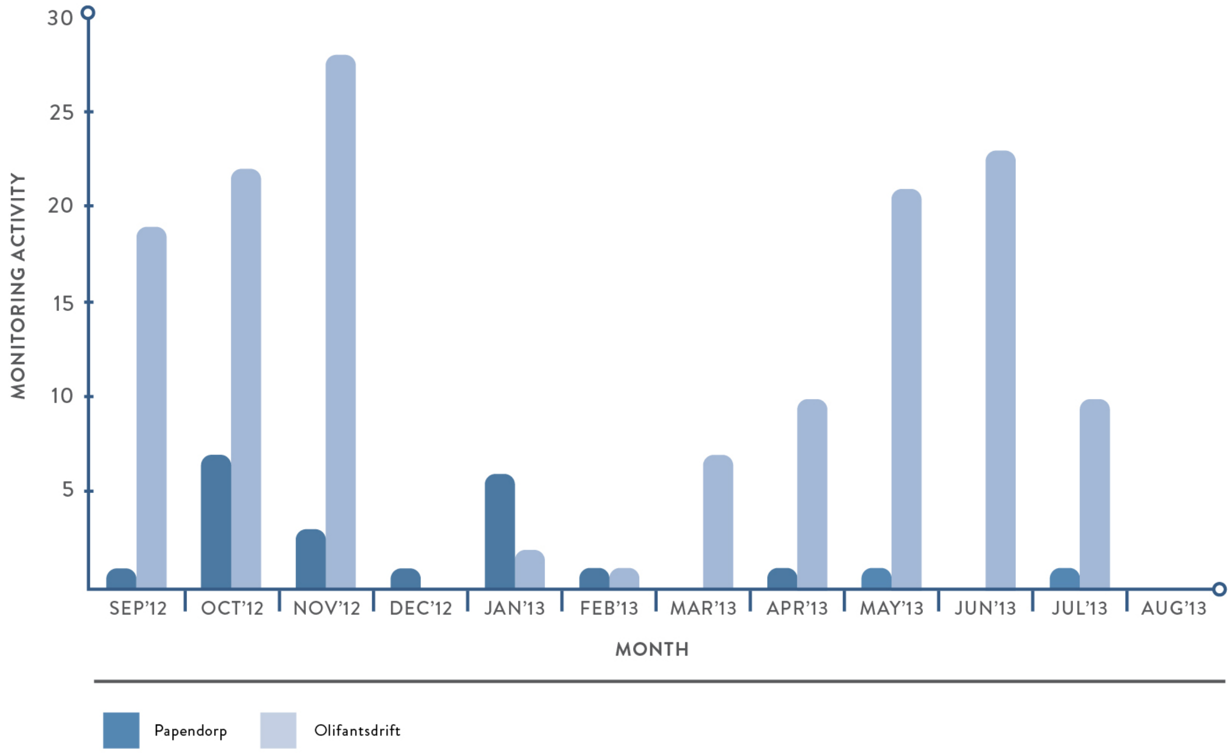

Figure 9: Monitoring activity, where activity is measured in recordings made by monitors. Recordings include all records of catches, no catches and no fishing activity by monitors from Olifantsdrift and monitors from Papendorp.

5.2. FISHERY INDICATORS

5.2.1 Gear used by fishers

Details of the gear used between 1st September 2012 and 31st August 2013 are given in Table 3. On average the fishers used increased net length compared to Fielding et al. (2007) observation of the 2004-2006 period. The net depth was also found to be slightly deeper than in previous years. However, recorded mesh size has also increased by +- 3mm. Maximum net lengths and depths were 60m and 3.1m respectively but few nets differed markedly from the parameters given in Table 3. The measurements were mostly in line with permit conditions with only the net length average being over the allowable net length of 45 m.

Table 4: Gear used in the Olifants River estuary harder fishery between 1st September 2012-31st August 2013 compared to Fielding et al (2007) and permit conditions.

Month	Mean Net length (m)	Mean net depth (m)	Mean net Area (m^2)	Mean Mesh size (mm)
Sep-12	54.70	2.68	146.60	49.80
Oct-12	52.91	2.56	135.25	45.82
Nov-12	46.88	2.69	126.09	46.17
Jan-13	45.43	2.52	114.33	52.00
Mar-13	46.33	2.77	128.42	47.00
Apr-13	47.89	2.74	131.43	48.33
May-13	46.92	2.84	133.15	47.48
Jun-13	47.71	2.87	136.90	48.22
Jul-13	46.83	2.88	134.65	47.00
Average	**48.40**	**2.73**	**131.87**	**47.98**
Fielding (2007)	**47.2**	**2.5**	**116**	**45**
Permit condition	**45**	**5**	**225**	**48-64**

5.2.2 Total catch as recorded by the monitors

Yearly catches

The total number of harder caught as recorded by the monitors between the 1st September 2012 and 31st August 2013 was 31822 (Figure 10). In summer (October-March) 17908 harder were caught and in winter (April-September) 13914 (Figure 10). Total weight of harders caught and recorded was 2533 kg, where 1174.5 kg were caught in summer and 1358.5 kg in winter. However, the total weight was often not recorded by the monitors[2]. The total calculated weight

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[2] Weight estimate were obtained by dividing number of harder by the number/weight conversion ratio 8.5 as per Fielding et al. (2007). This formula was used to calculate all other weights as a comparison to the actual weight measured.

of harder caught was 3743.77 kg (Figure 11). It is important to note that data recordings were lost for half the month of January and full month of February from Olifantsdrift. Thus the total catch is likely to be higher.

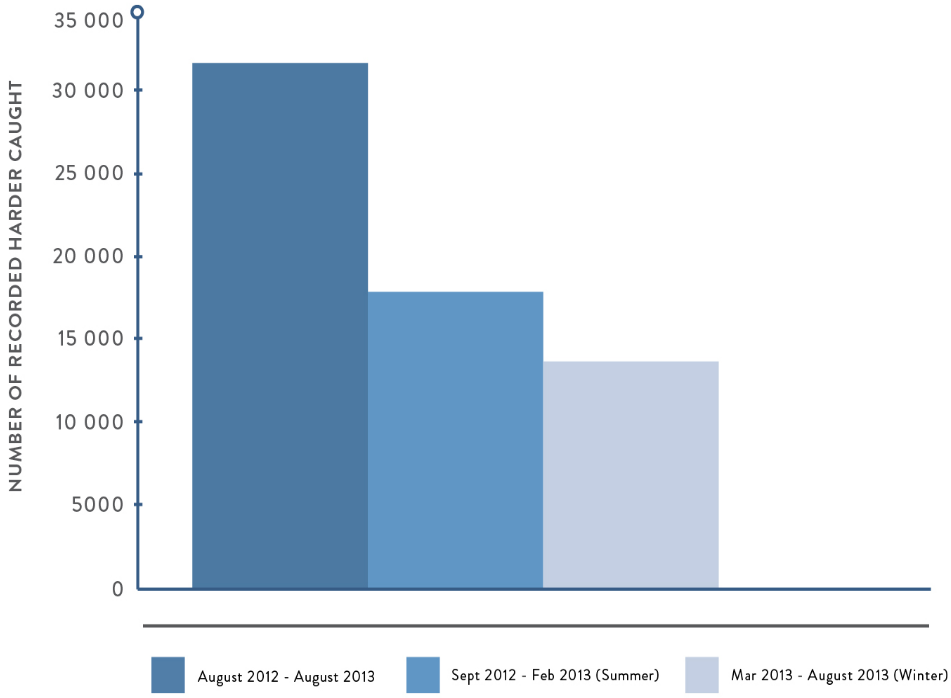

Figure 10: Total number of recorded harder caught over the period 1st September 2012- 31st August 2013 in summer (October to March) and winter (April to September).

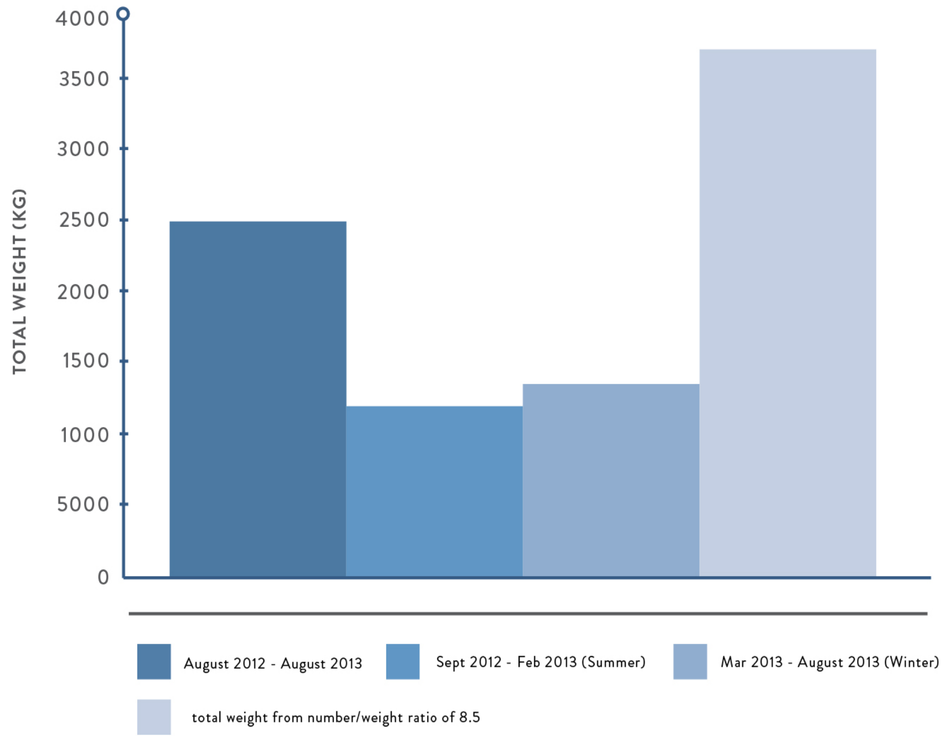

Figure 11: Total weight of harder caught from 1st September 2012- 31st August 2013 with summer (October to March) and winter (April to September) catches and weight extrapolated from number/weight ratio of 8.5.

Monthly catches

Over the period 1st September 2012- 31st August 2013 the highest number of harder caught in a month was during October 2012 (Figure 12). In December, February and August no fish catches were recorded (Figure 12, Table 3) and as the data for January was lost these catches could be higher. According to the monitors the weather conditions in December and August were so bad that no fishermen went out to fish. In October and November over 500 kg were recorded for both months although about 3000 less fish were recorded in November (Figure 12 and 13). This again shows that weights were not accurately or always recorded by the monitors and hence the numbers were converted using the 8.5 weight ratio.

