

Progress in implementing the ecosystem approach to fisheries in South Africa in principle and in practice

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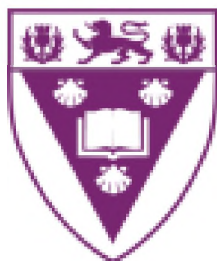
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Abstract

Over the last century, the population of the world has more than doubled, resulting in an increase in seafood consumption (FAO 2010), and placing strain on fisheries wild stocks, their habitats, and the coastal communities that rely on them for food and survival. The ecosystem approach to fisheries (EAF) differs from other management approaches by combining all aspects of ecosystem management, and strives to conserve ecosystem structure, maintain diversity, productivity, and integrity, and to meet human food and economic needs. This study aims to assess how South Africa is progressing in implementing EAF in principle and in practice, to identify challenges, and suggest solutions, where appropriate.

The law sets precedence on governance. An assessment of the Marine Living Resources Act, (MLRA) and the South African Policy for Small-scale Fisheries (SSFP) revealed that, although these instruments recognise and contain elements of EAF, this management approach has not been adequately implemented. In practice, the status of implementation of EAF was assessed through the Southern African Sustainable Seafood Initiative (SASSI) and the Ecological Risk Assessments (ERA). The scores of 65 assessments, conducted in 2013 and 2014, were obtained from SASSI. Of the 65 species assessed; 18.4% were listed as Green, 50.8% were listed as Orange and 30.8% were listed as Red. Two methods were used to analyse the data; non-metric multidimensional scaling (NMDS), and cluster analysis in the statistical program R. Analysis of the SASSI assessments indicates that there has been progress in implementing EAF since the World Summit on Sustainable Development in 2002. The high number of Orange and Red listed species however, indicate that major sustainability issues still exist. Species in commercially important fisheries enjoy the bulk of research and management attention compared to other species, including bycatch species, as reflected by a high proportion of Green-rated commercially important species. Based on these results, four fisheries were chosen for further in-depth analysis using additional information found in ecological risk assessments: offshore demersal trawl, inshore demersal trawl, West Coast rock lobster fishery and the line fishery. The documents and published literature of the Department of Agriculture, Forestry and Fisheries Internal Scientific Working Groups provided further information. A Wilcoxon signed rank test conducted in the programme R on the results

of the ERAs showed that there was a decline in implementation of EAF and reinforced the earlier conclusion that large commercial fisheries, offshore and inshore demersal trawl, were progressing in implementing EAF faster than West Coast rock lobster and line fisheries, which are examples of smaller-scale fisheries that are more accessible to many resource users. Both progress and challenges appeared to be largely influenced by several common factors, which include the presence or absence of positive incentives, co-management, management plans, access, compliance, economic importance, capacity, and the interests of rights holders and other stakeholders.

Chapter 1: Introduction

1.1. Background and literature review

1.1.1. Towards an ecosystem approach to fisheries (EAF)

Over the last century, the population of the world has more than doubled, resulting in an increase in seafood consumption (FAO 2010). Fisheries provide livelihoods, including employment and food security for humans, to the estimated 58.3 million people currently employed in the primary sector of the fishing industry, and an estimated 4.3 billion people source 15% of their protein from fisheries and aquaculture products (FAO 2014). These products are traded on a global scale, with a gross value of over USD217.5 billion in 2010 (FAO 2012).

Human activities in the ocean have negatively impacted marine ecosystems, the functioning of which is a complex phenomenon that is yet not entirely understood (Murawski 2007). Different species have been observed to occupy different trophic levels within an ecosystem, with most food fish occupying a trophic level between 3.0 and 4.5 (Pauly et al. 2002; Shannon et al. 2003). Some of the negative impacts caused by fisheries on marine ecosystems include the removal of predator species which reportedly causes cascading effects where prey species are released from predation and subsequently increase in numbers, shifting the balance of ecosystems and affecting the food chain (Pauly et al. 2002). The biomass of exploited species has been reported as decreasing over the years and, further, removal of large individuals may cause selection against larger, fast-growing individuals, so threatening intraspecific genetic diversity of species, (Pauly et al. 2002; Mullon et al. 2005). Another negative impact includes the damage to benthic habitats caused by bottom trawling. These habitats are important for demersal species as well as for the juveniles of some species. Trawling reportedly also affects the physical and chemical properties of the seabed, leading to mortality of benthic species (Bergman and van Santbrink 2000; Pauly et al. 2002) which can, in turn, affect biodiversity of ecosystems (Bergman and van Santbrink 2000; Jennings and Reynolds 2000). Bycatch is also a problem faced by many fisheries (Jacquet and Pauly 2008). Bycatch typically includes undersized target species, low or no commercial-value species, invertebrates, and protected,

vulnerable, threatened and endangered species (van Marlen 2000). Unwanted bycatch is often discarded as it is economically not viable to land it (Attwood et al. 2011).

The goal of the ecosystem approach to fisheries management is to balance the social and economic benefits obtained from fisheries with the wellbeing of marine ecosystems and sustainability of resources (FAO 2003). Many concepts have been developed in an attempt to define what EAF is, as illustrated by Short et al. (2008) (Table 1.2). This thesis uses the term 'ecosystem approach to fisheries' to encompass all the different concepts listed in Table 1.2. These concepts share similarities in recognising the different drivers that influence ecosystems. Another common feature between these concepts is the recognition of an integrated approach to fisheries management, which is necessary to reduce the negative impacts of fisheries on ecosystems, rebuild damaged ecosystems, and ensure optimal and sustainable benefits for humans (Murawski 2007; Short et al. 2008). EAF includes (1) a better understanding of the complexities and functions of ecosystems, (2) the realisation that fisheries are broader than fishing activity, and (3) the involvement and participation of stakeholders (co-management) along with a strong political commitment (Sigurjonsson 2008). EAF combines ecosystem management with fisheries management (Symes 2000; FAO 2003). Ecosystem management strives to conserve ecosystem structure, and maintain diversity, productivity, and integrity, while fisheries management strives to meet human food and economic needs (Symes 2000; FAO 2003). Short et al. (2008) described EAF as a way of managing human activities on the ocean. The FAO defines EAF as follows: "*An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries*" (Fig. 1.1) (p.14, FAO 2003). Its purpose is "*to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems*" (p.14, FAO 2003).

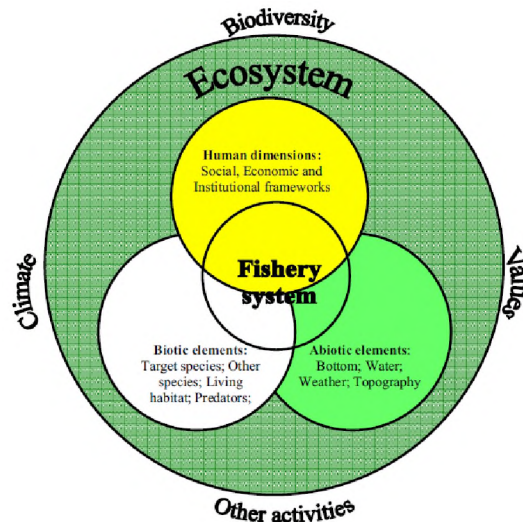


Figure 1.1: Schematic representation of the components of an ecosystem approach to fisheries (FAO 2009).

Institutional foundation of EAF

Over the years, as the understanding of negative impacts caused by humans on the environment broadened, ecosystem-related issues became the focus of many international conferences and conventions. These discussions led to the conceptualization of sustainable development. Sustainable development in fisheries is said to be central to EAF (FAO 2003; Garcia et al. 2003). Bianchi (2008) described the institutional development of EAF as having three strings; environmental, legal, and fisheries management (Fig. 1.2).

The legal string originated with the 1982 United Nations Convention on the Law of the Sea (UNCLOS). This convention led to the development of the United Nations Law of the Sea (UNLOS, UN 1982), which provided the legal foundation for use of the oceans and seas, and included the legal responsibilities of states in conserving living resources in and beyond their own exclusive economic zones (EEZs). This convention contains important elements relevant to EAF. The 1995 United Nations Fisheries Stock Agreement (FSA, UN 1995) stresses the importance of conserving biodiversity and maintaining ecosystem integrity by (1) protecting biodiversity, (2) adopting measures that will ensure long-term sustainability of fish stocks but can still be utilized optimally, (3) being cognisant of environmental and economic factors, (4) adopting an

approach that takes into consideration dependent or associated species in an ecosystem, and (5) adopting measures to prevent overfishing. The FSA emphasised minimizing risk and also dealt, in detail, with a precautionary approach (Garcia et al. 2003, Bianchi 2008).

The United Nations Conference on Human Environment (UN 1972) was the origin of the environmental string, where concerns about negative human impacts on the environment were stressed. It also underlined that *“economic and social development is essential for ensuring a favourable living and working environment for man and for creating conditions on earth that are necessary for the improvement of the quality of life”* (as quoted by Bianchi 2008) and *“the right of Man to modify the environment for its development and the dangers behind the huge capacity developed to do so”* (as quoted by Garcia et al. 2003). With concern for the environment in mind and the interest for human development and advancement, scientists came up with the concept of sustainable development. Sustainable development is *“meeting the needs of the present without compromising the ability of future generations to meet their needs”* (WCED 1987). The 1992 United Nations Conference on Environment and Development (UNCED, UN 1992a) was a continuation of the environmental string of the international developments of EAF. This conference finished the work of the WCED, led to the adoption of a number of conventions and agreements such as the Framework Convention on Climate Change, the Convention on Biological Diversity (CBD) and United Nations Fisheries Stock Agreement (FSA), and resulted in the signing of the Rio Declaration (UN 1992b), and the development of Agenda 21 (UN 1992c). Agenda 21 was the basis for implementing the ecosystem approach to ocean management. It recognised that utilizing marine resources and protecting the environment cannot exist without each other, and that integrated management was necessary to achieve these objectives. The Agenda addressed, in detail, the integrated management and sustainable development of coastal areas, marine environmental protection, sustainable use and conservation of marine resources in the high seas, and uncertainties related to natural variability and climate change.

The CBD (1992)¹ emphasises conservation of biodiversity, sustainable use of ecosystem components, and sharing of benefits. The CBD further links the right of users to exploit biological resources with the responsibility to manage activities that threaten biodiversity and to collaborate to manage those threats. At the Convention's fifth meeting, in 2000, the CBD developed and recommended the application of twelve principles for multiple-use management of biodiversity (Table 1.1). Two years later, the World Summit on Sustainable Development (WSSD 2002a) highlighted the importance of the Reykjavik Declaration (described later) and adopted a Plan of Implementation (WSSD 2002b) which saw heads of states committing to implement EAF by 2010 (FAO 2003, Garcia et al. 2003, Bianchi 2008).

The last of the three strings deals with fisheries management; the Food and Agricultural Organisation (FAO) is the primary agency of the United Nations for this string. As a United Nations' agency, the FAO has a mandate to promote the implementation of EAF by assisting governments to understand EAF in order to develop appropriate policies, promote best practices and to collect global fisheries information and statistics, amongst others. The FAO Code of Conduct for Responsible Fisheries (CCRF, FAO 1995) reached a milestone in 1995 by developing an internationally accepted voluntary framework for the sustainable use and development of fisheries and aquaculture. The term 'ecosystem approach to fisheries' (and the closely allied 'ecosystem-based fisheries management', or EBFM) had not been commonly adopted at the time of the development of the Code of Conduct, but the Code of Conduct was, nevertheless, a significant foundation of the fisheries management string leading to the adoption of EAF. The 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem (FAO 2001) is considered a notable achievement in turning high-level international policies and agreements into national policies and management plans. The core focus of the Declaration was introducing more ecosystem considerations into conventional fisheries management. The Declaration called for "*(i) immediate introduction of management plans with incentives for sustainable use of ecosystems, (ii) strengthening of governance, (iii) prevention of adverse effects of non-fisheries activities on the marine ecosystems and fisheries, (iv) advances in the scientific basis for incorporating ecosystem*

¹ <http://www.cbd.int/ecosystem/default.shtml> (accessed 26 September 2014)

considerations in management (including the precautionary approach), (v) strengthening of international collaboration, and (vi) development of guidelines by the FAO”, amongst others (p.79, FAO 2003). The Declaration was signed by 42 countries (FAO 2003; Garcia et al. 2003; Bianchi 2008).

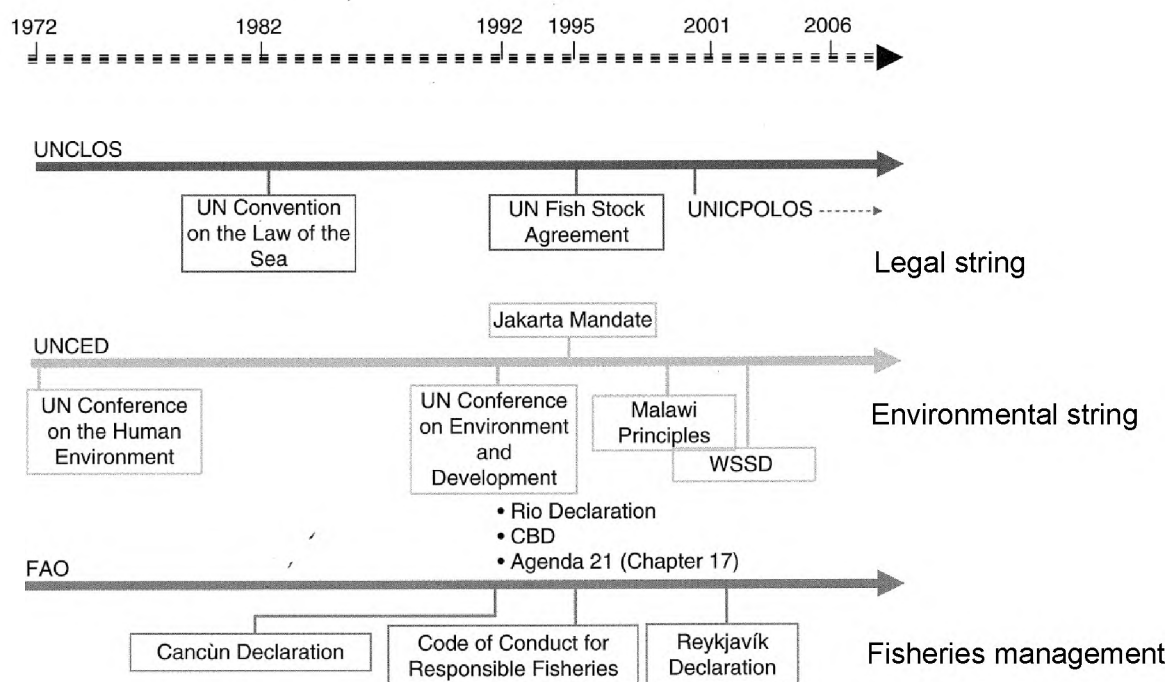


Figure 1.2: Schematic representation by Bianchi (2008) portraying the three strings in the development of EAF.

Table 1.1: Principles of EAF developed by CBD and FAO (CBD 1992; FAO 2003).

Principles of EAF provided by Convention on Biological Diversity (1992)
1. The objectives of management of land, water and living resources are a matter of societal choices. 2. Management should be decentralized to the lowest appropriate level. 3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

4. Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:
 - a) reduce those market distortions that adversely affect biological diversity;
 - b) align incentives to promote biodiversity conservation and sustainable use;
 - c) internalize costs and benefits in the given ecosystem to the extent feasible.
5. Conserving ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
6. The ecosystem must be managed within the limits of its functioning.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management must recognize that change is inevitable.
10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and the use of biological diversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific, indigenous, and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Principles of EAF provided by FAO (2003)

1. Fisheries should be managed to limit their impact on the ecosystem to the extent possible.
2. Ecological relationships between harvested, dependent and associated species should be maintained.
3. Management measures should be compatible across the entire distribution of the resource (across jurisdictions and management plans).
4. The precautionary approach should be applied because the knowledge of ecosystems is incomplete.
5. Governance should ensure both human and ecosystem well-being and equity.