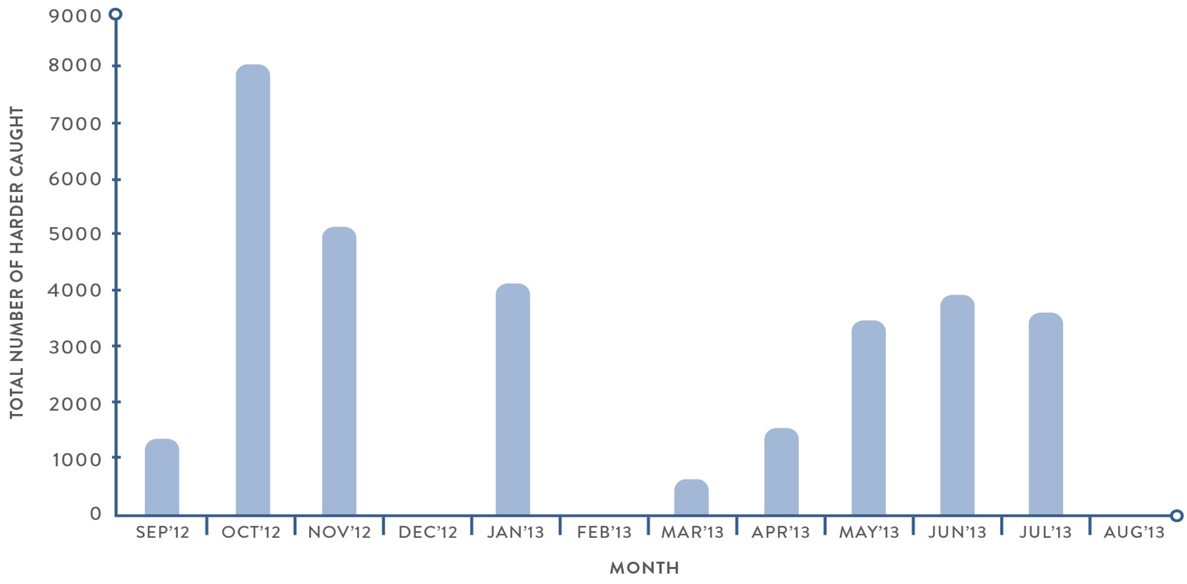

Figure 12: Total number of harder caught per month in the period 1st September 2012- 31st August 2013.

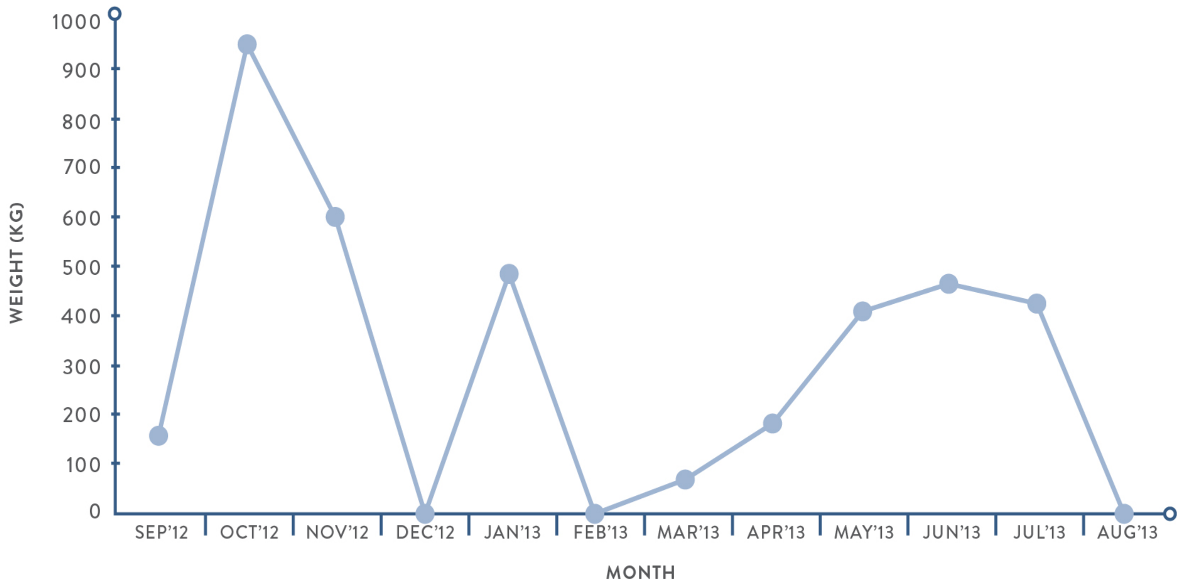

Figure 13: Total converted weight (kg) of harder per month in the period 1st September 2012- 31st August 2013.

Daily catches

On average the highest number of harder caught per day occurred in January with on average just under 600 fish or 70 kg caught per day (Figure 14 and 15). However, one fishing event occurred when one fisherman caught 800 harders on one trip. The maximum number of fish caught on a day of fishing was in October and January with 700 and over. The lowest catch recorded on any day was in November 2012 when only 23 fish were caught. One needs to be reminded that the days that fishers returned with no catches were not properly documented in the database and are therefore not reflected.

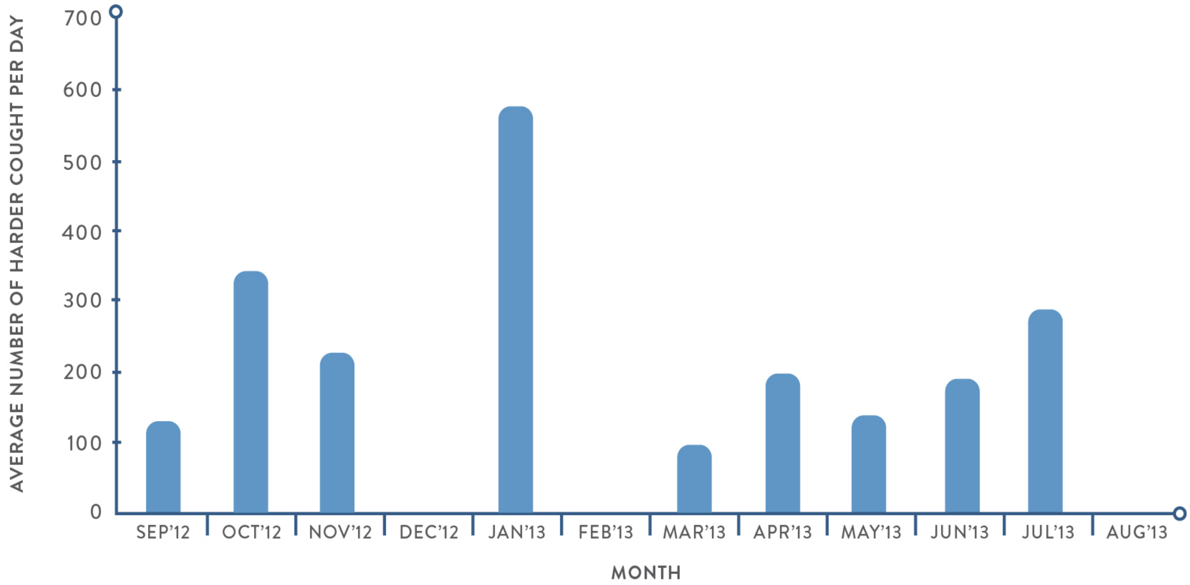

Figure 14: Average number of harder caught per day for each month for the period 1st September 2012- 31st August 2013.

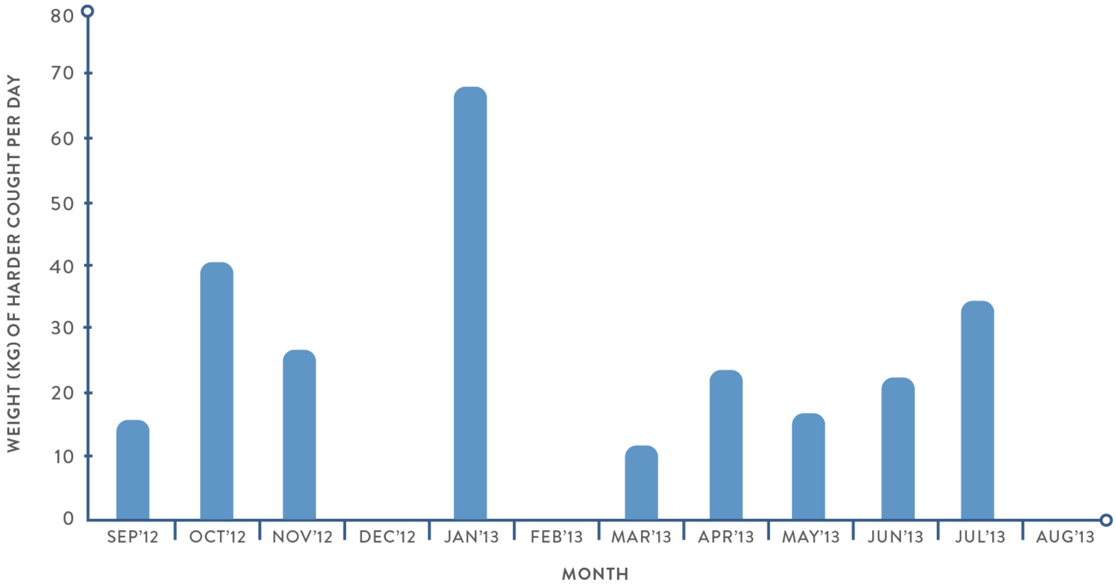

Figure 15: Converted weight (kg) of average harder caught per day.

5.2.3. Fishing Effort

In the period 1st September 2012- 31st August 2013 most fishing took place in May and June and in October and November (Figure 16). According to the monitors no fishing took place in December and August due to bad weather conditions (Table 3 and Figure 16). There seems to be no difference in fishing effort, which is defined as fishing trips per month, between summer and winter months. According to Fielding et al. (2007) most fishing in the period 1994-1997 appears to have occurred in the summer months, with little activity in winter. Yet, from the year 2000 onwards, it is reported that fishing has occurred throughout the year (Fielding et al., 2007). Data collected from the monitoring system seems to confirm Fielding et al.'s (2007) report.

A total of 86 fishing events were recorded by the catch monitors for the entire period from 1st September 2012 – 31st August 2013 (Table 5). In May 2013, 25 trips were recorded for the month and 24 were recorded in June 2013, October 2013 and November 2013. Results from the monitoring system suggest an average of 16 trips per month over the entire period (Figure 16).

Table 5: Number of fishing events recorded per month for the period 1st September 2012- 31st August 2013.

Month of Year	Number of fishing events recorded
Sep-12	8
Oct-12	16
Nov-12	15
Dec-12	0
Jan-13	5
Feb-13	0
Mar-13	4
Apr-13	6
May-13	14
Jun-13	12
Jul-13	6
Aug-13	0
Total	86

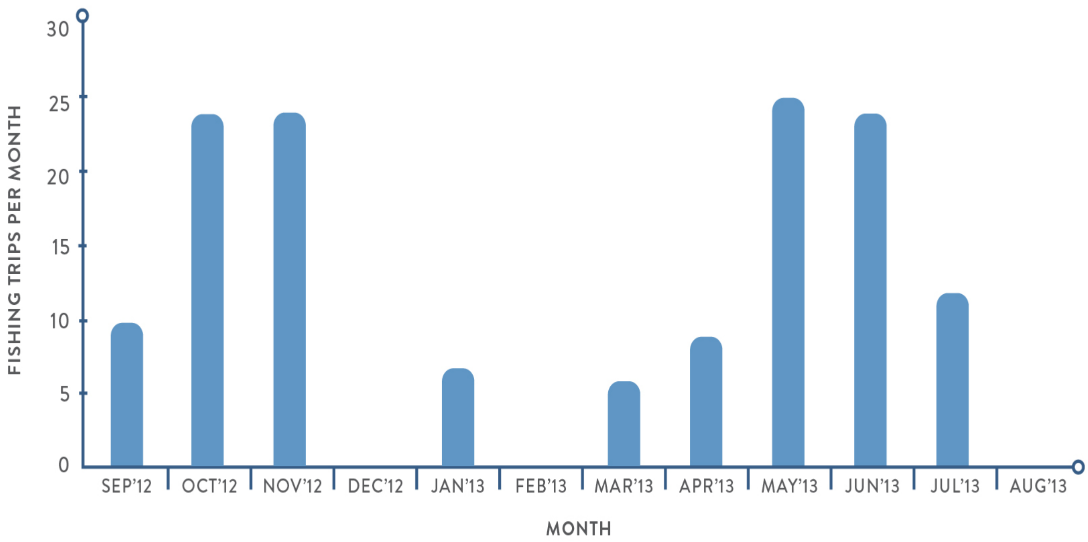

Figure 16: Number of fishing trips per month recorded by monitors in Olifantsdrift and Papendorp from 1st September 2012- 31st August 2013.