Table 1.2: Concepts and definitions of EAF (Short et al. 2008).

Ecosystem-based management (EBM) – management of the uses and values of ecosystems in conjunction with stakeholders to ensure ecological integrity is maintained, recognizing that ecosystems are dynamic and inherently uncertain (Ward et al. 2002).

Ecosystem management – a synonym for EBM; often interpreted incorrectly to imply management of ecosystems, but more correctly interpreted to mean management of human activities that affect ecosystems, often detrimentally (Ward et al. 2002).

Ecosystem-based fisheries management (EBFM) – a new direction for fisheries management, essentially reversing the order of management priorities to start with the ecosystem rather than target species (Pikitch et al. 2004).

Ecosystem approach to management (EAM) – an ecosystem is a geographically specified system of organisms (including humans), the environment, and processes

that control its dynamics. Characteristics of EAM are: adaptive; incremental; takes account of ecosystem knowledge and uncertainties; considers multiple external influences; strives to balance diverse social objectives, and is geographically specified (NOAA working definition in Murawski 2007)

Ecosystem approach to fisheries – strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions, and applying an integrated approach to fisheries within ecologically meaningful boundaries (FAO 2003).

Marine ecosystem-based management – EBM is an integrated approach to management that considers the entire system, including humans. The goal of an EBM is to maintain a system in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors.

The ecosystem approach to the fisheries process

The process of implementing EAF in a fishery or ecosystem can be initiated at any level (Fig. 1.3). Factors that influence the initiation of EAF could stem from a number of causes: political commitment resulting from international agreements, stakeholders concerned about conservation and the environment, and government(s) wanting to implement EAF (FAO 2009). EAF can be incorporated into existing approaches by using current management measures, adapting and expanding them to fit this approach (FAO 2005). EAF is an integrated approach that requires multidisciplinary and multi-stakeholder teams (FAO 2009).

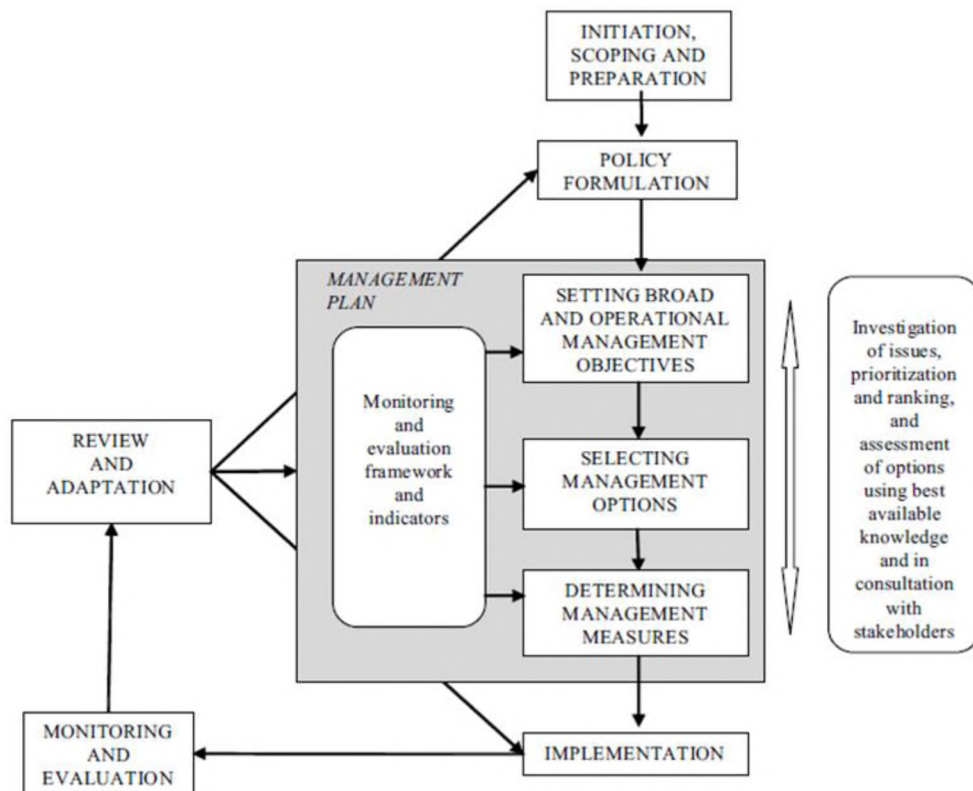


Figure 1.3: Conceptual framework of an ecosystem approach to fisheries (FAO 2009).

Criticism of the ecosystem approach to fisheries

EAF has not been without criticism. Murawski (2007) reviewed the ten most common criticisms of EAF and responded to each:

1. *EAF as a concept is not well defined and it is difficult to implement.* There exist a number of concepts and definitions of EAF (Table 1.2). EAF has already been implemented in a number of institutional bodies. There are obstacles in its implementation, especially regarding governance and science, but these do not demonstrate the inability to define the concept.
2. *Implementation of EAF requires a paradigm shift in management institutions and scientific support.* Management institutions have already adopted some of the principles of EAF, though it may be in isolation. Instead of calling for abandonment of existing scientific programmes, EAF rather calls for expansion

of these programmes to include other disciplines in order to gain more understanding of the drivers that influence ecosystems.

3. *EAF is not feasible, there are no examples of the success of EAF in practice.* There are numerous successes of EAF at all levels of governance. The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) is an international example. USA, Australia, Canada and other countries have included principles of EAF in policies and legislation.
4. *There is insufficient scientific information available to answer all ecosystem questions necessary for EAF.* EAF acknowledges the lack of adequate information and that uncertainty will always exist; however existing information can be used to start implementing EAF. EAF is an adaptive management approach that incorporates new information as it becomes available.
5. *EAF is a difficult concept that cannot be applied to multinational regional organizations; furthermore, developing countries do not have the technical and financial resources to implement it.* EAF has been implemented regionally in many places through large marine ecosystems (LMEs) which often occur in multiple countries. Significantly for developing countries, these cooperative efforts are strengthening regional science and management capabilities through the infusion of scientific and technical expertise and support for basic information collection which underpins the development of these institutions.
6. *EAF does not have good principles for its implementation.* The CBD and FAO provided principles for the implementation of EAF (Table 1.1). In addition, operational frameworks have been developed and reviewed (Sainsbury et al. 2000; Pitcher and Preikshot 2001; Ward et al. 2002; Garcia and Cochrane 2005; Fletcher 2008).
7. *There are no benchmarks and indicators for management success.* EAF takes cognisance of different drivers that influence the ecosystem and that no one ecosystem will be the same. Indicators should be collectively identified and prioritized by stakeholders. There is published literature on indicators that can be used to identify a healthy ecosystem (Cury et al. 2005).

8. *Complex models of species interaction among all components of an ecosystem are required to guide EAF.* Ecosystems are not sufficiently understood, and complex models require a lot of data. Simple models, such as food webs can be used to guide EAF. Complex models can still be used to quantify risk and help identify management options.
9. *Boundaries to define EAF cannot be established.* Murawski (p.687, 2007) states that “*the definition of appropriate scales for EAF is hierarchical in nature, and may change, given the specific sets of problems to be addressed*”.
10. *The use of Marine Protected Areas is synonymous with EAF.* EAF does not have to implement MPAs in order to manage resources successfully. MPAs are one of a variety of tools that can be used to manage resources successfully within an EAF management approach.

1.1.2. Ecosystem approach to fisheries globally

Pitcher et al. (2009) conducted an evaluation of the progress in EAF implementation in 33 countries, using the EAF framework of Ward et al. (2002). The criteria consisted of five attributes for principles of EAF, six key elements of a successful EAF, and twelve attributes for implementation steps. A score of over 70% was considered good and likely to lead to implementation of EAF, a score between 60–70% was considered acceptable with room for improvement, and a score of 40% or less was considered a failure and was unlikely to lead to implementation of EAF. The overall score combining the different criteria demonstrated that only the United States of America (USA) and Norway scored an overall ‘good’ score above 70%. Iceland, South Africa, Canada and Australia received an overall ‘acceptable’ score between 60–70%, and sixteen countries, UK, Argentina, France, India, China, Brazil, Pakistan, Indonesia, Taiwan, Morocco, Turkey, Viet Nam, Myanmar, Russia and Thailand scored 40% or less. Most countries tended to score higher on principles of EAF than on other elements, due to several factors, which included good intentions, advocacy pressure, trade requirements and/or immediate crises. Twenty-two of the 33 countries scored lower in indicators of a successful EAF and 30 scored lower in implementation steps. This shows that it is easier to have principles on paper than it is to carry them out in action.

These results also indicated that very few countries were on their way to implementation, and almost half of the countries were considered by the authors as unlikely to progress towards implementation of EAF. Surprisingly, even with adequate resources, many developed countries had not progressed in implementing EAF at national level, and some were judged to be surpassed by developing countries such as South Africa and Mexico. Areas with the lowest performance in the study included setting up training courses in EAF for fishers as well as managers, implementing ecological risk assessments, and the existence of strategies agreed upon by all stakeholders.

1.2. Motivation of study

1.2.1. South Africa and its fisheries sector

The fisheries sector, which includes aquaculture, has an annual turnover of about ZAR80 billion, contributing 0.5% to the overall GDP of South Africa (Statistics SA 2014). Wild capture fisheries consist of large commercial, small-scale (commercial and subsistence) and recreational sectors. Many of the marine living resources in South Africa are fully exploited, and some species over-exploited, particularly high-value species (DAFF 2012a).

There are 19 fisheries within the commercial sector which include, *inter alia*, the demersal hake fishery, pelagic, line fishery, and rock lobster fisheries (Hara et al. 2008). The large commercial fisheries are managed through a total allowable catch (TAC) or total allowable effort (TAE) system, in which participants are allocated, in a form of leasing, fishing rights within that TAC/TAE. This sector generated ZAR4.2 billion catch sales in 2009/2010, with an average sale of ZAR19 454 per ton of fish, and employed 22 105 people (DAFF 2012b). The demersal hake fishery is the largest fishery by value with a landed value over ZAR5.2 billion (DAFF 2014). The purse seine fishery is the largest fishery by landed mass and the second largest fishery by value (DAFF 2014). People employed in this industry generally earn more than their counterparts employed in other industries (Mather et al. 2003). Production of the major commercial fisheries peaked in the 1950's–1980's (Cochrane and Payne 1998).

The recreational sector is managed through a permit system. Of the approximately 750 000 participants in this sector, fewer than 200 000 are issued with licenses annually (DAFF 2012a). An estimated 17 000 tons constitutes the annual catch of the recreational fishery; however, there has been no proper assessment of this sector (DAFF 2012a).

There are varying reports on the number of small-scale fishers fishing for livelihood in South Africa, with numbers ranging from 30 000 to 100 000 (Cox 2013; DAFF 2014). The Policy for the Small-scale Fisheries Sector in South Africa (SSFP) was promulgated to manage this sector (DAFF 2012c).

1.2.2. Overview of the ecosystem approach to fisheries in South Africa

At the WSSD in 2002, a Political Declaration accompanied by a Plan of Implementation was adopted by 42 countries, with South Africa as one of the signatories that committed to implement EAF by 2010. The declaration mandated heads of states to “*develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive practices, the establishment of marine protected areas and the integration of marine and coastal areas into key sectors*” (p. 9 in Goby et al. 2012). After a series of mishaps with implementation, this political commitment was renewed in 2012 at the UN Conference on Sustainable Development (Rio+20) (Veitch et al. 2012). Although the need to implement EAF in South Africa has been recognised (Shannon et al. 2004), progress has been slow (Cochrane et al. 2009, Sowman 2011).

Focused attention on ecosystem-based issues in South Africa is reported to have started in the 1980s with the establishment of the multi-disciplinary, ecosystem-based Benguela Ecology Programme (BEP) which continued into the 1990s which laid the foundation for future programmes like the Benguela Environment Fisheries Interaction and Training (BENEFIT) and the Benguela Current Large Marine Ecosystem (BCLME) (Cochrane et al. 2008; Petersen et al. 2010a). The BCLME programme, in conjunction with FAO and the governments of the Benguela Current (South Africa, Namibia and Angola), was established to investigate the feasibility of implementing EAF in the BCLME region (Nel et al. 2007; Petersen et al. 2010a). The Strategic Action

Programme initiative by the BCLME programme resulted in the formation of the Benguela Current Commission (BCC). The BCC, led by the Benguela Current Commission Interim Agreement (2007), and later, the Benguela Current Convention (2013), allows for inter-governmental management of the Benguela Current resources (Cochrane et al. 2009). More recently established programmes that centre on EAF principles include the Aguhlas-Somali Current Large Marine Ecosystem (ASCLME) and the South-West Indian Ocean Fisheries Programme (SWIOFP). EAF-related research in South Africa enjoys continued support from the FAO through the EAF Nansen project (Petersen et al. 2010a).

Nel et al. (2007) developed a framework to assess the feasibility of implementing EAF into the BCLME region, based on the application of Ecological Risk Assessments (ERA - discussed in detail in Chapter 4). ERAs work through the involvement of all stakeholders, but even with the participation of industry, NGOs and managers, the ERA workshops were particularly dominated by natural scientists, possibly due to the misconception that EAF is a natural science-based approach (Cochrane et al. 2008). Collectively, stakeholders identify problems in a specific fishery, rank these issues from most important to least important and prioritize management responses in order of importance. ERAs in South Africa were conducted from 2004, with the first ERA reviews commencing in 2008 and the second ERA review process commencing in 2011. The ERAs succeeded in expanding knowledge of what EAF is among participants, identifying knowledge gaps and key priority issues.

In addition to the ERAs, the Worldwide Fund for Nature, South African office (WWF-SA) started the Southern African Sustainable Seafood Initiative (SASSI - discussed in detail in Chapter 3) in response to the unsustainable harvest of many marine fish species. The intention was to educate all those who are involved in the seafood value chain about the status of the fisheries they participate in, whether by consumption or other roles, the ecological impacts of those fisheries, and management by means of assessments conducted regularly. As a result of this initiative, 40% of regular seafood consumers are now more aware of the sustainable or unsustainable manner in which the products are harvested (WWF 2014b). Educating consumers about issues of sustainability has placed pressure on, as well as given incentives to, producers and fishers to harvest fish in a sustainable way. The objectives of SASSI are to *promote*

voluntary compliance of the law through education and awareness; shift consumer demand away from over-exploited species to more sustainable options, and create awareness around marine conservation issues (p.14, WWF 2014a). The advantage of this initiative is that bycatch species are also assessed, thus giving a good indication of the effects of a fishery on other species. The disadvantage of this initiative is that social impacts of fisheries are not considered.

1.2.3. Research aim and objectives

Aim

The aim of this project is to assess the progress in implementing an ecosystem approach to fisheries in South Africa in both principle and practice.

Objectives

- i.* To evaluate the progress made in implementing the ecosystem approach to fisheries in South Africa's marine fisheries policies and legislation;
- ii.* To assess the progress that has been made in implementing the ecosystem approach to fisheries in South African fisheries by using available information and knowledge on the status of stocks, ecological impacts on fisheries and management measures in place; and
- iii.* To identify any obstacles that may have hindered better progress, or factors advancing progress.

Key questions

- i.* To what extent do South Africa's national policies and legislation address the need to implement EAF in the country's marine fisheries?
- ii.* What progress has been made in implementing EAF and how does this vary between different fisheries?
- iii.* Are there differences in progress between data-rich and data-poor fisheries?
- iv.* In what aspects of EAF has progress been most limited and what are the barriers to improved implementation?