According to monitors and fishermen there are a maximum of 8-10 fishers on the river at any one time but mostly there are far less fishers on the river at a time although 45 permits have been issued. Personal observation further strengthens this statement from fishers and monitors as very little fishing activity was taking place whilst on field visits. However, it needs to be highlighted that a realistic estimate of total fishing effort for the year is difficult to obtain because monitors did not capture all fishing activity (see section 5.1).

Time and effort per fishing trip

Fielding et al. (2007) suggests an alternative to the method of estimating time and effort per fishing trip used. Until 2006, the EEU monitoring system used length of fishing trip from the time a boat departs from shore to the time it returns. But focus group meetings indicated that this is a poor method of estimating fishing time, and it is not well correlated to the time actually spent fishing. Hence, the addition of the "duration of fishing" question in the *Catch Return Card* in August 2012. Using this method to calculate the average time spent fishing per trip, it was found to be slightly more in May, June and July (Figure 17). Fishermen also mention that the actual effort put into fishing differs. Some fishers cast their nets frequently during one fishing trip, whilst others leave theirs to drift behind the boat. The decision to set the nets or allow them to drift would depend on various factors including the weather conditions, catch rates and presence of seals. Furthermore, it was mentioned that the position of the net also influences catches. The net that has been set out first and is therefore in front catches more than the nets set out behind it (depending on the current).

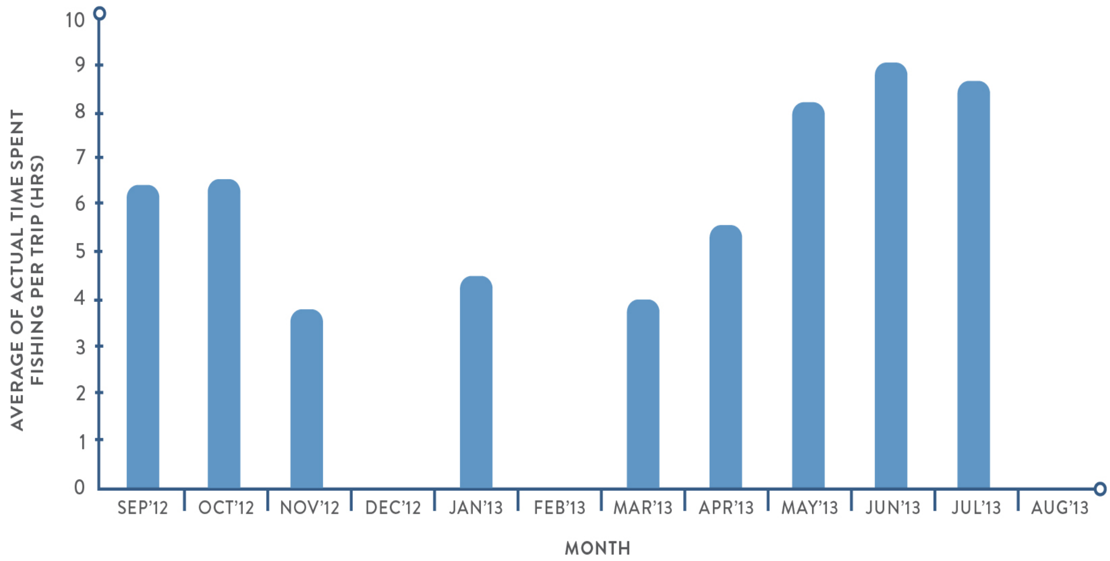

Figure 17: Average time spent fishing per trip in hours each month for the period 1st September 2012- 31st August 2013.

5.2.4. Catch Per Unit Effort

Monthly 1st September 2012- 31st August 2013

Catch per unit effort (CPUE) was calculated as the number or kg of harder caught per boat per fishing trip. The actual time spent fishing was not used to keep consistent with previous analysis of Fielding et al. (2007). There was no significant difference in monthly catches ($p > 0.05$) for those months where data existed. Furthermore, to mention again that the data for January and February collected in Olifantsdrift was lost and therefore not included in this analysis. The highest monthly average of harder caught per boat per fishing trip was in January, which was 593 fish or 70 kg per boat per trip (Figure 19 and 20). Other months of high catches were October and July with 335 fish or 39 kg and 302 fish or 35.5 kg harder per boat per trip respectively (Figure 18 and 19). The maximum number of harder caught per boat per fishing trip was in January and October, when some fishermen returned with over 900 fish. As mentioned earlier in January there was one recorded fishing trip with 900 harders caught. This one trip accounts for the high CPUE of January. The minimum catch per boat per fishing trip was in May 2013 with a catch of 12 fish. There were however ten days when fishers returned with no catches (Table 3).

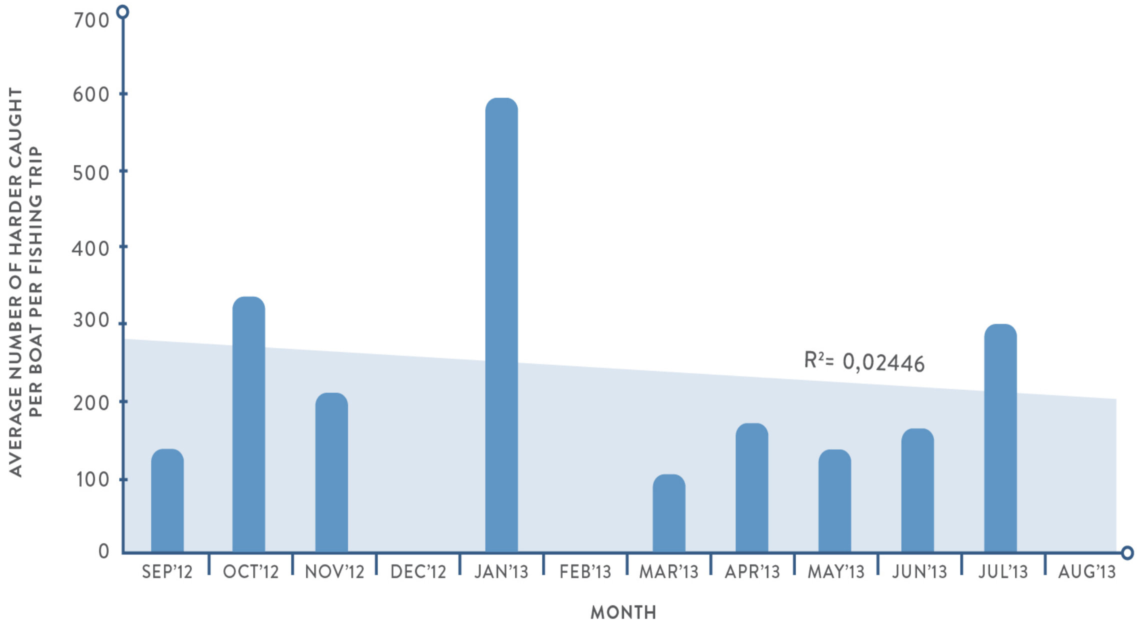

Figure 18: Average number of harder caught per boat per fishing trip for September 2012-Septmeber 2013.

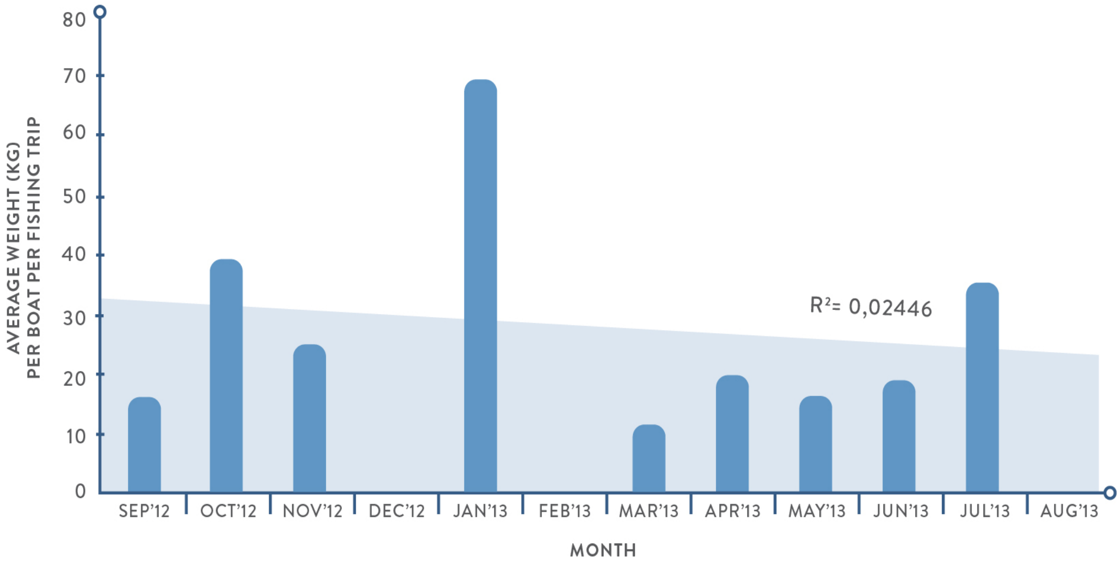

Figure 19: Converted weight (kg) of harder caught per boat per fishing trip in the period 1st September 2012- 31st August 2013.

Yearly

Looking at catches over the entire monitoring period, on average 230 harder, or 27kg were caught per fishing trip in 2012-13. The CPUE for the periods 2004-2006, 2008, 2010 and 2012-13 fluctuated considerably (Figure 20). On average the CPUE in 2004 was 29kg/fishing trip, in 2005 17kg/fishing trip, in 2006 44kg/fishing trip, in 2008 17 kg/fishing trip and 19kg/fishing trip in 2010 (Figure 20). However, these differences were not significant ($p>0.5$).

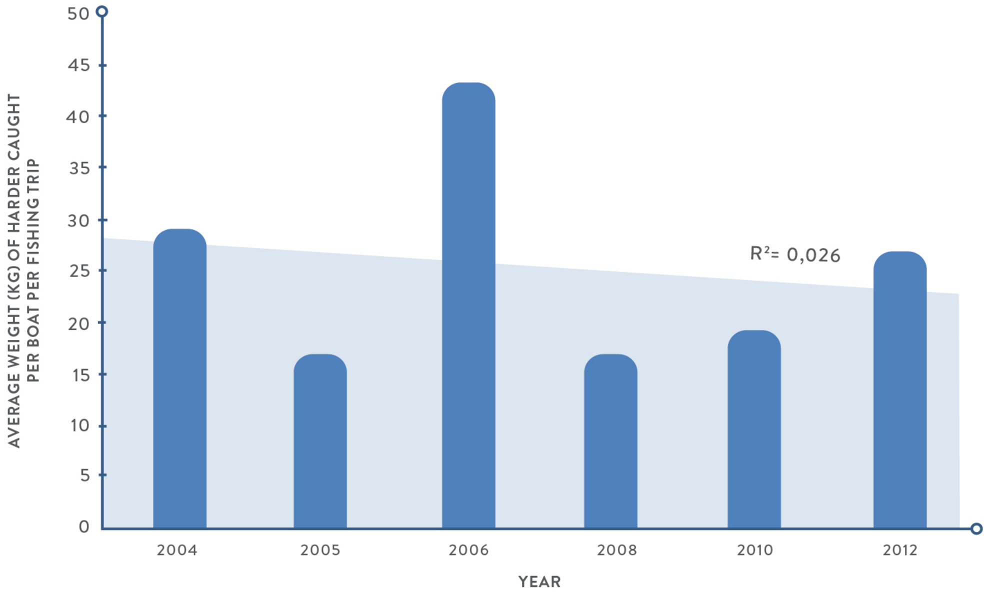

Figure 20: CPUE for the earlier monitoring periods (2004-2006, 2008 and 2010) and the period 1st September 2012- 31st August 2013.