Chapter 2: Assessment of progress in implementing the ecosystem approach to fisheries in legislation and policies, with examples from best practices

2.1. Introduction:

The segregation of South Africans based on race commenced long before Apartheid was formally legislated in 1948. The first significant racial exclusionary law was passed in 1913. The Natives Land Act No. 27 of 1913² restricted black people, who made up over 80% of the population, to occupy less than 8% of South Africa's arable land, and promoted residential segregation by race in urban areas (Hauck and Sowman 2001). Subsequent laws under the National Party government further promoted spatial restriction of people of colour. The Promotion of Bantu Self- Government Act No. 46 of 1959 and the Bantu Homelands Citizen Act of 1970 segregated black people according to their ethnic groups, restricted them to these homelands and stripped them of their South African citizenship (Hauck and Sowman 2001). These laws prevented many South Africans from accessing land and coastal resources and dispossessed indigenous coastal communities of their lands adjacent to the coast (DAFF 2012c).

As a result of this systematic exclusion, South Africa is one of the most unequal societies in the world, and poverty is widespread (The World Bank 2014). Access to natural resources, which is still skewed as a result of the policies of apartheid, is especially important in cases where people do not have access to capital; land and coastal resources are sources from which they can generate their livelihood (DAFF 2012c; Stern 2013).

The first democratic elections in 1994 sought to bring about social justice through reform and redistribution, and the fishing industry was no exception (Isaacs 2011). The Freedom Charter states that "*South Africa belongs to all who live in it*", therefore all South Africans have a right to benefit from marine living resources. The Marine Living Resources Act 18 of 1998 (MLRA) (DEAT 1998) and the Policy for the Small-scale Fisheries Sector in South Africa (SSFP) (DAFF 2012c) provide a mandate and legal framework for government and the people of South Africa to optimally utilise, manage

² <http://www.sahistory.org.za/dated-event/native-land-act-passed> [Accessed 19 January 2016].

and monitor the use of these marine living resources. In line with this, the social and economic goals of the MLRA and the SSFP are consistent with those of the National Development Plan (NDP), and the Constitution of the Republic of South Africa. These goals include restructuring the fishing industry to address historical imbalances caused by racial exclusionary laws of the past, and utilising marine living resources in a sustainable manner to achieve economic growth.

Section 24 (b) of the Constitution of the Republic of South Africa Act No. 108 of 1996 states that *“Everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that (i) prevent pollution and ecological degradation, (ii) promote conservation, and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development”* (p. 1253, South Africa Constitution 1996).

Since South Africa became a democratic state, its laws have been influenced by international legal instruments and treaties the country is a part of.

“The changes that have occurred in South African fisheries policy and law must be seen against the backdrop of international and regional developments in fisheries regulation. This is due to the fact that, while historically the relationship between South African and international law was strained, international law now exerts significant influence on the domestic legal regime, as formalised by the Constitution. The international legal framework that informs the South African fisheries sector is determined by the agreements to which South Africa is a party, as well as relevant rules of international customary law” (p. 30, Witbooi 2006).

One such agreement was the commitment to implement the ecosystem approach to fisheries (EAF) by 2010 (WSSD 2002a), a commitment that was further reaffirmed in 2012 (Veitch et al. 2012).

The Marine Living Resources Act No 18 of 1998 (MLRA)

Prior to the 1994 elections and the subsequent promulgation of the MLRA, fisheries in South Africa were governed under the Sea Fisheries Act No 12 of 1988 and its Amendments No. 98 of 1990, No. 57 of 1992 and No. 74 of 1995. This Act was enacted under the Apartheid government at a time when most South Africans were denied access to marine living resources, therefore only a few large, white-owned, commercially driven companies dominated the fishing industry (Cochrane and Payne 1998; Wilson et al. 2006; Stern 2013). The MLRA, which was promulgated in 1998 and amended in 2000³ and 2014⁴, draws its objectives from the Constitution. The aim of the MLRA was to afford all South Africans access to marine living resources through increased participation of previously excluded race groups, while also ensuring sustainability of the resources, rebuilding over-exploited resources, and maintaining stability of the already existing fishing industry (DEAT 1998; Cockcroft et al. 1999; Witbooi 2006). This would be a challenge because exploitation of most major fisheries peaked in the first half of the 20th century or shortly thereafter. These included the demersal, pelagic, linefish, rock lobster and the abalone fisheries (Cochrane and Payne 1998). Consequently, many species were declared unsustainable or recovering from over-exploitation (Cochrane and Payne 1998).

The Policy for the Small-scale Fisheries Sector in South Africa (SSFP)

Under the Sea Fisheries Act, small-scale fishers were not legally recognised as a sub-sector (Hauck et al. 2002; de Greef and Raemaekers 2013). The MLRA recognised three different sectors of fishers: commercial, recreational, and subsistence. The MLRA defines a subsistence fisher as “*a natural person who regularly catches fish for personal consumption or for the consumption of his or her dependants, including one who engages from time to time in the local sale or barter of excess catch, but does not include a person who engages on a substantial scale in the sale of fish on a commercial basis*” (p.13, DEAT 1998). Permit conditions for subsistence fishers

³ The Marine Living Resources Amendment Act (MLRAA) No. 68 of 2000.

⁴ The Marine Living Resources Amendment Act (MLRAA) No. 5 of 2014.

included, *inter alia*, a catch limit of 10 fish per day and restricted sale of excess stock to a 20 km radius (Stern 2013). The Act was found to have restricted development of the subsistence sector and excluded small-scale commercial fishermen, ultimately criminalising people under this cluster (Sowman 2011; Stern 2013). The failure of the MLRA to adequately address issues of the small-scale fisheries sector resulted in the promulgation of the Policy for the Small-scale Fisheries Sector in South Africa (SSFP).

FAO (2009) lists key policy concepts that are relevant for an EAF management framework, with good governance as the basic foundation. These are: fishery and ecosystem management, which includes allocation of rights, effective stakeholder participation, a precautionary approach, coordination, and inter-sectoral interaction. Cochrane et al. (2015) conducted an in-depth assessment that examined the extent to which the MLRA and the SSFP have addressed EAF, following on preliminary analyses conducted by Joyner in 2013. Their work is particularly important for this thesis because it assessed whether South Africa's fishery policy and legislation meet the requirements of recognising and supporting EAF as the appropriate approach to manage fisheries and therefore set the premise for practical implementation. This chapter will review their findings with the aim of assessing progress that has been made in implementing EAF in the national legal instruments of South Africa, and focusing on lessons to be learnt from the laws of countries considered in the vanguard of implementing EAF.

2.1.1. An evaluation of the Marine Living Resources Act and supporting legal instruments as a framework for implementing an ecosystem approach to fisheries in South Africa (Cochrane et al. 2015)

The Cochrane et al. (2015) assessment conducted two different analyses for the MLRA and the SSFP. The MLRA was analysed using the scientific and a legal perspective, which were amalgamated into six fields: General; Fisheries Management, Conservation and Development (divided into two sub-fields; a) Management plans and measures, and b) Issues to be considered); Data, information and research; Access, licensing, control; and Human well-being and equity. The scientific perspective was undertaken by natural scientists with a lot of experience in fisheries science and

management, while the legal perspective was undertaken independently from the scientific perspective by an international expert in fishery laws and policies. A traffic light system was used to signal how adequately the MLRA addressed a particular criterion. Red indicated no provision, Orange indicated partial or inadequate provision, and Green indicated full provision. A histogram was plotted to demonstrate their findings.

Since the SSFP was promulgated to address the small-scale fisheries sector, a major weakness of the MLRA, this policy was assessed to determine if it adequately filled gaps in the MLRA in relation to EAF.

2.2. Methods

This study used the MLRA and the SSFP to evaluate progress in implementation of the ecosystem approach to fisheries in South Africa's key fisheries legislation and policies. Three sub-headings (*i*, *ii* and *iii* of 2.3.1) were formed by amalgamating the components of the ecosystem approach to fisheries discussed in the previous chapter, and the Southern African Sustainable Seafood Initiative (SASSI) and ecological risk assessments (ERA) (Nel et al. 2007; Petersen et al. 2010). Attributes from the Cochrane et al. (2015) assessment were discussed, under the three subheadings, and were expanded to demonstrate strengths or weaknesses of the MLRA and SSFP in implementing EAF, as observed. In this chapter, the MLRA is referred to as 'the Act' or 'the legislation', while the SSFP is referred to as 'the policy'.

A summary of the Cochrane et al. (2015) results were plotted into a histogram to demonstrate the number of attributes that were listed as Green, Orange or Red by the scientific and legal perspectives. The findings of the Cochrane et al. (2015) assessment are italicised in section 2.3.1 to differentiate between findings of this assessment and conclusions of this study.

In addition to assessing local legislation and policy, Cochrane et al. (2015) evaluated three countries; Namibia, Australia and the USA, which they considered demonstrated best practices in implementing EAF. In another study, conducted by Pitcher et al. (2009); Australia, USA, South Africa, Norway, New Zealand and Canada received a

good score of over 70% for containing EAF principles in writing. In this chapter, Australia and the USA are selected for comparison with South Africa, as these were the common countries present in the studies by Pitcher et al. (2009) and Cochrane et al. (2015).

2.3. Results and Discussion

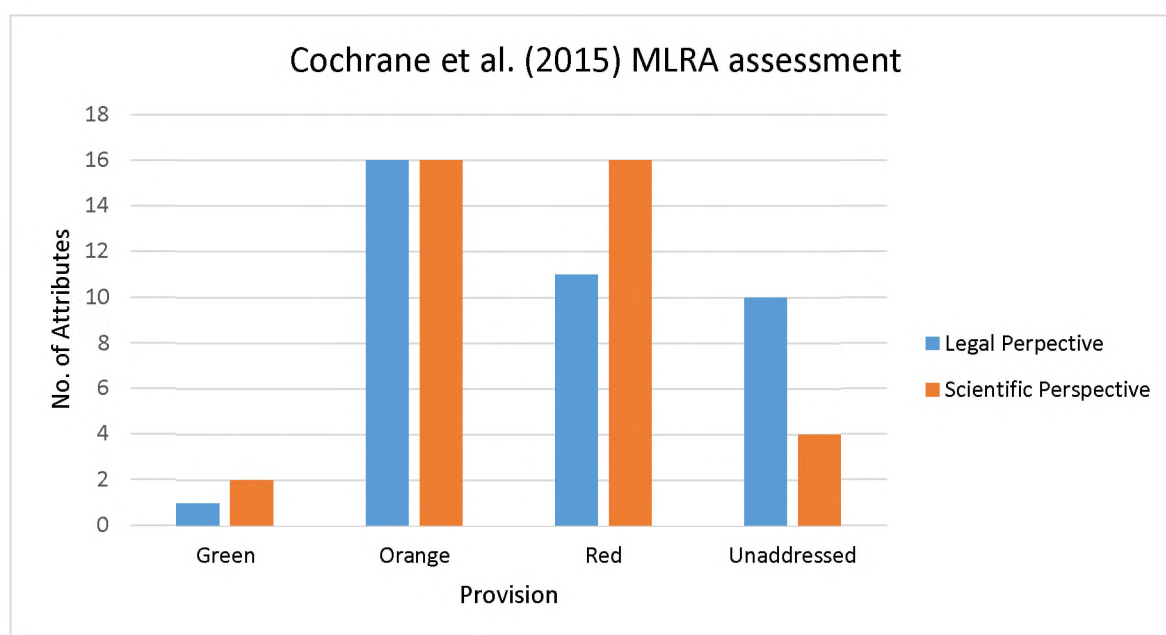


Figure 2.1: A histogram that summarises findings of the Cochrane et al. (2015) assessment, which used a traffic light system to determine the extent to which the MLRA addresses EAF. Red indicated no provision, Orange indicated partial or inadequate provision, and Green indicated full provision.

The Cochrane et al. (2015) assessment (hereafter referred to as ‘the assessment’) showed that a vast majority of EAF criteria have not been adequately addressed in the Act (Fig. 2.1). Of the 38 combined criteria from a legal perspective, there was full provision for 2.6%, partial provision for 42.1% and no provision for 29%, with 26.3% that were not scored. From a scientific viewpoint, there was full provision for 5.3%, partial provision for 42.1%, no provision for another 42.1%, with 10.5% criteria not scored.

2.3.1. Ecosystem approach to fisheries in South African laws

i. Ecosystem management

Target stock, dependent species and conservation of biodiversity and endangered species

Section 2(e) of the Act states, as one of the objectives of the Act, “*The need to protect the ecosystem as a whole, including species which are not targeted for exploitation*”. The Act does not go into detail about how this objective will be accomplished under the management section, *but the Cochrane et al. (2015) assessment found the Act provided partial provision for rebuilding depleted stocks*. This study supports that finding. This is a very important issue as most of the exploitable species were either depleted or recovering at the time of the promulgation of the Act (Cochrane and Payne 1998). *The Cochrane et al. (2015) assessment found the Act to contain no provision for the maintenance of ecological relationships between target species and dependent species*, possibly because it was promulgated before the ecosystem approach to fisheries gained prominence. However, the Code of Conduct was already in existence and it contains elements and principles similar to EAF. The second section of principle 6.2 of the FAO Code of Conduct addresses the issue of target species and dependent species: “*Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent upon the target species*” (p. 5, FAO 1995).

Unlike the Act, the small-scale fisheries policy does place emphasis on the importance of the ecosystem approach by recognizing that it is central to fisheries management. In some cases, the policy goes into detail about how co-management objectives will be achieved, but fails to elaborate on the importance of the ecosystem approach with regard to the policy. Neither the Act nor the policy take into consideration the fundamental processes of an ecosystem and therefore do not adequately stress the importance of a healthy ecosystem. Predator-prey relationships that exist in marine ecosystems are, to a large extent, ignored in both the Act and the policy.

MPAs are often seen as a useful tool for addressing ecosystem management (FAO 2003). There are 22 marine protected areas (MPAs) gazetted in South Africa, eight of which are no-take zones (WWF 2014b). Section 43 (1) of the MLRA states that marine protected areas are “(a) *for the protection of fauna and flora or a particular species of*

fauna or flora and the physical features on which they depend, (b) to facilitate fishery management by protecting spawning stock, allowing stock recovery, enhancing stock abundance in adjacent areas, and providing pristine communities for research, or (c) to diminish any conflict that may arise from competing uses in that area” (p. 35, DEAT 1998). This Section also makes provision for the Minister to make regulations prescribing conservation measures such as closed seasons and areas. In 2013, this Section 43 was, however, transferred to Section 22 of the National Environmental Management: Protected Areas Amendment Act No. 21 of 2014 (NEMPAA) which is under the jurisdiction of the Department of Environmental Affairs (DEA) (Cochrane et al. 2015).

Bycatch, discards and as destruction to marine habitats

The assessment by Cochrane et al. (2015) observed that the legislation does not clearly state the need to reduce bycatch, but only grants the Minister powers to make regulations regarding determination of rights for bycatch species. This study found the policy also fails to make reduction of bycatch species a requirement; it only refers to bycatch species in a section for promotion of small-scale fisheries enterprises through development of suitable eco-labelling. In addition, some linefish species are caught as bycatch in other fisheries (DAFF 2014). The policy fails to elaborate on how small-scale fisheries will exist with other fisheries in order to minimize animosity between different sectors (Attwood et al. 2011; Greenston and Attwood 2013). Neither the Act nor the policy make any reference to discards and managing discards. The Act does impose gear restrictions that must be adhered to, making it a criminal offence to use prohibited fishing methods such as blast fishing. Appropriate gear restrictions are very important in that gear selectivity can reduce the amount of bycatch and discards, and can also minimize the destruction to habitats (Bjorndal 2009).