Fishing community opinion

Generally fishermen and monitors agreed that the total catches over the monitoring period from 1st of September 2012- 31st August 2013 were low compared to previous years. However, the CPUE was considered "reasonably good" compared to other years (Figure 20). However, in summer and over Easter, catches were much less than the fishing community is used to. Monitors mentioned that there was no enough fish to be pickled for a traditional dish served over Easter. Although the weather in December was unusual with high rainfall and gusty conditions it is still questionable that no fishing took place as reported by monitors. Summer is usually the season with high catches, therefore no fishing events over December and February is doubtful. Yet, fishermen confirmed that the conditions and general catches were bad.

5.2.5 Size of fish caught

For each monitored fishing event in 2012-13, 50 harders were sampled by monitors and measured (total length) to the nearest 1mm. The mean total length over the monitoring period was 23.7 cm (Table 6). Most fish sampled were between 20 and 25 cm (Figure 21). The most frequent size caught is between 22 cm to 25 cm and size frequency distribution is normal (Figure 22). Therefore, most fish caught were mature[3] (De Villiers, 1987). The distribution is typical of fish catch-at-length frequency distribution and there is no evidence of unusual distribution, such a spike in the frequency at a particular size.

Table 6: Mean Total Length

Month 2012-13	Mean total Length (cm)
Sep	22.29
Oct	24.13
Nov	23.15
Jan	25.47
Mar	24.03
Apr	23.79
May	23.58
Jun	23.21
Jul	23.88
Average	23.72

[3] Size at maturity of *Liza richardsonii* is 220 mm according to De Villiers (1987) and 230 mm according to Lamberth (unpublished data).

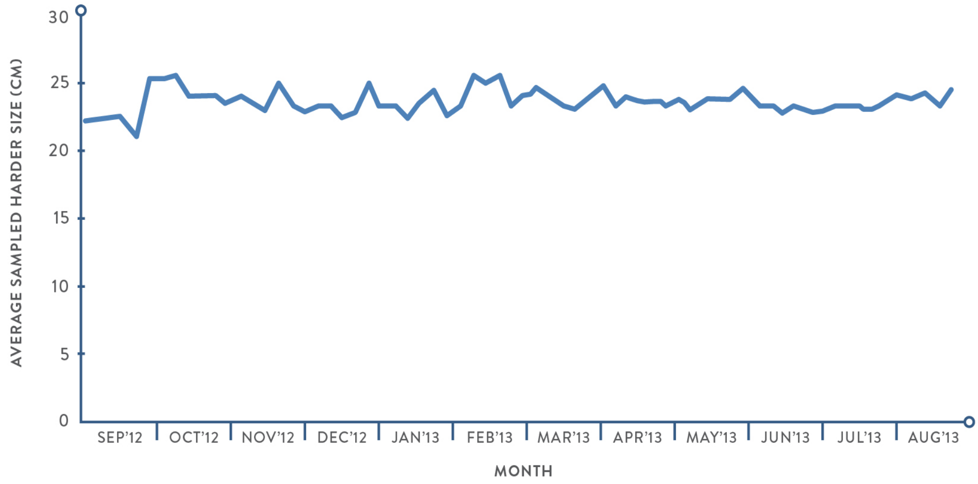

Figure 21: Average total length of sampled harder in cm.

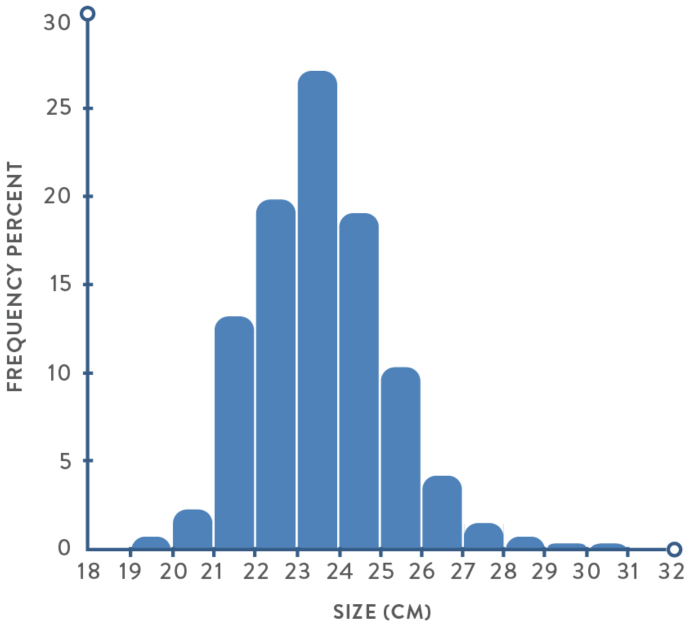

Figure 22: Length- frequency (total length) of harders in samples collected by fishing community monitors in the Olifants River estuary gillnet fishery from 1st September 2012- 31st August 2013 (n=6069).

5.2.6. License

55% of the fishing trips in June where unlicensed i.e. no permit holder was on board. In July it was reduced to only 21% of trips without permit holder (Table 7). The question on whether or not the fisher was in possession of a permit was only added at the end of May 2013 to the *Catch Return Cards* therefore the other months are not available.

Table 7: Percentage of unlicensed fishing events

Month	Nr of trips when no permit holder on boat
June	55%
July	21%

5.2.7. Fishing area

Most fishing of 2012-2013 took place in Hottentotskop followed by Stootwal and Ribboksbaai (Figure 23). Baken, which is near the mouth of the estuary, does not appear to be the most popular site as was found was in Fielding et al. (2007). Furthermore, no fishing activity in the river mouth was reported and monitors from Papendorp never reported any fishing occurring in the mouth. In addition monitors often recorded that more than one fishing site was visited per fishing trip.

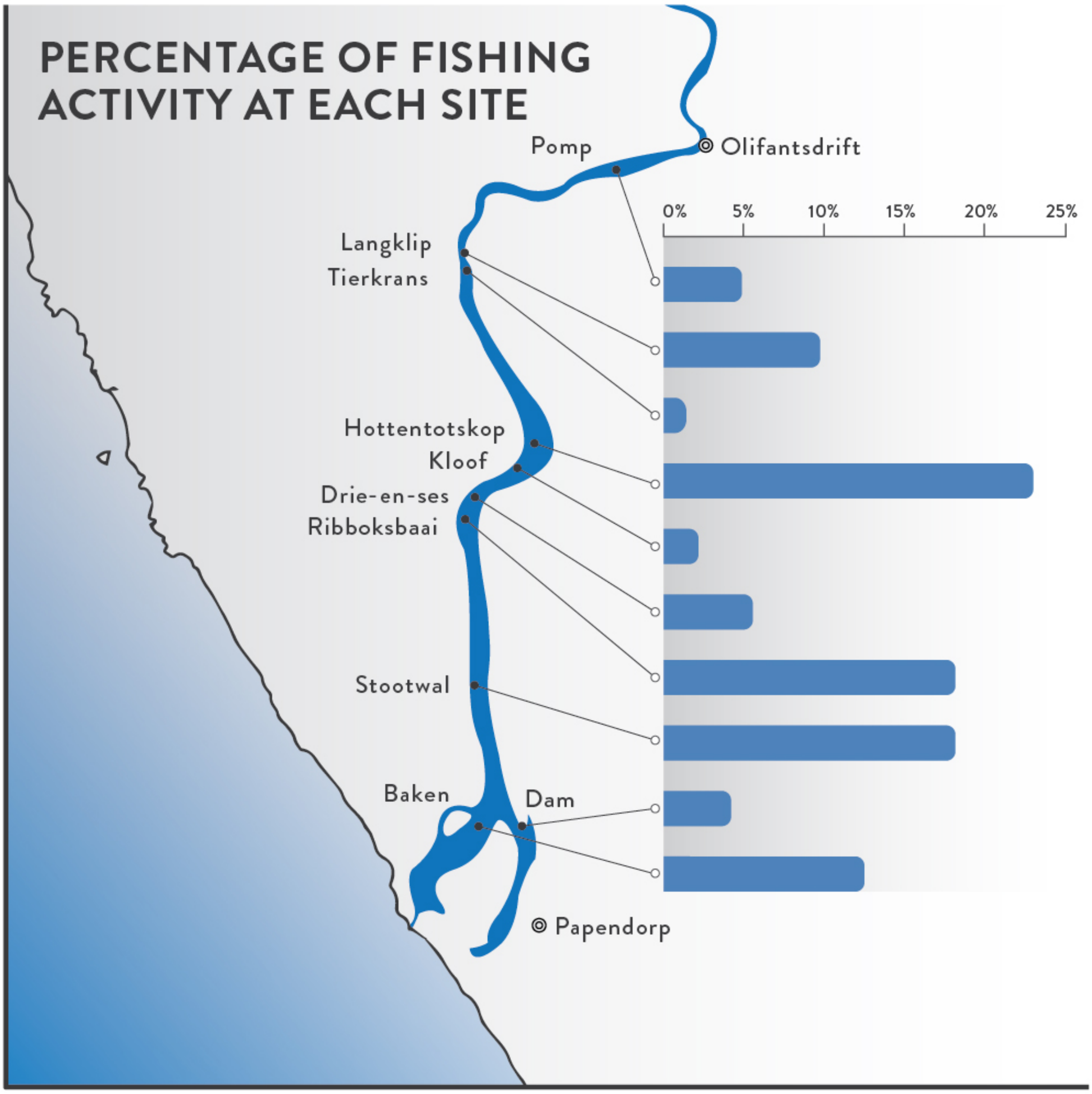

Figure 23: Most popular fishing sites in percentage with sites left being closest to river mouth moving right further upstream.

5.2.8. Recorded bycatch

Bycatch recorded for the monitoring period of 1st September 2012- 31st August 2013 was relatively small. Elf (*Pomatomus saltatrix)* is the main bycatch species that was recorded (Figure 24). However, over the entire period bycatch was generally low with only 24 Elf, 11 Kabeljou (*Argyrosomus inodoru*) and 10 Leervis (*Lichia amia*) being reported. These numbers are substantially lower than what Fielding et al. (2007) and Carvalho et al. (2009) reported. Furthermore, only 0.2 % of the recorded total catch for the monitoring period 1st September 2012- 31st August 2013 was bycatch (Figure 25). A lot of the bycatch species caught were well below their size of maturity (Table 8). Furthermore, *Pomatomus saltatrix, Lichia amia* and *Lithognathus lithognathus* were under the minimum allowable catch size (Table 8).