Other ecological impacts caused by the fisheries

Cochrane et al. (2015) found the Act makes no provision for controlling genetic resources, abandoning objects in fishery waters, introducing alien species, or importing and exporting live fish. The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEMBA), amended in 2013⁵, under the jurisdiction of the DEA, addresses the issues of alien species and of importing and exporting live fish, but the Act does not refer this issue to NEMBA, as found by this study. The Cochrane et al. (2015) assessment also found the Act only partially provides for controlling pollution of fishery waters.

Environmental impacts

Cochrane et al. (2015) reported that the Act makes no provision for addressing causes of environmental impacts on fisheries and that the reference to the environment refers only to impacts caused by fisheries on the environment. Environmental impacts such as physical driving forces and chemical composition of the ocean need to be monitored as they contribute to and influence the production of marine resources (Hutchings et al. 2009). The policy does take into account possible environmental and climate change impacts on coastal communities, but does not elaborate further on these matters.

ii. Fisheries management

Management plan

Cochrane et al. (2015) noted that the Act makes provision for an operational management procedure (OMP) but does not require management plans. The authors noted that management plans are broader than OMPs: Chapter 4 of the FAO (2003) EAF guidelines lists all the information that is important and should be included in a management plan. The policy does emphasise the development and continuous re-assessment of a management plan.

⁵ National Environmental Management: Biodiversity Amendment Act No. 14 of 2013.

Management measures

FAO's (2005) publication, 'Putting into Practice the Ecosystem Approach to Fisheries', deals with the process of making EAF operational. The process includes determining management measures, which are supposed to be included within the management plan. Management measures include technical measures, such as regulation of fishing gear; spatial and temporal controls, such as closed seasons and/or no-fish areas; and input (effort) and output (catch) control to limit resource mortality through limiting capacity, effort and catch (FAO 2005). *Cochrane et al. (2015) found the Act makes only partial provision with regard to fishing gear and methods, including stowage of gear and use of fish aggregating devices, and with regard to spatial and temporal controls.* The Act gives the Minister powers to decide on closed seasons and areas. MPAs (discussed above) are an example of spatial controls. *The assessment by Cochrane et al. (2015) found the Act has full provision for effort and catch, but no provision for controlling fleet capacity.* The Act focuses on effort and catch as the most important operational measures necessary for sustainable management of a fishery. This is a flawed idea inherited from the target-oriented approach to management (TROM).

Section 5.1.4 of the policy sets out several technical control measures that will be adopted by the policy; however, there is no explanation how these measures will be implemented. Possibly the policy did not go into detail about the scientific and ecological aspect of fisheries on the assumption that this aspect is supposed to be adequately covered in the Act, which, unfortunately, is not the case.

Co-management of resources

The four main elements for a successful co-management system include an enabling policy and legal framework, participation and empowerment of resource users, effective linkages and institutions, and sustainability of resources (FAO 2009). Such a system encourages participation, consultation, transparency and compliance (FAO 2009). In a co-management system, responsibilities are shared among government, resource users, and other stakeholders (Stern 2013; Hersoug 2014). The Act does not

place emphasis on decentralizing management decisions and responsibilities to allow for a co-management system. *The assessment found the Act has partial to no provision for addressing stakeholder consultation.* During the formulation of the Act, there was a process of public participation, which indicated government's interest in promoting public participation (Hauck and Sowman 2001) and which resulted in recommendations of co-operative governance. However, many of these were not considered in the resulting Act (Hauck and Sowman 2001). The policy, on the other hand, places great emphasis on the importance of co-management of the resources, and resources under the jurisdiction of this policy will be managed under a co-operative system (DAFF 2012c). Section 4.3.1 of the policy acknowledges that co-management empowers fishers and fishing communities to be part of decision-making of management plans. Co-management is a social incentive that gives resource users a sense of 'ownership' and stewardship over resources and the ecosystem (Kuemlangan et al. 2014).

iii. Human dimensions

Social and economic benefits

Under the attributes related to the NDP, which include increased employment, transformation of asset ownership to include historically disadvantaged groups, improved disaster management, and sustainable development and use of resources, *Cochrane et al. (2015) found the Act made partial provision in addressing the interests of all stakeholders.* Apart from fishers, there are many other users of the ocean who affect fisheries either directly or indirectly. The Act focuses on the interests of fishers only; it does not take into consideration other stakeholders such as NGOs and those from other industries. It is important to consider this wider group in order to make sure that interests of all stakeholders are addressed and to minimize conflicts between the different user groups. The policy similarly focuses on the interests of the fishing communities only.

The 2014 amendment to the Act makes full provision for small-scale fishers. The failure of the Act, prior to the 2014 amendment, to address issues of small-scale fishers adequately (see Introduction) saw them taking legal action against the Minister of

Environmental Affairs and Tourism. This oversight by the Act also resulted in small-scale fishers disregarding regulations (Sowman 2011). The Equality Court ruled against the Minister, mandating the Minister to provide interim relief access to resources for small-scale fisheries until the finalisation of the policy (Sowman 2011). After its promulgation, the Act was amended to comply with the policy.

The Act was found by the assessment to makes partial provision for equal benefits for all races and genders. Given the history of South Africa, equity is at the heart of the Constitution, as well as legislation culminating from it. Witbooi (2006) noted that the Act has not elaborated on how transformation will be achieved. Nielsen and Hara (2006) think that the vague definition of transformation affords the managing authority advantage to implement transformation while avoiding lawsuits. A possible contributing interference to the inclusion of other race groups, women, young people and the disabled is the objective to maintain stability in the industry (Witbooi 2006). *“It has been suggested that the need to maintain international competitiveness has ‘severely constrained’ the government’s scope for reform”*, with Constitutional Court Justice Ngcobo’s warning that *“transformation should not be sacrificed at the altar of stability”* (p.37, Witbooi 2006). Transformation is one of the objectives of the policy. It recognises the need to include other races and women, who are often marginalised by this sector, and will do so through economic empowerment, training and education (DAFF 2012c).

The Act was found to make partial provision in meeting the needs of fishing communities. Cochrane et al. (2015) found that even though the Act places importance on small-scale fishing communities and their needs, it lacks plans and guidance on how it will achieve that. The policy, on the other hand, elaborates on actions to be taken in order to meet the needs of fishing communities. Section 1.4 of the policy spells out the importance of small-scale fisheries in alleviating poverty, providing employment, livelihood and food security, and developing alternative livelihoods to ease pressure on resources.

Uncertainty, the precautionary approach and the role of science

A great deal of uncertainty must be taken into account in management and decision-making under the ecosystem approach to the fisheries paradigm. The precautionary approach provides a way in which uncertainty can be incorporated into decision-making (FAO 2009), *and the assessment found that the Act makes partial provision for the precautionary approach*. To deal with any uncertainty that might arise, be it ecological, social or economic, contingency plans need to be put in place. Joyner (2013) found that both the Act and policy lack contingency plans to deal with uncertainty. The Act does allow for ecological precautionary plans to be put in place by granting the Minister the right to suspend fishing, restrict the number of fishing vessels or lower the total allowable catch (TAC) in case an ecological emergency arises. However, it does not stipulate what actions will be taken to ensure economic and social stability should such an emergency arise. In terms of the policy, in the case of an emergency, the government is required to put in place plans to assist the small-scale fishers and fishing community through the provision of relief assistance such as social security schemes and trust funds for financial assistance, should fishers not be able to fish, as well as other forms of assistance, but lacks plans that will address ecological emergencies. An ecological emergency was declared by the Minister for the linefishery due to concerns about status of some target species in that fishery (DAFF 2014).

2.3.2. Best Practices

Australia

Australia is renowned as one of the leading nations in implementing EAF (Fletcher 2008; McLoughlin et al. 2008) and their policies reflect their commitment to implementing EAF. Australia's commitment to implementing EAF dates back to the World Commission on Environmental Development (WCED) in 1987 and the subsequent adoption of Ecologically Sustainable Development (ESD) in 1992 (Cochrane et al. 2015). Steps towards implementing EAF included the establishment of the Marine and Coastal Committee (MACC) which was mandated to develop a framework for ecosystem-based management for Australian fisheries (Cochrane et al.

2015). Other implementation frameworks were developed in Australia by Fletcher et al. (2002) and Ward et al. (2002). The practical framework developed by Fletcher et al. (2002) has been applied to more than 50 fisheries in Australia (Fletcher 2008).

The Australian Fisheries Management Act (AFMA) No. 162 of 1991, which was recently amended, Act No. 31 of 2014, is one of the key items of legislation for fisheries. The Act makes no reference to EAF but contains ESD principles and division 2 of part 3 is dedicated to the determination of a management plan. Section 17(1) states that, *“AFMA must, in writing, after consultation with such persons engaged in fishing as appear to AFMA to be appropriate, and after giving due consideration to any representations mentioned in subsection (3), determine plans of management for all fisheries”* (p. 31, Office of Parliamentary Council 2014). The Commonwealth Fisheries Harvest Strategy Policy and Guidelines mention that AFMA recognises EAF as an appropriate management approach for fisheries (Cochrane et al. 2015). The 1999 Environment Protection and Biodiversity Conservation Act confers powers to the Minister to assess all 21 Commonwealth-managed fisheries along with export state-managed fisheries on their ecological sustainability with dire consequences for fisheries found to be unsustainable (McLoughlin et al. 2008).

United States of America (USA)

The USA, having taken part in the CBD and WSSD Declaration and Plan of Implementation and in the formation of the UN Law of the Sea Convention, is however, not a signatory of these international legal instruments (Cochrane et al. 2014). The complex political system in the US leads to a much more complex system of laws. There are over 140 laws regulating the use of the ocean, which sometimes conflict with and overlap management measures (Cochrane et al. 2014). Another addition to the complexity is the high diversity of fisheries in that country, with ecosystems that range from arctic to tropical (Tromble 2008). Although their legal instruments may not require EAF, when they are taken in combination, they contain elements of EAF, and the laws allow for practical application of EAF. As a result, several measures towards applying EAF have been introduced at the discretion of a managing authority (Cochrane et al. 2014; Cochrane et al. 2015). The Magnuson-Stevens Fishery

Conservation and Management Act (MSFCM), which is the legislation in place for marine fisheries, contains EAF requirements and emphasises the importance of the role of science in formulating management plans (Cochrane et al. 2015). Fishery Ecosystem Plans (FEPs) were developed in 1999 to assist managers with the transition from single species management to an ecosystem approach to fisheries management, (Tromble 2008). The National Ocean Policy Implementation Plan, an implementation plan for an 'Executive Order on Stewardship of the Oceans, Our Coast and the Great Lakes', emphasises the importance of EAF compared to the conventional single-species management (Cochrane et al. 2015).

2.4. Conclusion

The MLRA, although hailed as superior to previous fisheries legislation in many respects, has not fully incorporated the principles and requirements for EAF. The lack of emphasis on the ecosystem approach to fisheries management by this Act could be due to the fact that the Act was promulgated in 1998, before the ecosystem approach became prominent. The Act however, has since been amended twice, in 2000 and in 2014, but results of the Cochrane et al (2015) assessment and this study show it has not been amended to comply with South Africa's WSSD commitment. Figure 2.1 is an indication that the Act still has a long way to go.

Some of the principles and objectives of this legislation do reflect the objectives of EAF. However, the Act does not elaborate on how these objectives and principles will be translated into operational objectives, nor does it call for a comprehensive management plan or plans that will break down these broad principles and objectives into clear, concise operational objectives.

The small-scale fisheries policy on the other hand, recognises that the ecosystem approach is central to the management of the small-scale fisheries sector, but fails to elaborate on how this will be translated into practice to make the link between a healthy ecosystem and its benefits for humans. The policy must nevertheless be commended for its recognition that poverty and fishing pressure co-exist and therefore includes as one of its aims finding alternatives for these fishing communities where necessary in

order to decrease pressure on fishing by reducing dependency on marine resources (DAFF 2012c; WWF 2013).

There is a lot to be learned from the Australians. The development of an enabling framework is of key importance and leads the way to legislation and policies that are committed to implementing EAF. This framework needs to stem from stakeholder engagement and it must encompass EAF concepts enshrined in international legal instruments. Also, the Australian framework allows for regular evaluation of management and review of management performance and goals, as well as revision of objectives and principles. This process allows the implementation of EAF to be adaptive (FAO 2003).

Another lesson to be learned from the Australians is the development of management plans. Principle 7.3.3 of the Code of Conduct states that, “*Long-term management objectives should be translated into management actions, formulated as a fishery management plan or other management framework*” (p. 11, FAO 1995). The Australian Act devotes an entire section to the development of a management plan. The MLRA and the SSFP consistently failed to provide a clear plan of implementation. Cochrane et al. (2015) noted that, “*The Act focuses on catch and effort as the basis for management, and as such, those are reasonably well covered; however, there is a wide range of other management tools that are omitted*”. Instead of emphasising the need to formulate a detailed management plan, the MLRA rather places a lot of decision-making at the discretion of the Minister, without requiring comprehensive stakeholder consultation. The political landscape is always changing, but a management plan in place can ensure continuity. A management plan would contain and go into detail about how the objectives and principles of these laws are going to be achieved. The formulation of this plan would need to be conducted in consultation with other stakeholders (FAO 1997). The USA fishery ecosystem plans are similar to management plans; they are not regulations, but form the basis of a fishery management plan (Tromble 2008).

The MLRA does not incorporate or promote incentives for responsible fisheries while the SSFP does provide incentives in the form of supporting small-scale fishing communities through, *inter alia*, financial subsidy schemes for the establishment of

companies, skills training, and developing certification for environmentally caught resources. The Australians have implemented incentives in order to encourage fisheries to comply with good practices. Although EAF promotes the increased use of positive incentives, negative incentives are not entirely excluded. Positive incentives reward participants for promoting EAF objectives while negative incentives penalize them for the contrary (FAO 2009).

Chapter 3: Assessment of progress in implementing the ecosystem approach to fisheries in practice, using the Southern African Sustainable Seafood Initiative assessments

3.1. Introduction

The sustainable seafood initiatives, termed ‘the sustainable seafood movement’ by Roheim (2009), started in the mid-1990s (McGovern 2005; Jacquet and Pauly 2007) and consist of social marketing initiatives that create a demand for sustainable seafood through eco-labelling, seafood guides and, in some cases, boycotts of non-complaint producers (Roheim 2009). The aim of the sustainable seafood initiatives is to influence the social behaviour of consumers by shifting their purchasing power away from over-exploited or unsustainably produced species. This is achieved through educating consumers and creating awareness around environmental issues faced by marine species and ecosystems (Jacquet and Pauly 2007; Konefal 2012). These initiatives make use of criteria which are used as sustainability indicators. The criteria generally considered include species response to fishing pressure, species abundance, impacts caused by gear, bycatch, and management measures in place (Jacquet and Pauly 2007; Roheim 2009). Parties that comply with sustainable seafood initiatives are incentivised with access to markets, especially the European Union and USA markets (Jacquet and Pauly 2007; Konefal 2012; Perez-Ramirez et al. 2012). Sustainable seafood initiatives have been in existence for less than two decades, a relatively short time to observe positive influences on the environment and a change in behaviour of international markets (Roheim 2009). There have been some positive effects, however. A few examples include giant companies like Unilever and Wall-mart committing to sourcing seafood products that are MSC certified; the ‘give swordfish a break’ boycott campaign is said to have resulted in positive effects on rebuilding swordfish, and the National Environmental Trust (NET) successfully lobbied for the US government to require pre-approval of Patagonian toothfish imports from the National Marine Services before landing (Jacquet and Pauley 2007). Effectiveness of these sustainable seafood initiatives can be used to lobby for changes in legislation (Jacquet and Pauly 2007). Examples of these initiatives are discussed in more detail below.

Certification schemes and eco-labelling:

There are three types of eco-labels: (1) first-party labels are created by companies to promote their own products, (2) second-party labels are created by industry or government, and (3) third-party labels are created by independent institutions with an accredited labelling and certifying system (Landey 2013). The most widely known and accepted accreditation system for fisheries is the Marine Stewardship Council (MSC), which is a third-party label. The MSC has a criteria system for assessments that includes status of target stock, ecological impacts, and effectiveness of management measures. The MSC has proved to be relatively successful, with certified fisheries accounting for about 7% of global production with numerous other assessments under way (Perez-Ramirez et al. 2012). The FAO published guidelines for the eco-labelling of fish products and fisheries from wild capture fisheries, which assisted in standardising the consumer awareness labelling process (FAO 2005).

Consumer awareness campaigns (seafood guides):

Several initiatives using seafood guides use the traffic light ranking system to differentiate species that are sustainably produced from those that are not. The first seafood guide was produced by the Monterey Bay Aquarium in 1997 under the Seafood Watch Programme (Jacquet et al. 2009; Roheim 2009). The criteria used as sustainability indicators are similar to the eco-labelling criteria mentioned above. Worldwide Fund for Nature subsequently started similar programmes in its different regions (Jacquet et al. 2009).

Boycotts:

Sustainable seafood boycotts include protesting against the consumption of unsustainable products by withdrawing from buying those products. Two major boycotts events are recorded: the first one was the 'Give swordfish a break' in which more than 700 chefs boycotted swordfish for two years, and the other was the 'Give the Chilean seabass a pass' (Jacquet and Pauly 2007; Landey 2013).

The rise of these sustainable seafood initiatives has not been without criticism. Jacquet and Pauly (2007) are critical about whether these initiatives have had a positive impact on the environment because their effectiveness is rarely measured. They believe these movements have not achieved their mandate, arguing that conservation efforts need to target consumers and shift the perception that fish are not wildlife. Additionally, they also argue for the promotion of 'slow fishing', which focuses on decreasing the rate of fishing, reducing fishing capacity, and supporting small-scale fishing over industrial fishing. Fuchs et al. (2011) noted that, in the private governance of global food systems, large private corporations set the rules, implement, monitor and enforce those rules. As a result, big retailers develop initiatives to ensure quality of food product with standards that suppliers must abide by. An example is the Marine and Stewardship Council (MSC), which was started by a joint venture between WWF and Unilever, the latter being the one of the world's biggest seafood retailers, after Unilever announced its intention to procure all fish from sustainable sources by 2005 (Jacquet and Pauly 2007). *"As emerged from interviews with MSC officers in London, certification is driven not by consumers, but by supermarket chains and branded processors based in the Organisation for Economic Co-operation and Development countries which use it as a tool in their 'corporate social responsibility' portfolio"* (p. 23, Crosoer et al. 2006). Other limitations cited by Jacquet and Pauly (2007) and Jacquet et al. (2009) include market-based shortcomings. More than a third of global seafood supply is consumed in Asia, but most of the Asian consumers cannot differentiate seafood products based on environmental impacts to the point that this market is not targeted by sustainable seafood campaigns (Cawthorn et al. 2011). Other markets that are considered unlikely to be responsive to sustainable seafood initiatives include Africa and Latin America because of their economic status. Consumer awareness campaigns rely on education and awareness on the part of consumers to make better conservation choices. Impacts of these initiatives on consumer behaviour can be limited where there is limited access to information and environmental involvement of consumers (Jacquet and Pauly 2007). Poor people do not have the luxury of choosing sustainable seafood (Cochrane 2008). Another shortcoming of sustainable seafood initiatives is their tendency to target large-scale fisheries, excluding a large proportion of the small-scale fishers around the world. An example is the offshore and inshore trawl compared to the hake longline and hake landline fisheries (Crosoer et al. 2006).

Although the hake longline and handline fisheries are not classified as small-scale fisheries, they operate on a much smaller scale compared to the MSC certified offshore and inshore trawl fisheries.

Seafood trade is conducted on a global scale; lack of traceability, re-labelling, mis-labelling or renaming can compromise the legitimacy of sustainable seafood initiatives. Many fish are caught and relabelled as different species because of the incentives sustainable seafood initiatives provide (Jacquet and Pauly 2007). Deceptive advertising which leads to customer confusion is another shortcoming of these initiatives. Fuchs et al. (2011) found that in private food governance, social aspects of sustainability are often paid the least attention, if any. Even when formally included in the criteria, social issues like income and well-being of producers in developing countries are often ignored. There is also lack of representation of producers from developing countries at the decision-making level of these initiatives.

Despite these limitations, these schemes do have a role to play and are having some positive impacts. In South Africa, the certification of the demersal trawl fisheries has resulted in more consideration of bycatch species for these fisheries (DAFF 2014).

The ecosystem approach to fisheries emphasises the formation of incentives that will encourage fishers to utilise the resources sustainably and end-users to realise the long-term benefits of consuming sustainably produced resources (Cochrane et al. 2004). The aim of this chapter is to use the SASSI assessments to determine progress made by South Africa in implementing the ecosystem approach to fisheries in practice.

3.1.1. The Southern African Sustainable Seafood Initiative

The Southern African Sustainable Seafood Initiative (SASSI), launched in 2004, is a consumer outreach and awareness programme under the Worldwide Fund for Nature's (WWF) Nature's Sustainable Fisheries Programme. This initiative aims to address sustainability concerns in the seafood value chain, encourage consumers to choose species that are not over-exploited, and promote compliance by stakeholders to the Marine Living Resources Act (MLRA) as well as the Policy for Small-scale Fisheries in South Africa (SSFP) regulations (Basson 2011; Cawthorn et al. 2011).

The programme produces easy-to-use materials for consumers, based on the traffic light system. The SASSI list of sustainable species is available through their website, pocket cards and a mobile phone application. Lobbying has resulted in Pick' n' Pay, one of South Africa's biggest retailers, committing to purchasing and selling seafood deemed sustainable by SASSI by 2015 (Basson 2011; Landey 2013). Other big retailers like Woolworths, Spar, Fruit and Veg City, I&J, Ocean Basket, John Dory's, La Marina, Supapackers and Breco are part of the WWF-SASSI Retailer/Supplier Participation Scheme (Landley 2013). In addition to wild capture fisheries species, SASSI also assesses aquaculture species.

The assessment questionnaire (Appendix 1) is divided into three categories: stock status, ecological impacts of the fishery in which the species is caught, and the management measures in place for that particular fishery. Category 1: stock status, is species specific (Fig. 3.1). This category is further divided into three tracks: Track A for data-rich species that have defined reference points and which are assessed regularly. Track B is for species that have data but no defined reference points, or for which assessments are done sporadically. Track C is for species that have only very limited data or no data on the target stock specifically in that fishery. This track includes bycatch species. Categories 2 and 3 are fishery specific, meaning responses in these categories will be similar for species in the same fishery. For each question in the assessment, responses range from 2 to 5. The assessor chooses the best response, based on available information. The responses are then scored and a total score is given which will determine whether the species is given a green, orange or red code. Species listed on the green list are produced sustainably; the stocks are healthy and can handle current fishing pressure, and their fishery does not pose threats to the environment. Species on the orange list have sustainability concerns; either the species is depleted as a result of overfishing and cannot sustain current fishing pressure, or the fishery poses a threat to the environment. Lastly, species on the red list are produced unsustainably; the stocks are depleted and cannot handle fishing pressure, and the fishery poses threats to the environment. The red list also includes species that are not sold commercially.

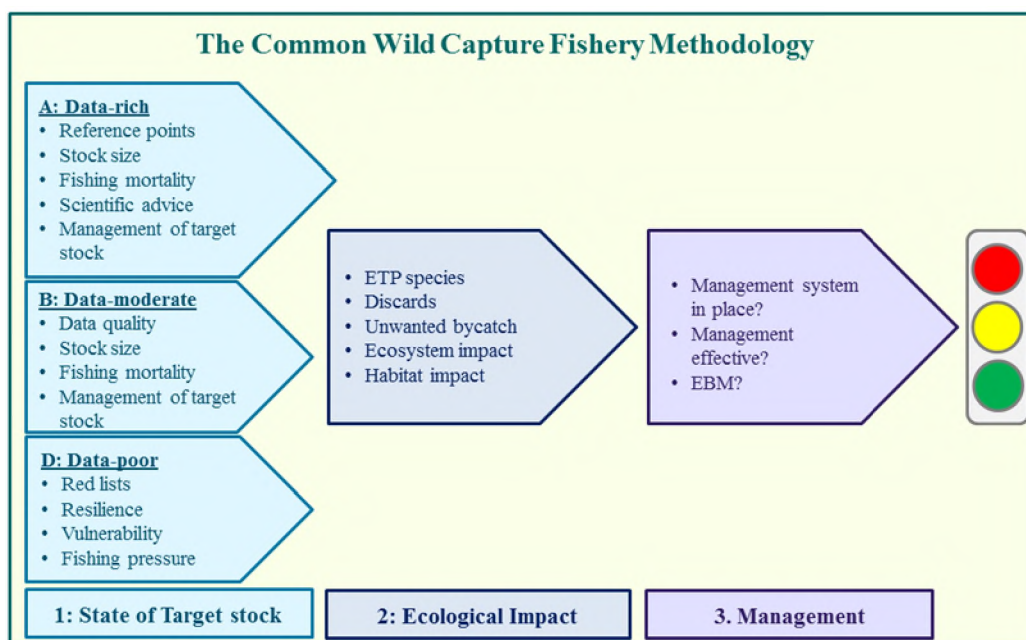


Figure 3.1: Schematic representation of the SASSI common wild capture fisheries methodology (SASSI).

The assessment process involved in assessing a species is a rigorous one that strives to include all interested parties:

- WWF-SASSI compiles a list of species to be assessed for the year. An announcement is made available on their website and through the South African Network for Coastal and Oceanic Research (SANCOR) mailing list. A period of 30 days is opened to interested parties to submit any documents and commentary that is relevant to the assessment.
- The draft assessments are compiled by a WWF representative with extensive knowledge of South African fisheries.
- The draft assessments are submitted to relevant Scientific Working Groups at the Department of Agriculture, Forestry and Fisheries (DAFF) for a period of up to 30 days, where they can review the assessments and offer input. At this point, other interested or affected parties will also be notified of the draft colours for each species, and can also submit comments, backed by scientific evidence.

- In some cases, an assessment may be sent for external review to two experts on that species: one for stock status and the other for ecological impacts, for a period of up to 30 days.
- The external review panel that consists of fisheries experts convenes for a day or two to review, discuss and decide on comments submitted by interested parties. Decisions taken by this panel are final and the outcome of this meeting will take effect.
- Interested parties are notified of the final outcome through the WWF-SASSI website, the SASSI and SANCOR mailing lists. Final colours of the assessments are published 60 days after announcement of the final outcome.

3.2. Methods

Data collection:

A total of 65 assessments were obtained from the SASSI. These were two sets of assessments, the first conducted in 2013 and another in 2014. Eight controls; CA1, CA2, CB1, CB2, CC1 CC2, Control 1 and Control 2 were also included in the analyses. These consisted of the best and worst responses for each Track and each Category. The positions of those extremes in the results of the statistical analyses assist in interpreting the results for actual species or fisheries. CA1 consisted of all the best responses in Track A, and CA2, all the worst responses. CB1 was all the best responses in Track B and CB2, all the worst. Similarly, CC1 was all the best responses in Track C and CC2 was all the worst. Control 1 consisted of all the best responses in Category 2 and Category 3, and Control 2 consisted of all the worst responses in Category 2 and Category 3.

Data analysis:

A histogram was plotted to demonstrate the number of species that were listed as Green, Orange and Red.

The data were presented in the form of $n \times p$ matrices that contained p species and n responses for different categories. Two independent methods were used to analyse the data; non-metric multidimensional scaling (NMDS) and cluster analysis, in the statistical program R (Crawley 2007) using *vegan* package (Oksanen 2013). Each track and category were analysed separately.

NMDS is a multivariate ordination technique that determines community similarities or dissimilarities by making use of a distance measure (Anderson 2001; Oksanen 2013). In this analysis, binomial distance was used to measure community dissimilarity of the data. The model does not make predetermined assumptions about the data (Anderson 2001; Clarke and Warwick 2001).

“The purpose of NMDS can thus be simply stated: it constructs a map or configuration of the samples, in a specified number of dimensions, which attempts to satisfy all the conditions imposed by the rank (dis)similarity matrix, e.g. if sample 1 has higher similarity to sample 2 than it does to sample 3 then sample 1 will be placed closer on the map to sample 2” (p. 5–1, Clarke and Warwick 2001).

This ordination technique produces a two-dimensional plot to demonstrate the assemblage of the samples in relation to each other. A script (Appendix 2) was developed using Oksanen (2013) as a reference. Goodness-of-fit was measured based on the stress value of each ordination. A general rule of thumb used by Clarke and Warwick (2001) is that a stress value of less than 0.05 indicates an excellent ordination plot without probability of misinterpretation. A stress value of less than 0.1 gives a good ordination, with no probability of misinterpretation. An ordination plot with a stress value of less than 0.2 would be beneficial to use in conjunction with another analysis e.g. a cluster analysis. Lastly a stress value over 0.3 should be discarded.

A cluster analysis is a classification method which links samples together, based on similarities or dissimilarities (Oksanen 2013). Of the many clustering techniques available, the commonly used hierarchical agglomerative methods was chosen for this study. Combination starts with the most similar sites which form groups, then the process proceeds to combining these formed groups together (Clarke and Warwick 2001; Oksanen 2013). In the programme R, a cluster analysis based on Ward's classification criterion was performed. Ward's classification is based on average linkage clustering (Oksanen 2013). The analysis produces a hierarchical cluster dendrogram. The cluster heat map aids in visualization. Wilkinson and Friendly (p. 179, 2009) noted that heat maps "*compacts large amounts of information into a small space to bring out coherent patterns in the data*". The cluster analysis is beneficial for complementing NMDS analyses. In cases where the ordination technique generates large stress values, the cluster analysis will assist in obtaining reliable results.

The results of these analyses are presented for Categories 2 and 3 first, followed by the results for Category 1. Results are presented in this order because those from Categories 2 and 3, which refer to the fisheries in which a species is caught, can assist in the interpretation of the species-specific results in Category 1. In Category 1, the outcome of some of the responses was observed to depend on the outcome of other responses in the same track. Line plots were then constructed in Excel to demonstrate these positive relationships between responses, and a chi-square test was conducted to test association of these responses with the null hypothesis that there was no association.

Lastly, a permutation test was done to determine how the different categories influence the overall outcome of the assessment, which was conducted prior to the ordination method. Tables were created to compare NMDS colours to SASSI assessment colours to assist in determining where problems lie in the implementation of EAF.

3.3. Results

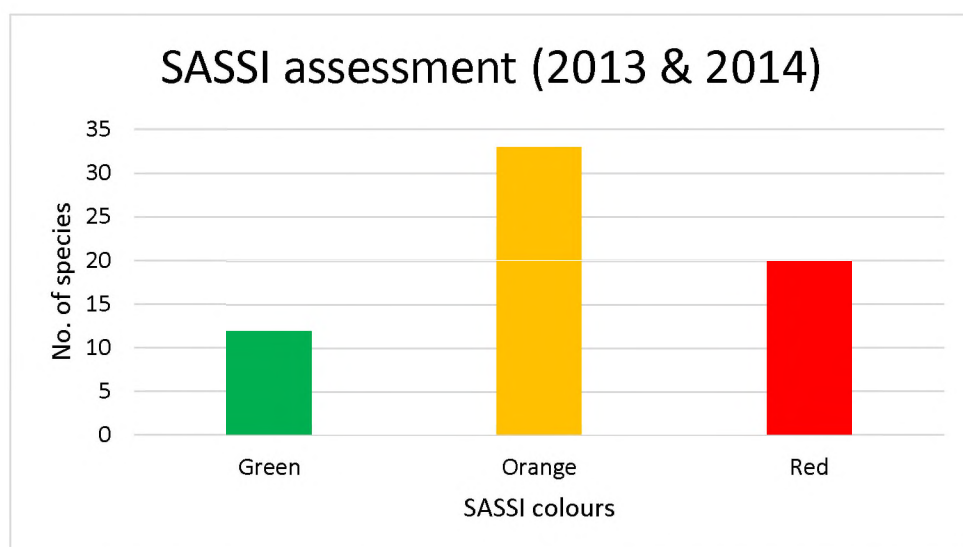


Figure 3.2: Histogram of the SASSI assessments used in this study showing the number of species that obtained Green, Orange and Red colour listing.