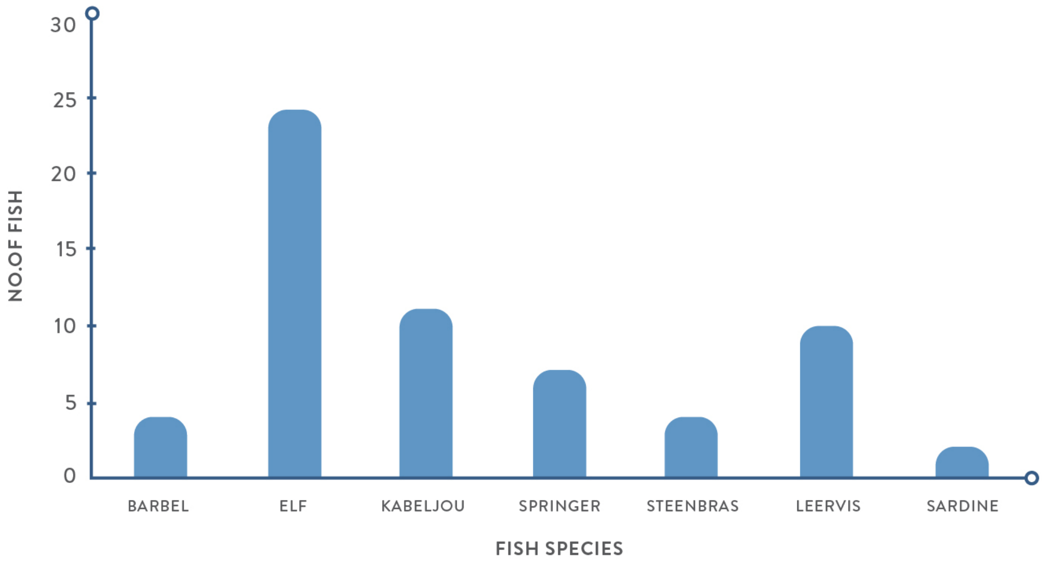

Figure 24: Bycatch recording from 1st September 2012- 31st August 2013.

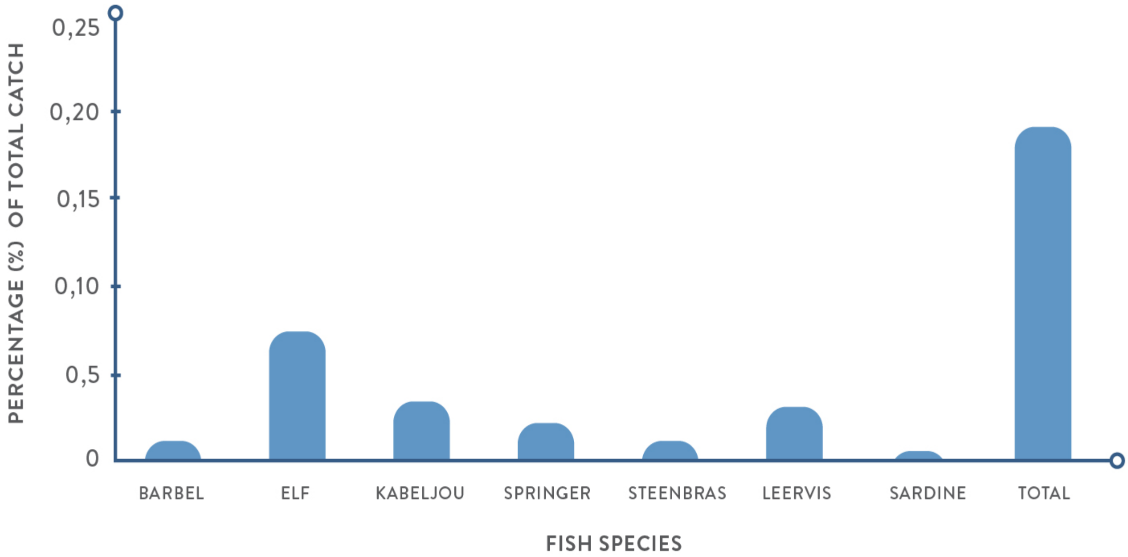

Figure 25: Percentage of bycatch of total catch in the monitoring period of 1st September 2012-31st August 2013.

Table 8: Average length of bycatch recorded and their size at maturity and minimum allowable catch size.

Species	Average Length (cm) in years 2012-2013	SD	Size at maturity (cm)	Minimum allowable catch size (cm)
Barbel	25.03	10.88	25	none
Elf	21.09	2.33	31	30
Kabeljou	56.86	14.75	30	50
Springer	41.13	11.56	75	none
Steenbras	28.13	8.01	55	60
Gunard	22.25	1.63	35	none
Leervis	28.99	3.06	75	70
Sardine	22.55	1.91	3	none

5.3 OVERALL FINDINGS

Overall data was not collected for 39% of the year. 45% of the year was monitored but of this period no catches were recorded for 3% of the time. There were minor gear changes from previous years (Fielding, 2007) with the mean net area and mesh size showing a slight increase. In the period from 1st August 2012- 31st September 2013 community monitors recorded a total of 31822 *Liza richardsonii*. Using the number to weight ratio it equates to 3744 kg of total recorded catch for the period from 1st August 2012- 31st September 2013. Over the entire year only 86 fishing events were recorded and the CPUE (kg per boat per fishing trip) was 27 kg with no significant difference from previous years. Size frequency distribution of the sampled *Liza richardsonii* is normally distributed, with on average most catches being between 23 and 24 cm. The most popular fishing site was Hottentotskop, whereas in previous years Baken near the mouth was the most popular site. Only 0.2 % of the recorded total catch was bycatch with several of the species caught being well below their size of maturity. The monitoring program has limitations in regards to capturing all fishing activity as monitors lost some of the data, took up other employment and were generally not active when fishermen returned in early hours of the morning.

CHAPTER 6: DISCUSSION

6.1. COMMUNITY MONITORING PROCESS

Community monitoring systems have many strengths by comparison to professional monitoring yet community monitoring still needs further development, verification and systematic comparisons between professional and locally based monitoring approaches (Danielsen et al., 2009b; Holck, 2008). In this chapter, the Olifants River estuary monitoring programme is discussed in relation to key features considered necessary for success and is categorised according to Danielsen et al. (2009b). Currently the monitoring can be categorised as a *Category 3* monitoring scheme as it involves local people in data collection and externally undertaken data analysis. In addition the strengths and weaknesses and areas of improvement are highlighted.

6.1.1 Development of the monitoring system

Overall the development of the Olifants River community monitoring system followed many of the features of developing a robust monitoring system (Danielsen et al. 2005b) although there were shortcomings that affected its efficiency. On ground implementation of the monitoring system in the Olifants River experienced problems that the design phase should have addressed. For example there were shortcomings in the sampling effort and monitoring activities (Section 5.1). There are gaps in the data that could have possibly been avoided with more attention to the design phase.

Furthermore, the lack of full stakeholder involvement from the inception of the monitoring system has resulted in the monitoring findings not effecting decision-making. Over the past year and in previous years when monitoring was undertaken, the monitoring data was collected and sent to the EEU for analysis and through community and stakeholder meetings fed back to the broader community and in some instances to DAFF. However, as the management authority, DAFF, has not been responsible for and involved in the community monitoring programme, the results have been met with caution and have not influenced decision-making greatly. The lack of involvement of government scientists in the monitoring system and their cautious attitude to the veracity of the process and data gathered, has meant that the findings have had limited impact on management decisions. Rather, the fishers, their research partners and lawyers have used the findings from the monitoring system to challenge the policy, proposals and recommendations by the fishery scientists and management authority to close the fishery (e.g. open letter to the Minister of DAFF). Although information gathered from the monitoring system aims to inform management and decision-making, the community-based structures to enable direct communication with DAFF and other agencies are not in place yet. The need to establish a co-management arrangement for the Olifants River estuary fishery has been emphasised for several years but since the promulgation of the MLRA and the designation of estuarine fisheries management to the national level, there has been no effort to establish such structures and arrangements. The lack of agreement between resource users and DAFF regarding the status of resources also called attention to the need for effective and ongoing resource monitoring. The lesson learned is that the entire process of the monitoring, from design to implementation, needs to be planned with all stakeholders and supported by all involved.

From informal interviews with fishermen, monitors and community members, it became clear that a more formal reintroduction of the monitoring project to the entire resource user group would have been advantageous. Hence, the first step of Danielsen et al.'s (2005b) monitoring system development, which is to discuss the need and aim of the monitoring system, is important. In addition, changes to the monitoring system should have been discussed in depth with the broader fisher community prior to implementation. Furthermore, although the monitors and the fishers were aware of the process of analysing the data, this aspect was never discussed with the broader community or management authority, nor was their clarity regarding how the results would be used, which is an important part of the design process (Danielsen et al., 2003).

In terms of Danielsen et al. (2003), the third step in the process of developing a community monitoring system is to agree on an institutional framework. Although it is important to set up an institutional framework in the design phase of the project, it can still be done at a later phase in the project. This highlights the importance of establishing institutions and structures that will and are able to take the process further so that the outcomes of monitoring actually influence management. The failure to establish functioning co-management arrangements at the Olifants estuary where government and local communities work collaboratively to manage resources has been one of the major shortcomings in establishing long-term effective local monitoring systems. As Danielsen et al., (2003) mention, the strength of local monitoring lies in strengthening local management of the land and resources and dealing with the threats to the resources.

According to Danielsen et al., (2003) the fourth step in the community monitoring process is to develop a simple but robust sampling strategy. The monitoring system of the Olifants sampling was simple and easily replicable. The main shortcoming was the detachment between the data sampled and the data analysed. A move to a *Category 4* monitoring scheme (Danielsen et al. 2009b) is therefore recommended.

In regard to on ground implementation various steps are vital to take. Through interviews with the fishers and monitors, it was communicated that it is essential that monitors and the project are introduced to the fishing community and their work explained as they are the communicators between the fishing community and the main representatives of the project. It is important for the monitors to be approved of and supported by the community. This became obvious when a monitor from DAFF was chased away by a fisherman who said he only gives his catch records to the UCT/EEU monitors (pers. com., monitor, 2013). The previous monitoring systems (Carvalho et al., 2009; Fielding et al., 2007) served as a pilot study to test feasibility of data collection protocols. The design of the monitoring system can easily be continued and replicated elsewhere (under similar socio-economic and environmental circumstances) as a common protocol was set up and followed and data collection was kept simple and standardized (Appendix 1 and 4). Generally the fishing community supported the monitoring project that made the implementation thereof easy. The main shortcoming was not having more constant supervision on site which resulted in inconsistency of sampling effort . However, this also indicated a lack of ownership, which can be attributed to the data collected not entirely influencing decisions (See section 6.1.3).

Currently the data is stored in dropbox, a cloud filing system accessible from any computer with Internet connection. This system has the potential of being highly useful if the resources such as computers with Internet and computer literate community members are available. Hence, this also has the potential for skills development and therefore capacity building of local communities. Especially if data gathering and analysis is done at different geographical locations can this system be highly effective as it can be shared and reviewed anywhere in the world. The data was stored in raw form making re-analysis and addition of new data possible. However, the feedback to monitors took a long time as data had to first be collected, then analysed and then taken back to the site. If data capture and analysis could be done on site the time lag can be avoided, resulting in a faster management response.

Overall the development of the Olifants River community monitoring system followed many of the features of developing a robust monitoring system although there were shortcomings that affected its efficiency. On ground implementation of the monitoring system in the Olifants River came up with problems that the design phase should have taken care of. For example there were shortcomings in the sampling effort and monitoring activity questionable (Section 5.1). There are gaps in the data that could have possibly been avoided with more attention to the design phase. The strengths and weaknesses of the Olifants River estuary will be elaborated on in the following sections.

6.1.2. Strengths and Benefits

One of the main strengths of a community monitoring system is that it is more cost effective than professional monitoring, which is important especially in areas where large funding is not readily available (Caughlan and Oakley, 2001; Danielsen et al., 2005b; Holck, 2008; Topp-Jørgensen et al., 2005). For professional monitoring the salary of the scientists will be high as well as transport and living costs for the scientists to the area where monitoring is undertaken.

Using local people to monitor the resource will eliminate the expenses of housing and transportation and they will generally not demand a high salary. In the Olifants River estuary accommodation of an outsider costs a minimum of 200-250 ZAR a day. Furthermore, should a scientist monitor the area for 5 days a week for a full year, then those costs will be much higher than simply employing a local community member. While the start-up costs of the community-based monitoring project will be high as equipment and training need to be provided, the project will be more cost efficient once it is operational. The main cost is the monthly salary for monitors. This salary also needs to be competitive enough for the monitors not to seek out other employment, especially in a poor rural setting. This research suggests that the salary of monitors of the UCT/EEU monitoring system was not sufficient for the monitors to not seek out other employment. Furthermore, the funding from the UCT project was limited to one year and hence the monitors knew that they would need alternative employment at the end of this period. For monitoring projects to be sustainable the funding pool needs to be adequate and ongoing or be financially supported by the community themselves for example funded by the community entity that benefits from sustainable resource harvesting. However, being in a developing country with financial limitations even funding from the state may not always be available and the community themselves currently cannot bear the costs of the monitoring.

The data collection method employed in the Olifants monitoring programme is not complicated. Data recording has been designed so that any literate community member with limited training can act as a resource monitor. Furthermore, the data gathered could be both used for management and scientific inquiry as it has been designed to inform both. The data collected by community monitors has the potential to be more accurate and realistic than professional monitoring as it is collected more consistently. Professional monitoring is often only done once a season via deploying nets at selected sites.

Monitoring and estimating catch-and-effort of the *Liza richardsonii* fishery on the Western Cape has generally been riddled with many problems for example changing market forces and receiving accurate information though surveys and catch return cards (Hutchings and Lamberth, 2002b). Hutchings and Lamberth (2002b) aimed at describing and quantifying the catch composition of the inshore fishery of the Western-Cape using interview questionnaires and access point surveys. Hence, management decisions, such as closing of the gill-net fishery in the Olifants River emanating from these stock estimates are controversial and have been met with disapproval from many small-scale fishing communities. The researchers came across many data collection problems which community monitoring has the potential to avoid. Yet, to substantiate this claim a more systematic comparison between professional and community monitoring approaches is required such as done by Holck (2008). Comparisons of locally based and professional monitoring are useful especially in locations where data-gatherers have received little or no formal scientific education. But not all local monitoring needs calibration to professional monitoring as this is costly, impractical and implies distrust. But methods need careful and well-documented checking against broadly accepted techniques.

One of the most important benefits of community monitoring is its contribution to promoting environmental democracy (Conrad and Hilchey, 2011). Through skills training and capacity building of local monitors and the sharing community information, environmental awareness increases and science is made more accessible to the public. Researchers, NGOs, other members of the fishing community and the monitors together discussed the future management of the estuary, which was made possible through the monitoring program. The monitors insights were shared with other members of the fishing community (mainly fishermen) and issues and opportunities were openly discussed resulting in increased awareness, local empowerment and a desire by the fishers to manage their own resources sustainably. Furthermore, this process made the scientists and government managers more aware of local knowledge and expertise and promoted the building of trust between stakeholders. Local empowerment can be taken further through allowing the data obtained from the monitoring system to inform the management authority (DAFF) and therefore allowing the fishing community to be involved in the management of the natural resources of the area. This step has not yet been achieved. Other benefits include increased understanding of the dynamics of the fishery, improved cooperation and problem solving due to a more informed community and stewardship ethic (Conrad and Hilchey, 2011). However, the extent to which the Olifants River estuary community monitoring program has achieved these outcomes needs to be further researched.

As mentioned previously, for the monitoring programme to reach its full potential the data must be interpreted locally. Hence, ideally the monitoring scheme should move from *Category 3* to the *Category 4* scheme (Danielsen et al. 2008). To move to a *Category* 4 scheme data interpretation or analysis must be by community members. Management can be more adaptive if data is interpreted locally and therefore is more closely linked to decision-making.

Involving the community in not only collecting data, but also interpreting it and making decisions based on it, is a form of co-management. Co-management of natural resources encourages participation and responsibility of local communities (Armitage, 2005; Berkes, 2009; Fraser et al., 2006; J. R. Nielsen et al., 2004; Pinkerton, 2011). Hence, moving the Olifants River estuary monitoring from *Catergory 3* to *Category 4* will further the good governance of resources by including and addressing divergent values and needs, by involving community members and local institutions in the management and conservation of natural resources, by transferring power and authority from central government to communities and local institutions and by including traditional values and ecological knowledge and thereby encourage sustainable communities and benefits to the ecosystem (Conrad and Hilchey, 2011; Folke et al., 2005). However, to take the Olifants River estuary monitoring project further and move it to a *Category 4* will require significant capacity development of monitors in terms of computer training, use of excel spreadsheets, and basic statistics. This will take time and mentorship and requires a secure source of funds for 3-5 years.

6.1.3. Weaknesses and Challenges

The predominant weakness of the Olifants monitoring program is the inconsistency of the sampling effort and monitoring activity and the gaps in data. For example, monitors did not collect fish catch data from the few fishermen that lived at 2 settlements, Nuwepos and Rooierwe, further up the river. Whilst this catch represents a relative small contribution to total catch (only three fishers) it nonetheless represents a gap in the data. It was difficult to be certain of the diligence of the monitors and whether they were methodical in recording all catches. Despite these gaps the trends are informative. Although there are some differences in terms of observations and trends obtained in this monitoring versus previous monitoring programmes (Fielding et al., 2007; Carvalho et al. 2009) e.g. such as total catch and most abundant fishing months, the trends with respect to length-frequency distribution, CPUE and bycatch are similar. In fact research by Carvalho et al. (2009) showed that the data collected by monitors are reliable.

There are obstacles to ensuring comprehensive collection of data in this context. Firstly, the working hours pose a problem as many of the fishermen return in the early hours of the morning and monitors are not yet active. This problem can either be avoided by making sure monitoring takes place at those times by for example, increasing the pay rate when monitoring is done during those hours or by establishing a landing site where catches can be stored until recording is done. Secondly, monitors can take up other employment (as was the case). This poses a problem as the monitors will not be available for recording catch returns and sampling effort will be inconsistent. However, it is understandable as the community is poor and any other income is sought after. All the monitors were single woman with one or more dependents. Hence, in such circumstances it must be realized in the design phase, that should other employment opportunities become available that the monitors will pursue them and contingency plans such as reserve monitors or a different data collection strategy needs to be determined.

Another solution to the issue of inconsistent sampling effort would be to develop a spreadsheet where every day activities are recorded to ensure that every day is accounted for. A system where daily recording are made should be implemented so that the fishing activity (or reason of lack thereof) can be accounted for. A further problem was that the monitors pooled some data. For example in December and February, the feedback received stated that there was no fishing taking place over the whole month because of bad weather conditions. December is one of the most important fishing months as it is in summer and usually associated with good catches. It is doubtful that not one single fisherman went out during this period even if no catches were recorded. Hence, the relatively limited recording of fishing events with no catches is questionable, and this data should be better captured. To increase the veracity of monitors' data a link between the monitoring data with environmental parameters such as rainfall, water temperatures, ambient air temperature, % salinity and % DOM could be created. By linking the fisheries monitoring data to environmental data low catch rate incidences due to environmental conditions can be ascertained (such as for example high freshwater content).

Another concern is the accuracy of the bycatch data. As the fishermen are not allowed to catch and keep bycatch they are reluctant to give this information to the monitors. This reinforces the importance in keeping resource monitoring and compliance separate. It must be noted that the resources in the area have always been managed in a top-down manner with a short period when co-management was implemented (Sowman, 2003). The community has always been told what to do (what to catch, what gear to be used, where to fish) via the permit system and their responsibility for and management of the fishery was never encouraged. Hence, the community has not been included in management decisions regarding the natural resource of the area although this is changing. Recently, with the development of the OEMP and the Olifants River Management Forum (ORMF) has the fishing community has been included in discussions and decisions with respect to the management of the river.

Most importantly the monitoring program must be economically and socially sustainable. Once, the funding from UCT/EEU project ceased, the program stopped. So economic feasibility in the long term must be addressed and hence a co-management structure where costs are shared must be implemented. The best situation would be a monitoring program that is supported by the relevant government agencies and receives adequate funding until such a stage when the system becomes self-sustaining. Another important question to address is social resilience. Should the findings recommend a reduction in fishing pressure due to the stock being overexploited, it needs to be asked whether the community can find alternatives or supplementary livelihoods to cease a reduction in effort. Hence, monitoring should not simply be for the sake of monitoring but should influence real outcomes (Conrad and Hilchey, 2011). Thus an important area of attention in taking the monitoring forward is strengthening the connection between the monitoring and the management process in order for its real effectiveness to be realized. As Danielsen et al. (2008) concluded, the connection between how conservation science is conducted and how it is applied needs to be improved.

6.1.4. Proposals to Improve Community-Monitoring

The last step in the process of developing locally-based monitoring according to Danielsen et al. (2005) is the discussion of the monitoring results with all national and/or local stakeholders who should be part of all monitoring programme. This is an important step for improving the application of participatory natural resource management. This includes revising the monitoring strategy from time to time as feedback is obtained from the monitors and fishers.

While improvements have been made to the Olifants River monitoring system, this research has highlighted further issues requiring attention. Sustainability issues such as post-project funding and ongoing training need to be addressed. Thus, engaging the fisheries management authority and obtaining their support and resources for the monitoring programme is essential. DAFF scientists have supported the need for monitoring and appointed a consultant to oversee a monitoring system in various coastal communities in 2013. Although DAFF contacted UCT/EEU with help in designing this monitoring programme, they had already appointed monitors before engaging with Olifants River fisher community. This lead to the fishing community of the Olifants River estuary complaining that the DAFF employed local monitors were appointed without their consultation and therefore not supported by the fishing community. However, researchers and fishers were involved in the design process of the DAFF monitoring programme. The extent to which the DAFF driven monitoring system will yield the results and outcomes expected, remains to be seen.

Another area requiring improvement is that the monitors' activities need to be overseen. There are various means of achieving this. The suggested method would be that monitors are part of the community entity that will be established in terms of the small-scale fishing policy and therefore self-control or internal control would be achieved. This calls for the strengthening of local institutions that develop and reinforce that resources are managed for social and environmental good (Place and Otsuka, 2001). The monitoring design must be sensitive to the local setting and practices. For example, the difficulty of recording catches of fishers returning in the early hours of the morning needs to be better integrated within the system. A suggestion would be that a logbook system is set up where fishermen enter the time when they left the landing site so that monitors know who was fishing that day.

Lastly, the tracking of management interventions resulting from monitoring should be kept and most importantly the monitoring programme must facilitate the development of national policy, guidelines or tools for monitoring (DAFF, 2012; Danielsen et al., 2005b). Recognition of the importance of community-based monitoring has been documented in the small scale fishing policy of South Africa (DAFF; 2013 S 4.3.2). All the above mentioned strengths, weaknesses and improvements of the Olifants River estuary monitoring system can be used as guidelines for community-based resource use monitoring required in terms of the Small-scale fisheries Policy.

6.2 STOCK TRENDS OF THE OLIFANTS RIVER ESTUARY

Although a stock assessment for *Liza richardsonii* in the Olifants River estuary was beyond the scope of this study the aim of the community monitoring program is to contribute to knowledge regarding the stock status and possible overexploitation. As highlighted in the previous section, the thoroughness of the monitoring programme can be improved. Nevertheless several key indicators present useful information regarding fishing effort, effort changes, bycatch issues as well as stock status of the harder.