Of the 65 SASSI assessments conducted in 2013 and 2014, only 18.4% were listed as Green, while 50.8% were listed as Orange and 30.8% were listed as Red (Fig. 3.2). Green species are sustainable species; the status of target stock is sustainable or moving towards sustainability, ecological impacts are minimal, and management measures are effective. Species listed as Orange indicate that there are some concerns with their sustainability; target stock status could be unsustainable, while ecological impacts are minimal and management measures are effective, or target stocks could be sustainable with more ecological impacts, and management measures that are less effective. Species that are listed as Red indicate that there are serious problems ranging from the status of target stock to ecological impacts and management measures.

Category 2: Ecological impacts

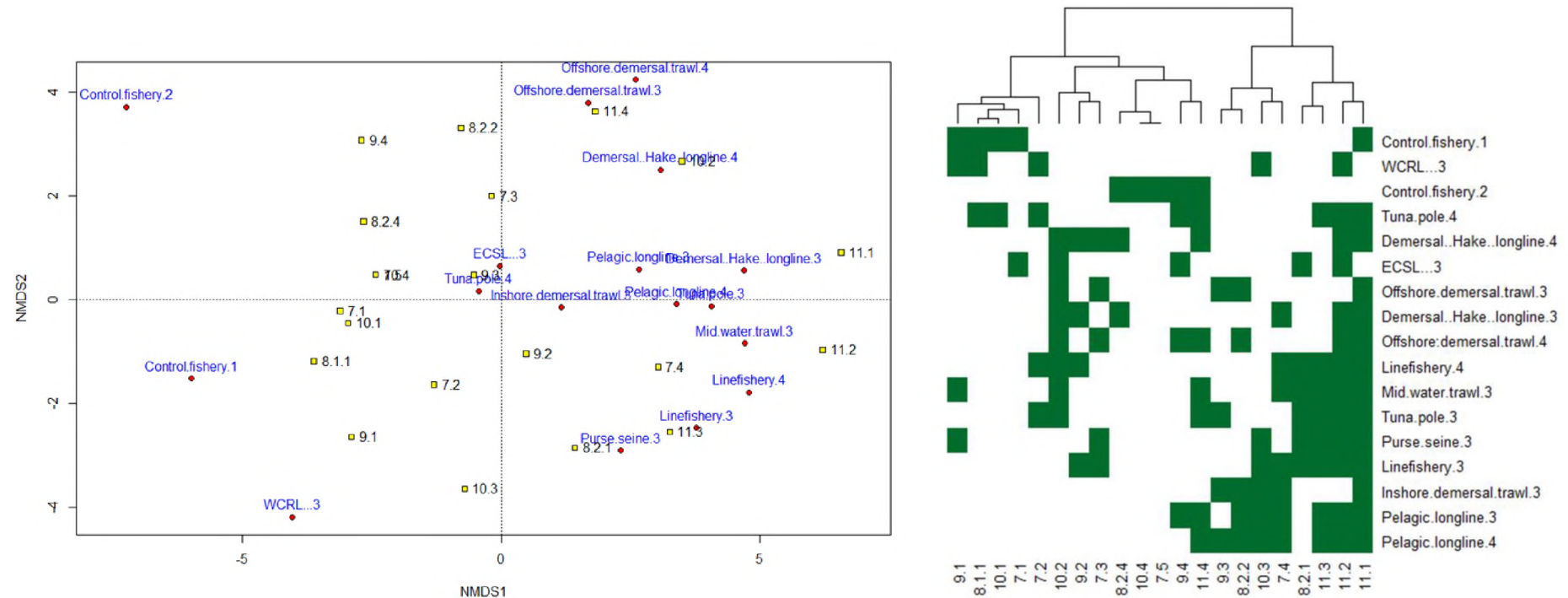


Figure 3.3a: Two-dimensional ordination plot from non-metric multidimensional scaling analysis of responses from the ecological impacts category, Category 2 together with fisheries. Responses are numbered in sequence: 7.1–11.4.

Figure 3.3b: Hierarchical clustering from Binomial distance of responses from Category 2 together with fisheries. Responses are classified into similar/dissimilar clusters based on Ward's criterion and Mantel statistics at the top of this figure. The clustering on the heat map shows fisheries with similar responses.

After three ordination runs, a stress value of 0.156 was recorded for Category 2. This stress value of the ordination indicated that the two-dimensional plot was not the best, but could still be useful in conjunction with another analysis.

The NMDS plot showed variation amongst the fisheries and the responses associated with them (Fig. 3.3a). There were no clear groupings of fisheries and responses. Examination of the cluster analysis (Fig. 3.3b) showed groupings of some fisheries and the responses responsible for these groupings. Line fishery 2014 and 2013, purse seine 2013, tuna pole 2013 and mid-water trawl 2013 were grouped by responses 8.2.1, 10.2, 11.1, 11.2 and 11.3. All these fisheries have less than 5% discards; however, less than 75% of those discards survive (8.2.1). Most of these fisheries were either unlikely to cause negative ecosystem changes, or their impact could not be determined due to insufficient information (10.2). The line fishery 2013 and purse seine 2013 were exceptions; both were likely to cause significant negative ecosystem changes (10.3). All these fisheries captured species on sand/mud/gravel (11.1), rocky reefs (11.2) and biogenic reefs/spongebeds/seagrass (11.3). It is important to note that these habitats may be affected differently, depending on the capture method used by the fishery.

Inshore demersal trawl 2013, pelagic longline 2014 and pelagic longline 2013 shared responses 7.4, 8.2.2, 9.3 and 10.3. All these fisheries were likely to cause significant damage to some listed, overfished or highly vulnerable species (7.4). Their discard rate was between 5–15% with less than 75% of those surviving (8.2.2). The retained catch of these fisheries either contained 5–30% juveniles and 5–30% non-target species, or there was inconclusive evidence for an evaluation (9.3). Pelagic longline 2013, which retained over 30% juveniles and/or non-target species, was an exception. All these fisheries were likely to cause significant negative ecosystem changes (10.3).

Category 3: Management measures

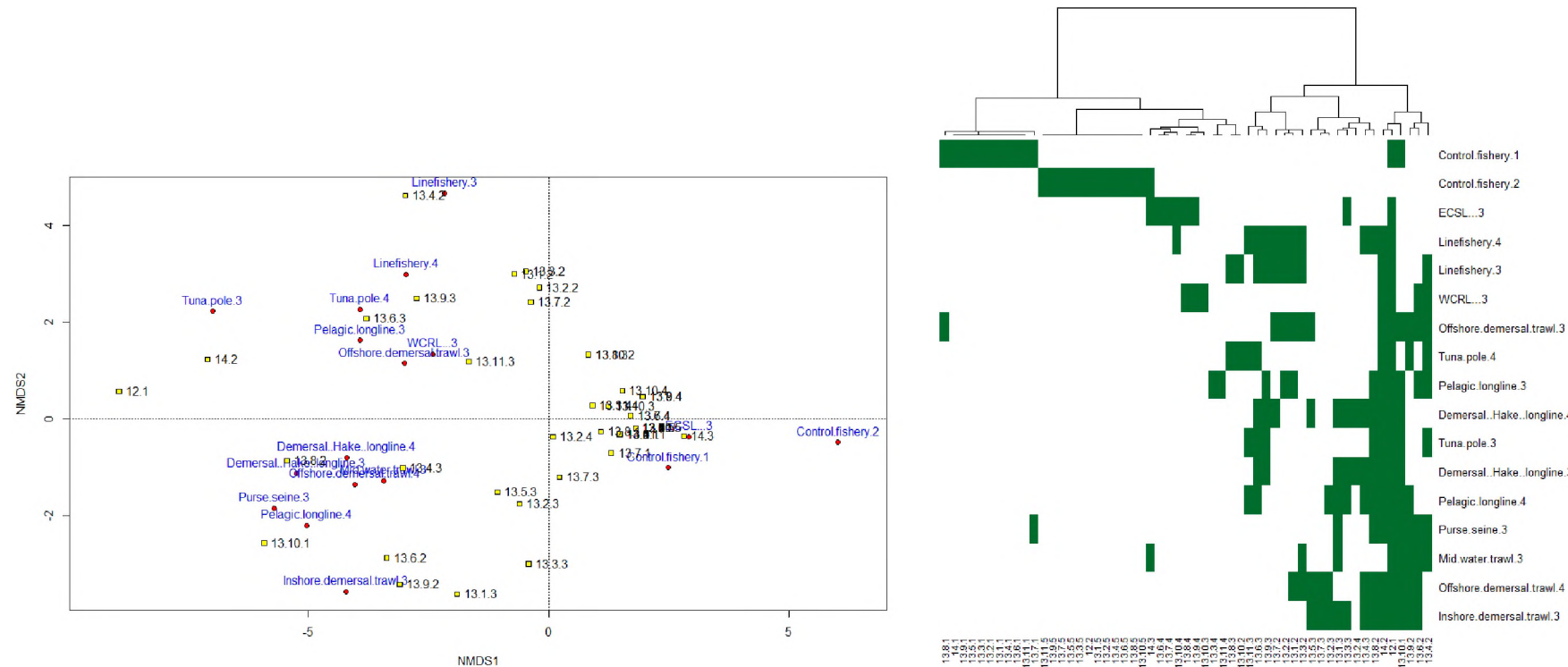


Figure 3.4a: Two-dimensional ordination plot from non-metric multidimensional scaling analysis of responses from the management measures category, Category 3, together with different fisheries. Responses are numbered in sequence: 12.1–14.3.

Figure 3.4b: Hierarchical clustering from binomial distance of responses from Category 3 together with fisheries. Responses are classified into similar/dissimilar clusters based on Ward's criterion and Mantel statistics at the top of this figure. The clustering on the heat map shows fisheries with similar responses.

A stress value of 0.112 was obtained after 20 ordination runs for the results of Category 3. This stress value indicated that the two-dimensional plot obtained from the ordination was potentially useful but needed to be used in conjunction with a cluster analysis.

The last number of the responses indicates the effectiveness of management measures: 1 – fully effective, 2 – largely effective, 3 – partly effective, 4 – marginally effective and 5 – not effective. For example, 13.1.1 indicates management measures were fully effective in managing ETP species, 13.1.2 indicates largely effective in ETP species (Appendix 1).

The NMDS plot revealed dissimilarities among both fisheries and responses (Fig. 3.4a). Two groups of fisheries could be discerned from the NMDS plot. Both groups were negatively correlated to NMDS1. The first group comprised fisheries that were positively correlated to NMDS2. These include line fishery 2013 and 2014, pelagic longline 2013, offshore demersal trawl 2013, tuna pole 2013 and 2014, and the West Coast rock lobster fishery (WCRL). Responses associated with these fisheries were 13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.6.3, 13.7.2, 13.9.3, 13.11.3 and 14.2. Closer examination of the hierarchical clustering (Fig. 3.4b) confirms that management measures in this group of fisheries were largely effective in relation to 13.1 (ETP species), 13.2 (discards), 13.3 (unwanted bycatch), 13.4 (ecosystem effects) and 13.7 (mixed fishery). Some exceptions to this pattern in the cluster include the line fishery (2013 and 2014) that were scored as partially effective in managing ecosystem effects (13.4.3), and pelagic longline 2013 which was considered to be only marginally effective in management of unwanted bycatch (13.3.4). Note 13.7 (mixed fishery) did not apply for this fishery. Other exceptions included the tuna pole fishery (2013 and 2014) and the WCRL 2013, which were not scored for questions 13.1 (ETP species), 13.2 (discards), 13.3 (unwanted bycatch) and 13.7 (mixed fishery) as they did not apply to these fisheries.

This group of fisheries tended to perform slightly worse in relation to 13.6 (monitoring and data availability), 13.9 (compliance and enforcement) and 13.11 (other), for which the group as a whole was associated with partial effectiveness. Exceptions include offshore demersal trawl, pelagic longline and WCRL 2013. These were scored as

performing better (largely effective) on monitoring and data availability (13.6.2) while the demersal trawl and tuna pole 2014 were found to be largely effective in compliance and enforcement (13.9.2), but WCRL 2013 was scored as only marginally effective (13.9.4). The response, 13.11 (other), did not apply to offshore demersal trawl 2013, while line fishery 2013, WCRL 2013 and pelagic longline 2013 were scored marginally effective (13.11.4). The last response to be associated with fisheries in this group was 14.2, which indicated that either an ecosystem-based management plan is in a state of implementation or singular measures of EBM are implemented.

The second group was negatively correlated to NMDS2. This group consisted of demersal hake longline 2013 and 2014, mid-water trawl 2013, purse seine 2013, offshore demersal trawl 2014, pelagic longline 2014 and inshore demersal trawl 2013. Responses associated with these fisheries were 13.1.3, 13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.8.2, 13.9.2 and 13.10.1. Hierarchical clustering confirms that management measures of 13.1 (ETP), 13.2 (discards), 13.3 (unwanted bycatch), 13.4 (ecosystem effects) and 13.5 (habitat effects) were partly effective for these fisheries. There were a few exceptions: management measures that were largely effective were for the offshore demersal trawl 2014 in ETP species (13.1.2), offshore demersal trawl 2014 and mid-water trawl in unwanted bycatch (13.3.2) and mid-water trawl 2013 and purse seine 2013 in managing ecosystem effects (13.4.2). Management measures that were marginally effective were management of discards for both the demersal hake longline fisheries (13.2.4). The response, 13.2 (discards), was not applicable for the mid-water trawl 2013 and purse seine 2013 or 13.3 (unwanted bycatch) for purse seine 2013. The response 13.5 (habitat effects) was not applicable for pelagic longline 2014, demersal hake longline 2013, mid-water trawl 2013 and purse seine 2013. Management measures for this group on 13.8 (IUU and misreporting) and 13.9 (compliance and enforcement) were largely effective, while management measures of 13.10 (transparency and participation) were fully effective. Exceptions were the demersal hake longline fishery (2013 and 2014) that was partly managed on compliance and enforcement (13.9.3), and 13.8 (IUU and misreporting) did not apply to the mid-water trawl 2013 fishery.

Track A, Category 1: Data rich, scientific assessments are available and reference points defined.