6.2.1 Monitoring Activity

As mentioned above a weakness of the Olifants River estuary monitoring system is ensuring that monitors capture all fishing activity so that adequate local fishing activity and stock trends can be drawn. As can be seen in Table 3, 40% of the year was not monitored. There is a high percentage of days which were not monitored and thus possible information on fishing effort has been lost. In order to cross validate monitoring activity, fishermen should have been interviewed separately and questioned on their fishing activity, perhaps even through the use of personal logbooks. Thereby monitoring activity and monitoring recordings could be matched up with fishing activity and patterns according to the fishermen.

6.2.2 Fishery Indicators

All fishery indicators are from the recorded monitoring of the Olifants River fishery and include gear used, total catches, fishing effort, CPUE, size distribution of the harders, fishing area and bycatch.

Gear used

The increase in mean net area from 116 m^2 measured by Fielding (2007) to the recorded 132 m^2 could be a consequence of the increased mesh size (Table 3). According to some fishermen, in order to catch the same amount of fish as with a smaller mesh size used in the past they had to increase their net area. Fishermen mentioned that they need longer nets to catch the amount of fish they need to survive but also suggested that it is important to have a bigger mesh size to allow the young fish to escape. To substantiate the change of gear exact measurements of the gear should be made by monitors. However, this will be time consuming and tedious and fishers may not be willing to cooperate However, for CPUE to be more accurate details of the gear used (as this is part of the effort) is important.

Total catches

As 40% of the year was not monitored the total catches are most likely underestimated. Furthermore, the recording made for January and February were lost in Olifantsdrift, which will also contribute to an underestimation of total catch and summer catches. It became evident that the monitors were not weighing catches. However, as numbers to weight conversion rates are well known only taking the number of fish caught is adequate. As catches are quite variable throughout the year (Figure 13 and 14), catch monitoring should be consistent throughout the year.

Fishing Effort

Fielding (2007) reports that between 2004 and 2006 roughly 35-50 fishing events were recorded by monitors each month. In the period from 1st September 2012- 31st August 2013 fishing trips per month were also far less than between 2004 and 2006 (Figure 17 and 27). In winter 2005, 58 trips per month were recorded - the highest recording by EEU monitors (Figure 17). While the number of fishing events seemed particular low during the latter half of 2012 and early 2013, it is interesting to note that overall fishing events have declined (Figure 17). The general decline in the number of fishing events could indicate reduced fishing pressure on the Olifants River estuary. Reasons for the overall decline in fishing events are numerous. It could be an underreporting of fishing activity, fewer active estuarine fishers as many of the younger fishermen hold interim relief permits to catch lobster and other line fish out at sea, or this reduced effort could indicate a general move away from fishing to other forms of supporting their livelihood.

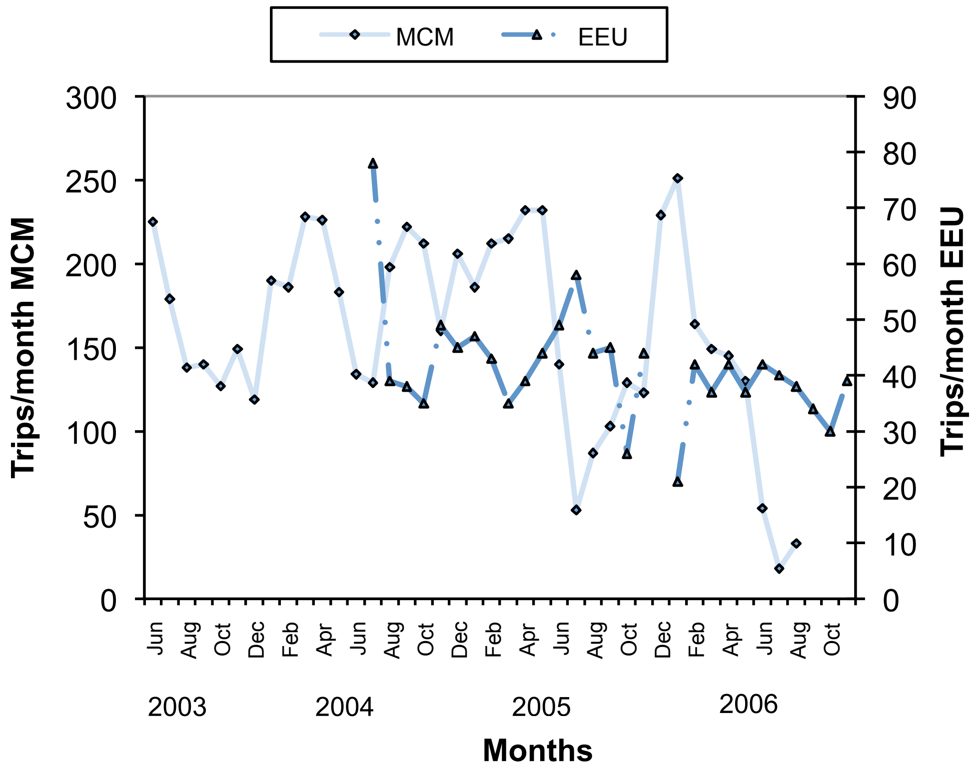

Figure 26: Number of trips per month recorded for Ebenhaeser gillnet fishers from Marine and Coastal Management catch card data and EEU monitors taken from Fielding (2007).

Catch per Unit Effort

Although an average CPUE of 27 kg per boat per trip is good compared to other years (Figure 11) the fishing community agreed that overall catches were low. Although one fisherman caught 800 fish on one day in January, this is still regarded as low as the community talks of catches between 1000 and 2000 fish on very good days. However, low total catch could also be due to many bad weather events preventing fishermen to go out to fish or fewer active fishermen or fishermen being busy with interim relief and other employment. Furthermore, there were very few events recorded that landed zero fish. This could also be an under recording of fishing events with no catches. However, this seems to be rather unrealistic as observations on numerous field visits indicated a few events where fishermen returning with no catch. Yet, these short fishing stints were communicated to the researcher as ‘testing’ if there were any fish around. If nothing was caught, the message was conveyed to other fishermen and the monitors and no further fishing took place. Overall, the CPUE trends indicate that the resource appears to be sustainably exploited. In order to make this conclusion more robust, the data should be more vigorously and statistically analysed (such as creating a general linear model and standardising CPUE).

Size of Fish Caught

The size distribution pattern of all harder caught in 2012-2013 is similar to the previous years of 2004, 2005 and 2005 (Carvalho et. al., 2009). However, the DAFF recommendations for management of sustainable gillnet fisheries (2012) found the highest size frequency of *Liza richardsonii* that was caught in the Olifants River to be at 26 cm with a mean of 25.9 cm. To be able to compare current findings to the DAFF report, more detailed information such as sampling effort and year of data collection is required. Furthermore, as there has been an increase in mesh size (Table 3) it can be suspected that the mean total length is slightly higher than in previous years, as larger mesh sizes catch larger fish (Marais, 1985). While more data and accurate analysis are needed, it appears as if the size distribution of harders has not changed significantly, possibly indicating a healthy fishery.

License

The apparent large number of unlicensed fishermen fishing in the estuary could be attributed to 1.) Daff issues the yearly license late, illegal fishers who lost out several years ago when permits were reduced drastically, or they could be interim relief permit holders who fish on the estuary if conditions at sea are rough or when their fishing season is closed. When interviewing one of the younger interim relief fishermen he mentioned that he still fishes on the estuary and catches a lot of fish. Furthermore, he mentioned that when the sea is rough or season for interim relief species is closed that many of the interim relief permit holders still rely on the estuary as a source of livelihood and therefore need to fish ‘illegally’. This highlights the importance of multi-species approach to fisheries management whereby small-scale fishers could target a range of species throughout the year but depending on seasonality, weather patterns and even market prices.

Fishing area

Hottentotskop is a popular fishing site as it is about 200m wide and therefore one of the principal fishing sites for the gillnet fishery (Huschlak, 2013). Furthermore, fishermen have mentioned that the biodiversity at Robboksbaai is high and that many fish forage here (Huschlak, 2013). That often more than one fishing area was visited indicates the need to move fishing grounds so that one fishing event can still amount to adequate catch. Reasons for less fishing activity at 'Baken' are unknown but could be due to the raised awareness that fishing near the river mouth is not good for the fish stocks that are entering the estuary. As fishers fish throughout the estuary makes it unrealistic to close off larger parts of the river.

Bycatch

Most of the bycatch caught in the river by the netfishers was under their size at maturity and further strengthens the importance estuaries hold as nursery grounds for juvenile species. Furthermore, because it is illegal to keep bycatch it is highly possible that not all bycatch is being reported. Although fishermen were assured that their catch would not be confiscated, there appears to be mistrust. In an effort to document and share fishers knowledge the EEU asked the fishermen which fish species and its frequency in catch are caught in the Olifants River (Table 9). This indicates their actual frequency in catch is much than recorded by the catch monitors. However, the monitors informed fishermen that the bycatch information is vital so that a realistic picture of the state of bycatch stock in the estuary can be drawn. After the monitors were active for a while the fishermen realised that the bycatch was neither confiscated nor were they reported, and this strengthening the trust relationship between fishers and monitors. However, closing the Olifants River gillnet fishery on basis of the recorded bycatch cannot be justified as bycatch levels are very low. According to Fielding (2007) the current levels of bycatch in the estuary are very small because of the generally reduced stocks of line-fish.

Table 9: The fishers identified the following 14 species that they catch in the river and ranked them according to their importance (predominance) in the catch.

Species Common Name	Scientific name	Frequency in catch
Harders	*Liza richardsonii*	1
Elf	*Pomatomous saltatrix*	2
Kabeljou/kob (silver)	*Argyrosomus inodorus*	
Barber/Barbell (fresh water)	Clarias Gariepinus or Galeichthyes feliceps	5
White Steenbras	*Lithognathus lithognathus*	3
Leervis	*Lichia amia*	
Springer	Elops machnata	4
Witstompneus	*Rhabdosargus globiceps*	3

This chapter has discussed the nature of the community-based monitoring system at the Olifants River estuary as well as its strengths and weaknesses. It has also discussed the findings of this monitoring system in relation to previous data and the literature. In addition to the practical improvements that are required to the Olifants River estuary community-based monitoring programme ideally it needs to move from its current *Category 3,* where local people are the data collectors and also participate in management-orientated decision-making on the basis of the results of monitoring, to a *Category* 4 monitoring scheme (Danielsen et al., 2009b). This move would entail training of local people to interpret and analyse the data emanating from the community-based monitoring programme and therefore further increase social capacity and empowerment. Research has shown that information obtained from the monitoring programme of the Olifants River estuary harder fishery is reliable (Carvalho et al., 2008) and can be used for resource monitoring. Although there were inconsistencies in the sampling effort and hence the data set was not complete for the year under study, the fishery indicators examined showed that the monitoring was informative and that trends such as CPUE, length frequency distribution and bycatch were similar to previous years. However, it must be pointed out that the period from 1st August 2012 to 31st September 2013 was generally a bad fishing year by all accounts.

Lastly, the question of who should be facilitating the community monitoring programme must be answered. As estuarine systems fall under the management competence of DAFF, DEA and DWA, integrated management is necessary. Currently, DAFF is responsible for management and law enforcement of fisheries within the estuary. However, due to being understaffed and underfunded, on ground management and monitoring is limited. Transgressions can be reported to the DAFF official but are rarely pursued. Responsability must be shared across and between government departments, local management agencies and local communities and stakeholders. This requires open and ongoing horizontal and vertical communication. Currently monitoring is in a state of flux as DAFF has appointed a service provider to employ local monitors to undertake monitoring of the fishery. However, ideally fisheries monitoring should be integrated with other environmental monitoring and overall estuarine management. Hence, other departments such as the DEA and the DWA need to be included in the process. Most importantly however, the resource user community must be consulted and included in the monitoring and management of the estuary.

CHAPTER 7: CONCLUSION

This research provided an overview and analysis of the community-based monitoring system developed for the Olifants River harder fishery. As part of this research the previous monitoring system operating on the estuary from 2004-2006 was slightly modified based on feedback from fishers and scientists, revitalised and re-implemented. Through participatory research the strengths and weaknesses of the community monitoring system are assessed and discussed and improvements are suggested. Furthermore, the data collected by community monitors was analysed and fishery indicators evaluated with reference to community data collected in previous years. Although a stock assessment was beyond the scope of this study, one of the aims of the study was to contribute to knowledge regarding the stock status and possible overexploitation Fishery indicators such as the gear used, total catch, CPUE, license, size frequency and bycatch were assessed against previous data for the fishery and data on catch and effort trends were obtained. Community-based catch monitoring showed to be extremely useful at providing information on catch and effort trends for the river system. The main shortcoming of the community monitoring programme was that monitors were not capturing all of the fishing activity. Nonetheless the monitoring programme provided useful information of the fishery with indications that firstly, fishing pressure has been reduced, and secondly, CPUE of the target species (*Liza richardsonii)* is stable and there is no indication of overexploitation. Although it is not possible to confirm total fish landed for the year monitored due to incomplete data, discussions with fishers and researchers suggest that there were fewer fishers active on the river due to some fishers getting involved in harvesting West Coast Rock Lobster and other line-fish through the interim relief permit system. Furthermore, according to the fishers and monitors, fishing was reduced during the study period by comparison to previous years, due to poor fishing conditions on the river. However, to arrive at more robust conclusions regarding the status of the fishery further research is required and more rigorous analyses are needed.

An integral component for securing the success of a monitoring programme is early inclusion and participation of resource users in the program (Danielsen at al, 2009b). The research demonstrated that communication with and involvement of resource users and other affected stakeholders at the development phase of the monitoring programme is important. This was accomplished through participatory action research where the community directed the research questions and confirmed the need for the research. Hence, the Olifants River fisher community voiced the need for independent monitoring of the fishery. Furthermore, one of the key strengths of the community-based monitoring programme, is its cost effectiveness, - it is simple yet sufficiently detailed to provide data for management decisions. Through the monitoring programme knowledge and skills of local monitors and the community are strengthened. Furthermore, information is shared, understanding and knowledge is gained and therefore awareness of environmental issues increases. Thus through the monitoring programme science is made more accessible to local communities. The monitors were part of stakeholder discussions regarding the future management of the estuary and therefore the data derived from the monitoring program were more closely linked to proposals that informed decision-making. Knowledge and insights gained from participation in the monitoring system were shared with other members of the fishing community and management authorities. Issues and opportunities were openly discussed resulting in local empowerment and a desire of the fishing community to be more actively engaged in managing their own resources. However, these outcomes can only become useful and truly effective if co-management is implemented and if community monitoring is part of the co-management process.

There are a number of weaknesses in the community monitoring system. Of concern are the gaps in the data set which can be attributed to data being lost and lack of commitment by monitors to gathering comprehensive catch records. Although not explicitly stated by the monitors, it appears that poverty and the need to earn income led to some monitors taking up other work opportunities during the study period resulting in some catches not being recorded. A further weakness of community monitoring in the Olifants River estuary is the absence of a clear link from data recording to analysis to decision-making. Currently the data gathered by monitors is analysed by the research team and fed back to the community at the end of the project or monitoring period-in this case after one year. The current system should attempt to move towards greater involvement of the local monitors in analysing and interpreting data locally so that decisions regarding the management of the fishery can be made faster. This will further increase the management adaptability and response to fluctuating conditions. The monitoring programme can be further improved by implementing a more rigorous monitoring and mentoring system that ensures that data from most fishing activity is captured. However, building local capacity to analyse local data will enhance sense of ownership and minimise risk associated with lost data. Strengthening local institutional capacity through the establishment of a community entity as required by the small-scale fishing policy will further ensure that monitoring activity is more streamlined and efficient. .

The indicators that were reviewed to get an idea of the state of the fishery suggest that the Olifants River harder fishery is sustainably exploited, that the fishing pressure on the estuary has been reduced compared to previous years and that the size frequency of caught harder has not changed from previous years. Recorded bycatch was very low (0.2% of total catch) which could be due to an underreporting of incidental catch or simply that estuarine fishermen do not land a lot of bycatch. However, as fishermen have to surrender all incidental catch to authorities it could be that they are reluctant to report the catch even to the local monitors. This highlights the importance at keeping enforcement and resource monitoring separate. Clearly, further research on bycatch is required not only to determine catch rates but also to gain a more holistic understanding of the role of this gillnet fishery in contribution to declines in certain line-fish species.

The Olifants River estuary harder fishery has been an issue of contention between national fisheries and conservation management authorities and local resource users. The conflict between local users and management about closing the gillnet fishery highlights the need to shift to the a new management approach. The new approach to management emphasizes the inclusion of resource users in monitoring, decision-making and management of natural resources. Developing countries like South Africa, where management authorities are under capacitated suggests that inclusion of resource users in monitoring and management can play an important role in natural resource management. Employing local resource users as community monitors can provide ongoing, reliable and invaluable data for decision-makers and natural resource managers. Lessons from the Olifants River estuary community monitoring program provide useful insights that can be incorporated into developing reliable and effective community monitoring systems required in terms of the new Small-scale Fisheries Policy for South Africa.

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APPENDIX

Appendix 1: Olifants River Bycatch Catch Return Sheet

	Species	Total length (cm)	Weight (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
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30			
31			
32			
33			
34			
35			
36			

	Species	Total length (cm)	Weight (g)
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
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68			
69			
70			
71			

Species	**Total weight of measured fish (kg)**

Appendix 1: Olifants River 'Harder' Catch Return Sheet

No. __________

Monitor's Name ________________________________

Date _________________________________Time of Interview __________________________

Fisher's District: Olifantsdrift ☐ Papendorp ☐ Nuwepos ☐ Hopland ☐ other _____________

Number of Fishermen on boat ___________________ Permits 1. Y / N 2. Y / N

Date and time start fishing _______________________ End fishing ________________________

Duration of fishing: 1-4 hrs ☐ 4-8 hrs ☐ 8-12 hrs ☐ 12-16 hr ☐ + 16 hrs ☐

Fishing places __________________________________ Number of Nets on Boat ___________

Net length (m): 35 m ☐ 45 m ☐ 60 m ☐ other __________

Depth of net (m) __________

Mesh size (mm): 44mm ☐ 48 mm ☐ 51 mm ☐ 54 mm ☐ other __________

Total number harders caught ________________ Total weight of harders (kg) ______________

Total number of salted harders __________Total weight of measured harders (kg) __________

Species: *Liza richardsonni* (harder)		
	Total Length (cm)	Weight (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

Species: *Liza richardsonni* (harder)		
	Total Length (cm)	Weight (g)
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
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50		

Appendix 2: Advert for the position of 'walskippers' for the Olifants river estuary

In a meeting held with the fishing community in May 2012, the fishermen recognised the need for the reimplementation of fishing monitors on the Olifants River Estuary. The Environmental Evaluation Unit (EEU) and together with the University of Cape Town (UCT) are looking for candidates to be trained as 'walskippers', who will be committed to the project for a one year period.

<u>Employment Criteria:</u>
The minimum education should be standard 8 to standard 10
The candidates should be unemployed or only be involved in part time work
The successful candidates should be able to work at flexible times (2-4hrs) every second day a week.
Salary: R 850 per month
The successful candidates should have a keen interest in the fishery, they should be honest reliable, responsible, and motivated to work with the fishers of Ebenhaeser
Please submit a short (one page) CV and a motivation letter (one page) explaining why you would be a suitable candidate.
These should be handed to the EPIOS office.
Short-listed candidates should be available for an interview from August 2012

CLOSING DATE FOR APPLICATIONS: (?) August 2012
Training is due to start in mid August 2012.

Please use the CV format outlined below as a guideline
Name:
Identity Number:
Date of Birth:
Age:
Gender (m/f):
Number of dependents:
Are you the primary breadwinner (yes/no):
Which languages do you speak?
Address:
How long have you been at the current address?
Contact number:
Highest education level:
Last three places of employment:
Current employment:
Which organisation are you a member of (e.g. Church group, fisher association, social club etc.)
Motivation letter
Q: Why do you think that you are most suited to be employed as a walskipper?

Table 1: Appendix 3 Past Olifants River estuary data overview

Year	Sampling method	Report	Data Location	Raw data months	Analysed
1994	CCf	OLRAC/EEU (2001)	SPSS.sav merge1.sav?	File "for Pete 1994-2001 results" in catch monitoring pre '12_from fielding	CPUE from 94-01 (standardized, relative, adjusted net length)
1995	CCf	OLRAC/EEU (2001)			
1996	CCf	OLRAC/EEU (2001)			
1998	No				
1999	No				
2000	CCf	OLRAC/EEU (2001)	In SPSS database?		
2001	CCf	OLRAC/EEU (2001)	In SPSS database?		
2002					
2003	CCf	Fielding (but only MCM data)	Dropbox_pre '12_from Fielding_MCM (03-06!)		
2004	CCm/ CCf	Fielding, Carvalho MCM	Dropbox,_Fielding; Dropbox_Database All Monitoring	July-December	Bycatch analyses with gaps/descriptive data full analyses!
2005	CCm/ CCf	Fielding, Carvalho MCM	Dropbox,_Fielding; Dropbox_Database All Monitoring	All excl. December (why?)	Bycatch analyses with gaps/ descriptive data full analyses!
2006	CCm / CCf	Fielding, Carvalho MCM	Dropbox,_Fielding; Dropbox_Database All Monitoring	All months available	Bycatch analyses with gaps/ descriptive data full analyses!
2007	CCm?	MCM? -	-	empty	
2008	CCm?	MCM? EEU report- not analysed yet?	Dropbox,_Fielding; Dropbox_Database All Monitoring	Jan-Sept excl June	
2009	CCf ? CCm	MCM? EEU report- not analysed yet?	Dropbox,_Fielding; Dropbox_Database All Monitoring	April, May, July, Aug,Sep	
2010	CCf ? CCM	MCM? EEU report- not analysed yet?	Dropbox,_Fielding; Dropbox_Database All Monitoring	Feb, Mar, Ap,Jun, Jul, Sep,Nov	
2011	CCf ? CCM	MCM?			

CCf: Catch Cards filled out by fishermen (MCM project)
CCm: Catch cards filled out by monitors (EEU project)
CCf 2003-06: MCM
Data Location: Raw data location (e.g. digital file, or hard copy)

Descriptive Data in Fielding folder pretty much has it all for year 04-06

Appendix 4: Liza richardsonii 'harder' Data Collection Protocol

1. Training of monitors (August 2012 by Samantha Williams, Merle Sowman, Nadine Soutschka)

History, motive and importance of research i.e. harder and by catch monitoring

Fish ID, measurement procedure, filling out of catch card*

2. Monitoring (Started beginning of September 2012)

Two female monitors from Olifantsdrif and two female monitors from Papendorp who will collect data when fishermen go out (data collection Monday-Friday)

Record days of no fishing and days of no catch (!)

Data collection from September 2012 till day of termination

3. Catch card *(Appendix 1)

Date, location, duration, gear used

Subsample of 50 harders

By catch (all caught, total weight of the 5 species caught most)

4. Data Pooling (Nadine Soutschka)

Monthly site visit (or more) for feedback from monitors

Catch cards to be collected

Information put into digital data base (EEU) -> Dropbox

5. Analyses (Nadine Soutschka)

Statistical analyses of data

Communicate findings and analytical procedure with fishermen, community and fisheries scientists