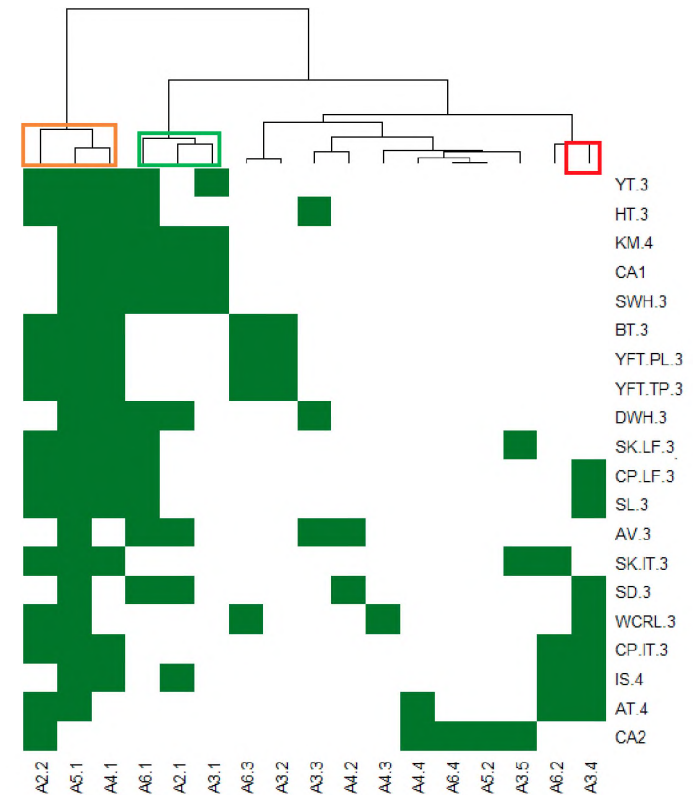
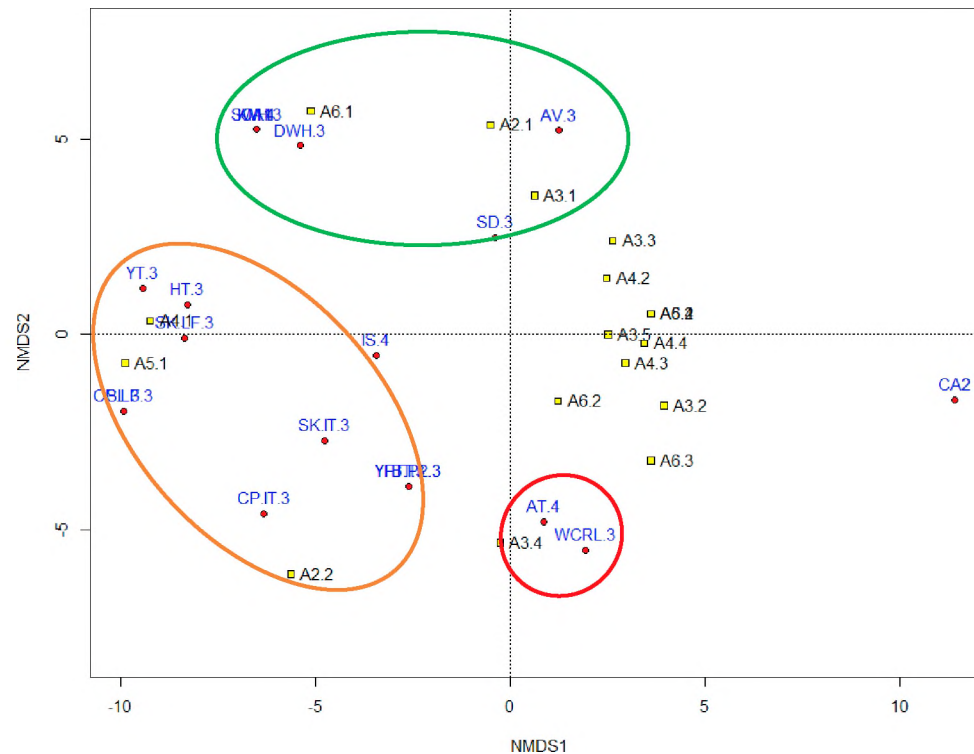


Figure 3.5a: Two-dimensional ordination plot from non-metric multidimensional scaling analysis of responses for Category 1 questions from Track A, together with species. Responses are numbered in sequence: A2.1–A6.4, with A representing the Track, the first number representing the question number and the last number representing the actual response to that question. Table 3.1 provides the full name and the abbreviation for each species.

Figure 3.5b: Hierarchical clustering of responses from Category 1, Track A, together with species. Responses are classified into similar/dissimilar clusters based on Ward's criterion and Mantel statistics at the top of this figure. The heat map of responses and species shows groupings of similar responses.

After a single ordination run, a stress value of 0.099 was recorded for Category 1 results. This indicated that the two-dimensional plot obtained from the ordination was good.

The NMDS plot revealed distribution of the species and responses (Fig. 3.5a). Three groups could be discerned. The first group (orange ellipse) comprised species that were negatively correlated to NMDS1. These species included linefish species: yellowtail (*Seriola lalandi*) 2013, carpenter (*Argyrozona argyrozona*) 2013, silver kob (*Argyrosomus inodorus*) 2013, slinger (*Chrysoblephus puniceus*) 2013 and hottentot (*Pachymetopon blochii*) 2013; inshore demersal trawl species: silver kob 2013 and carpenter 2013; pelagic longline species: Indian swordfish (*Xiphias gladius*) 2014, bigeye tuna (*Thunnus obesus*) 2013 and yellowfin tuna (*Thunnus albacares*) 2013; and tuna pole: yellowfin tuna 2013. Table 3.1 provides the full and abbreviated name for each species. Responses associated with these species were A2.2, A4.1 and A5.1. Two of these responses are the best while the other is the worst in their respective questions for this Track. Close examination of the hierarchical clustering (Fig. 3.5b) shows that either limit⁶ or target⁷ reference points are not implemented (A2.2) for these species with the exception of Indian swordfish, which has both limit and target reference points implemented (A2.1). The clustering also shows that fishing mortality was below Fmsy (A4.1) for all these species, and that scientific advice was adequately defined (A5.1) for all species. The second group (green ellipse) was positively correlated to NMDS2. Species in this group include demersal hake longline species: deep- (*Merluccius paradoxus*) and shallow-water hake (*Merluccius capensis*) 2013; purse seine species: anchovy (*Engraulis encrasicolus*) 2013 and sardine (*Sardinops sagax*) 2013; linefish: king mackerel (*Scomberomorus commerson*) 2014 and Control A1. Responses associated with these species were A2.1, A3.1 and A6.1, which were also positively correlated to NMDS2. All these responses were the best responses for their respective questions. The cluster analysis showed that limit and target reference points were implemented (A2.1) for all these species. It also showed that the spawning stock biomass (SSB) was above target reference point (A3.1) for some of

⁶ Limit reference points (LRPs) e.g. Bmsy-trigger, Fmsy or Bpa, Blim, Fpa, Flim.

⁷ Target reference points (TRPs) e.g. Bmsy, Fmgt, Ftargt.

these species, excluding deep-water hake and anchovy that had spawning stock biomass that was either below trigger⁸ or between limit and precautionary reference points (A3.3), as well as sardine with a spawning stock biomass that was below reference point (A3.4). The clustering also showed that management regulations determined from scientific evidence were implemented (A6.1) for all of these species. The last group (red ellipse) consisted of West Coast rock lobster (WCRL) (*Jasus lalandii*) 2013 and albacore tuna (*Thunnus alalunga*) 2014 of the tuna pole. These species were negatively correlated to NMDS2 and are aggregated around response A3.4. Hierarchical clustering shows that the spawning stock biomasses were below the target reference point for both these species.

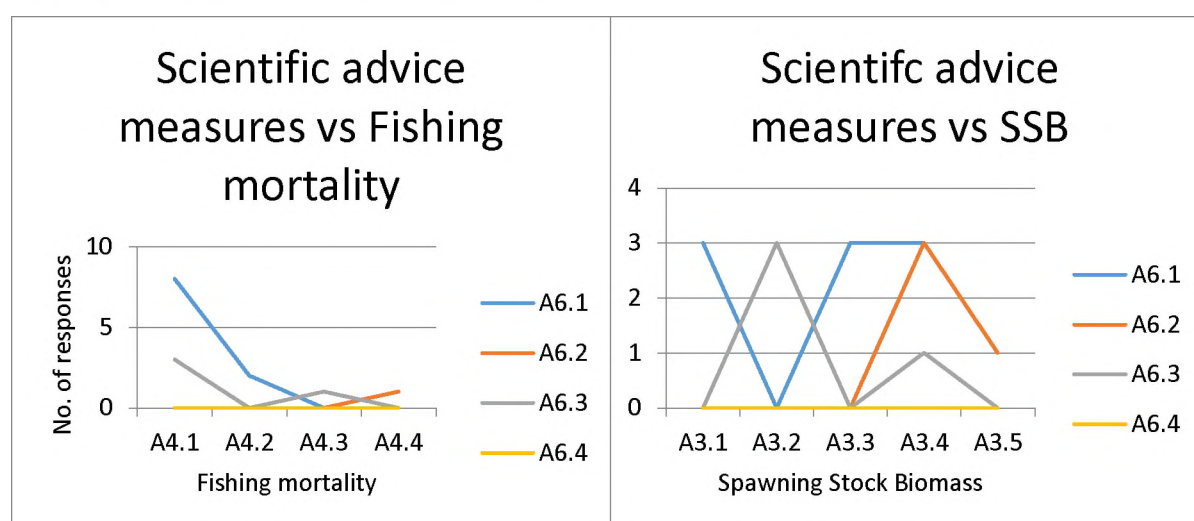


Figure 3.5c: Line plot demonstrating the relationship between regulatory measures in accordance with scientific advice (A6) and fishing mortality (F–A4). The legend consists of responses showing regulatory measures addressed in the previous paragraph.

Figure 3.5d: Line plot showing the relationship between spawning stock biomass (A3) and regulatory measures that are in accordance with scientific advice (A6). The legend consists of regulatory measures.

A positive relationship was observed between fishing mortality and the regulatory measures that are in place for target stocks (Fig. 3.5c). Species that have regulatory measures that were informed by scientific advice and were effectively implemented were likely to have a fishing mortality that is below F_{msy} . There was significant association between these responses (X-squared = 18.19, df = 8, p-value = 0.020). Bigeye tuna (pelagic longline) and yellowfin tuna (pelagic longline and tuna pole) were

⁸ Bmsy-trigger is defined as a biomass reference point that triggers a cautious response (see ICES 2011 for further information).

exceptions because catches in relation to regulatory measures and/or scientific advice are unknown (A6.3), yet they had fishing mortality that was below F_{msy} (A4.1).

The relationship between management measures and spawning stock biomass was not clear (Fig. 3.5d). It was expected that species with management measures informed by scientific advice and implemented would have a spawning stock biomass above target level ($SSB > B_{msy}$); however, chi-squared results showed that there was not a significant association between these responses ($X^2 = 8.6143$, $df = 6$, $p\text{-value} = 0.19$). Sardine, carpenter (line fishery) and slinger were exceptions to this expectation; their spawning stock biomass was below target reference point (A3.4), but their regulatory measures were in accordance with scientific advice, with target values met by their respective fisheries (A6.1). Silver kob (line fishery) was another exception; its spawning stock biomass was below limit reference point (A3.5), even with the existence of regulatory measures that were in accordance with scientific advice and target values met by the fishery (A6.1). Bigeye tuna and yellowfin tuna (inshore trawl and linefish) have spawning stock biomass that is above the precautionary reference point (A3.2) but their catches in relation to scientific advice were unknown (A6.3) because of unreported catches.

Table 3.1: Species with colours of the ellipses from the NMDS plot and final SASSI colours obtained by those species.

		NMDS	SASSI
KM.4	King mackerel – linefish		
DWH.3	Deep-water hake – demersal longline		
SWH.3	Shallow-water hake – demersal longline		
AV.3	Anchovy – purse seine		
SD.3	Sardine – purse seine		
IS.4	Indian swordfish – pelagic longline		
BT.3	Bigeye tuna – pelagic longline		
YFT.PL.3	Yellowfin tuna – pelagic longline		
YFT.TP.3	Yellowfin tuna – tuna pole		

CP.IT.3	Carpenter – inshore demersal trawl		
CP.LF.3	Carpenter – linefish		
SK.IT.3	Silver kob – inshore demersal trawl		
SK.LF.3	Silver kob – line fishery		
HT.3	Hottentot – linefish		
SL.3	Slinger – linefish		
YT.3	Yellowtail – linefish		
AT.4	Albacore tuna – tuna pole		
WCRL.3	West Coast rock lobster		

There are several factors that contribute to the placement of species within the different ellipses. Species in the green ellipse of the NMDS plot generally indicated that the status of their target stocks was in a relatively good, sustainable condition, or they were rebuilding towards sustainable levels. Status of target stocks for species in the orange ellipse were in a condition that was either decreasing stocks towards unsustainable levels, or the stock was neither sustainable nor depleted. Stock status of species in the red ellipse indicated that stocks levels were unsustainable. The overall SASSI assessment process includes consideration of ecological impacts (Category 2) and management systems in place (Category 3), as indicated in the introduction. The permutation test that was conducted concluded that each category independently influences the overall outcome of the SASSI assessment process. This means that SASSI colours will sometimes differ from the NMDS Category 1 colours, which are only an indication of the status of the stock, thereby excluding Categories 2 and 3. In Table 3.1, species in the green ellipse were listed by SASSI as either Green or Orange, those in the orange ellipse listed as either Orange or Red and those in the red ellipse listed as Red. This is due to Categories 2 and 3 receiving ‘intermediate’ to ‘worst’ responses. There were a few species that were orange and red on the NMDS Category 1 plot, but which are listed as Green and Orange, respectively, on the SASSI species list. The most probable explanation for this is that while the status of these stocks was intermediate and depleted or overfished, the fisheries in which these species were caught did not have significant ecosystem impacts and their management measures were considered to be largely effective.

After four ordination runs, a stress value of 0.082 was obtained. This stress value indicates that the two-dimensional plot obtained from the ordination is good with no possibility of misinterpretation.

The NMDS plot revealed dissimilarities among both species and responses (Fig. 3.6a). Three species groups could be discerned from the NMDS plot. The first group comprised species that were negatively correlated to NMDS1. This group (green ellipse) comprised offshore demersal trawl bycatch species: monkfish (*Lophius vomerinus*) 2013, snoek (*Thyrsites atun*) 2013, kingklip (*Genypterus capensis*) 2014 and Cape horse mackerel (*Trachurus capensis*) 2014; linefish species: snoek 2013, red roman (*Chrysoblephus laticeps*) 2014 and queen mackerel (*Scomberomorus plurilineatus*) 2014; demersal hake longline: kingklip 2014; inshore demersal trawl: East Coast sole (*Austroglossus pectoralis*) 2013; mid-water trawl: Cape horse mackerel 2013; pelagic longline: Table 3.2 provides the full and abbreviated name for each species. Atlantic swordfish (*Xiphias gladius*) 2014 and Control B1. Responses B2.1, B3.1, B4.1 and B5.1, which were also negatively correlated to NMDS1, appeared to be associated with the distribution of these species. All these were the best responses for Track B. Examination of the hierarchical clustering (Fig. 3.6b) shows that the available data were sufficient to allow for a solid and comprehensive description of target stocks (B2.1) for all these species and that the biomasses of target stocks were either in a good condition or under-fished for these species (B3.1), with some exceptions: kingklip from both fisheries, snoek from both fisheries and monkfish were either appropriately used or fully fished (B3.2), while stock size of Atlantic swordfish and red roman were either uncertain or unknown (B3.3). Target stocks of this group were fished at a rate that was likely to either maintain or increase the long-term yield of the stock (B4.1) for all species, and management measures of target stocks were fully effective (B5.1) apart from Atlantic swordfish, red roman and Cape horse mackerel (mid-water trawl) that were exceptions, as their management was either partly effective, or stocks were healthy despite the absence of specific management measures (B5.2). The second group (orange ellipse) comprised linefish species: Englishman (*Chrysoblephus anglicus*) 2014, catface rock cod (*Epinephelus andersoni*) 2014, white-edge rock cod (*Epinephelus albomarginatus*) 2014, yellowbelly rock cod (*Epinephelus marginatus*) 2014, soupfin shark (*Galeorhinus*

galeus) 2013 and smoothhound shark (*Mustelus mustelus*) 2013; pelagic longline: shortfin mako shark (*Isurus oxyrinchus*) 2014 and inshore demersal trawl: soupfin shark 2013 as well as smoothhound shark 2013. These species were positively correlated to NMDS1. Responses B2.2, B3.3, B4.2 and B5.3 appeared to be associated with these species. All these were intermediate responses. The cluster analysis shows that landings, total catch (including CPUE), fishing effort, and size/age distribution could not be described with sufficient accuracy (B2.2) for all these species, and that target stock size for these species was either uncertain or unknown (B3.3), with the exception of soupfin shark from both fisheries which are fully exploited (B3.2). Target stocks of all these species were either fished at a rate that risked maintaining it or decreasing it towards unsustainable levels, or the fishing rate was unknown (B4.2). Management of target stocks for these species was either marginally effective, or effectiveness was unknown (B5.3), except for smoothhound and soupfin sharks of both fisheries which had management measures that either did not exist or were ineffective (B5.4). The third group (red ellipse) comprised linefish species squaretail kob (*Argyrosomus thorpei*) 2014 and dageraad (*Chrysoblephus cristiceps*) 2014; inshore trawl geelbek (*Atractoscion aequidens*) 2013 and Control B2 that were negatively correlated to NMDS2. These species were associated with responses B3.4, B4.3 and B5.4 and were the worst responses in Track B. Examination of the cluster analysis showed the biomass of the target stocks of all these species was overfished (B3.4). Target stocks are fished at a rate that either reduces stocks to unsustainable levels or prevents recovery of depleted stocks (B4.3). Geelbek was an exception, with target stock either fished at a rate that risked maintaining it or decreasing it towards unsustainable levels, or the fishing rate was unknown (B4.2). The management measures of the target stocks for all these species were either ineffective or did not exist. A few other species were outside these three groups. These included linefish species: geelbek, scotsman (*Polysteganus praeorbitalis*), dusky kob (*Argyrosomus japonicus*), shad (*Pomatomus saltatrix*), white stumpnose (*Rhabdosargus globiceps*) and pelagic longline blue shark (*Prionace glauca*).

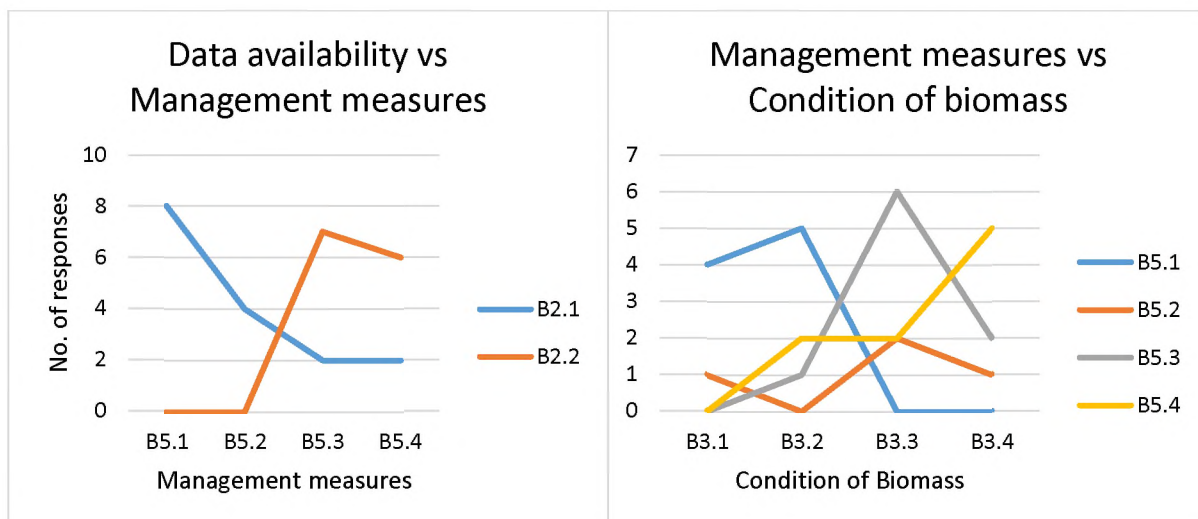


Figure 3.6c: Line plot demonstrating the relationship between available fishery specific information (B2) and effectiveness or ineffectiveness of management measures responses (B5) addressed in the previous paragraph. The legend consists of responses showing availability of data.

Figure 3.6d: Line plot demonstrating the relationship between condition of biomass of the target stock (B3) and effectiveness or ineffectiveness of management measures (B5). The legend consists of responses for management measures.

A linear trend (Fig. 3.6c) was observed between data availability and effectiveness of management measures. This trend suggests that where data are detailed enough to allow for a solid and comprehensive description of the target stock, management measures for that target stock are likely to be effective. This is further supported by the test of association results showing significant associations ($X^2 = 16.65$, $df = 3$, $p\text{-value} = 0.001$). Inshore trawl geelbek and line fishery dageraad are exceptions; both have sufficient data available (B2.1) yet there are no management measures (B5.4) in place for geelbek, and management measures in place for dageraad are ineffective (B5.4).

A positive relationship was observed between effectiveness of management measures and the biomass of target stocks (Fig. 3.6d); chi-square test results showed a significant association ($X^2 = 24.82$, $df = 9$, $p\text{-value} = 0.003$). Species with management measures that were more effective were likely to have biomass of target stocks in a good condition (B3.1 and B3.2), as was expected. Soupfin shark (inshore trawl and line fishery) and geelbek (line fishery) were exceptions. The biomass condition of soupfin shark indicated the stock was fully exploited (B3.2), even in the absence of management measures (B5.4) for both the inshore trawl and the line fishery. On the other hands, fisheries and geelbek, stocks were overfished (B3.4),

although management measures for the linefish sector are said to be partly effective (B5.2). Unsurprisingly, management measures of this species in the inshore demersal trawl fishery do not exist (B5.4), which could help to explain why the stock is overfished.

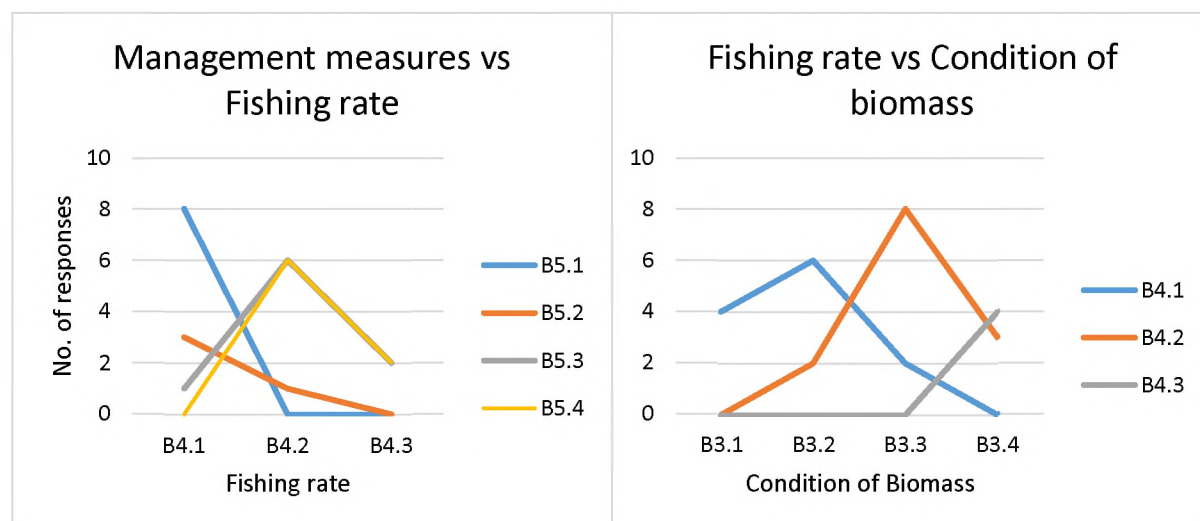


Figure 3.6e: Line plot demonstrating the relationship between the fishing rate (B4) in relation to that required to sustain long-term yield, and the effectiveness or ineffectiveness of management measures (B5). The legend consists of responses indicating management measures

Figure 3.6f: Line plot demonstrating the relationship between the condition of biomass of the target stock (B3) and the fishing rate (B4) in relation to that required to sustain long term yield. The legend consists of fishing rate responses

Similarly, there was a linear trend indicating that management measures influenced the rate at which fishing occurs (Fig. 3.6e). Chi-square results showed a significant association between these responses (X-squared = 22.41, df = 6, p-value = 0.001). This trend shows that effective management resulted in fishing at a rate that maintained or increased stock to sustainable conditions, as would be expected.

Another positive relationship was observed between fishing rate and biomass of target stock (Fig. 3.6f). Fishing that occurs at a rate that is likely to either maintain target stock to or increase it to sustainable levels was likely to result in biomass of target stocks that was in a good condition, with chi-square results showing a significant association (X-squared = 27.34, df = 6, p-value = 0.0001).

Table 3.2: Track B species with colours of the ellipses from the NMDS plot and final SASSI colours obtained by those species.

		NMDS	SASSI
KP.HL.4	Kingklip – hake longline		
KP.OT.4	Kingklip – offshore trawl		
CHM.4	Cape horse mackerel – offshore trawl		
AS.4	Atlantic swordfish – pelagic longline		
QM.4	Queen mackerel – linefish		
RR.4	Red roman – linefish		
MF.3	Monkfish – offshore trawl		
SN.OT.3	Snoek – offshore trawl		
CHM.3	Cape horse mackerel – mid-water trawl		
ECS.3	East coast sole – inshore trawl		
SN.LF.3	Snoek – linefish		
SMS.4	Shortfin mako shark – pelagic longline		
EM.4	Englishman – linefish		
CR.4	Catface rock cod – linefish		
WER.4	White-edge rock cod – linefish		
YBR.4	Yellowbelly rock cod – linefish		
SHS.IT.3	Smoothhound shark – inshore trawl		
SFS.IT.3	Soupfin shark – inshore trawl		
SHS.LF.3	Smoothhound shark – linefish		
SFS.LF.3	Soupfin shark – linefish		
DG.4	Dageraad – linefish		
STK.4	Squaretail kob – linefish		
GB.IT.3	Geelbek – inshore trawl		
BS.4	Blue shark – pelagic longline		
DK.4	Dusky kob – linefish		
SM.4	Scotsman – linefish		
SD.4	Shad – linefish		
WS.4	White stumpnose – linefish		
GB.LF.3	Geelbek – linefish		

Table 3.2 is similar to Table 3.1 with regard to the presence of species in the green, orange or red ellipses. The only difference is that there are no species that are in the orange and red ellipses which are listed as Green or Orange respectively. This track had a few species that were outside the three ellipses; these species typically had responses that were in different ellipses. Some were listed as Red and others as Orange on the SASSI list.

Track C, Category 1: Data deficient, very limited or no fishery specific data is available on target stock, or non-target species that are retained.

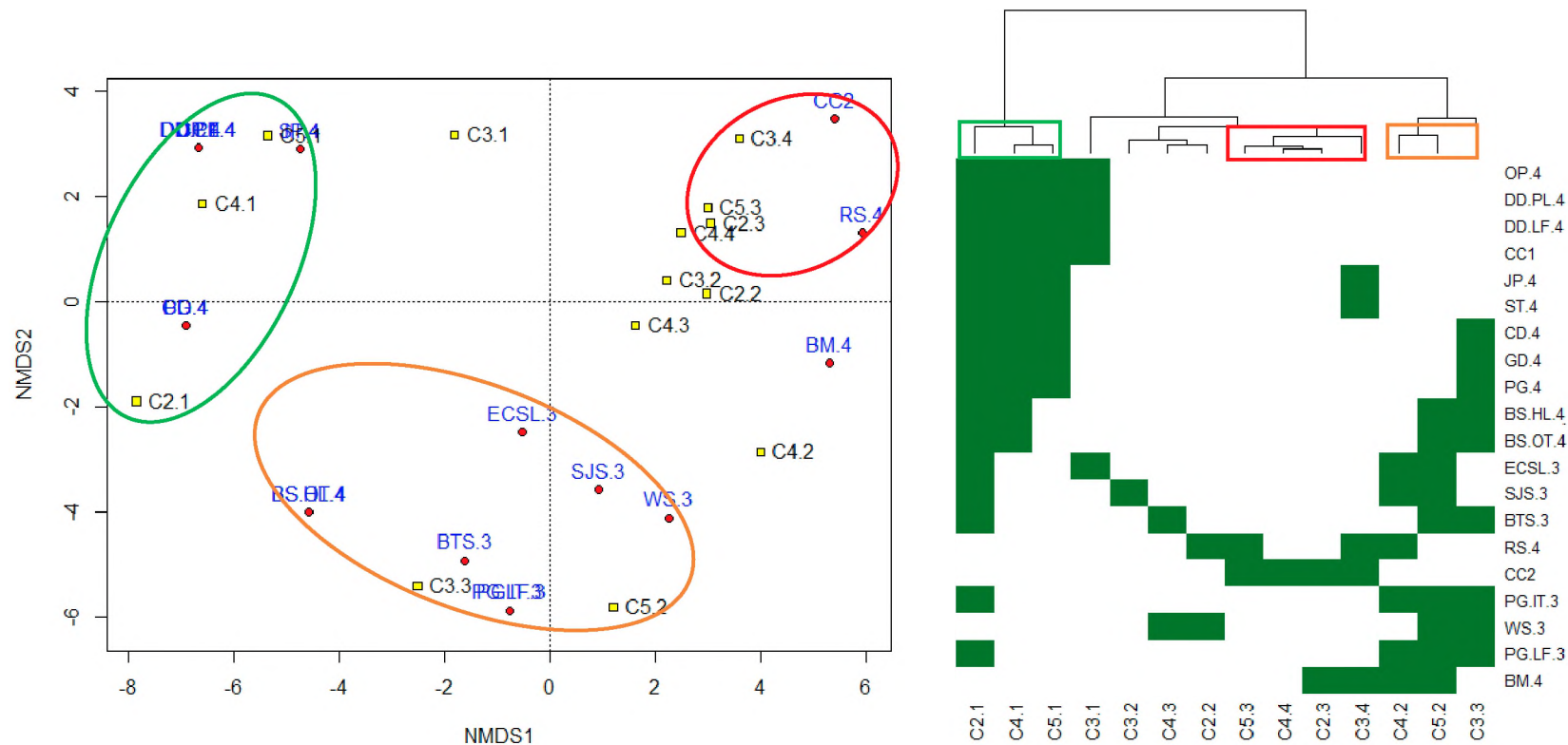


Figure 3.7a: Two-dimensional ordination plot from non-metric multidimensional scaling analysis of responses from Category 1, Track C, together with species. The responses were numbered in sequence: C2.1–C5.3. Table 3.3 provides the full and abbreviated names for each species.

Figure 3.7b: Hierarchical clustering from Binomial distance of responses from Category 1, Track C, together with species. Responses are classified into similar/dissimilar clusters based on Ward's criterion and Mantel statistics at the top of this figure

After a single ordination run, a stress value of 0.070 was obtained for Category 1 Track C, which indicates that the two-dimensional NMDS plot is a good ordination with no probability of misrepresentation.

Species and responses were distributed throughout the NMDS plot (Fig. 3.7a). Three groups were observed. The species and responses in the first group (green ellipse) were negatively correlated to NMDS1. This group consisted of offshore demersal trawl species: Cape dory (*Zeus capensis*) 2014, octopus (*Octopus magnificus* and *O. vulgaris*) 2014, jacobever (*Helicolenus dactylopterus*) 2014, gurnard (*Chelidonichthys capensis*) 2014 and panga (*Pterogymnus laniarius*) 2014; linefish species: santer (*Cheimerius nufar*) 2014 and dorado (*Coryphaena hippurus*) 2014; pelagic longline dorado 2014 and Control C1. Table 3.3 provides the full and abbreviated names for each species. The responses associated with these species included C2.1, C4.1 and C5.1, which also negatively correlated to NMDS1. The hierarchical cluster (Fig. 3.7b) showed that none of these species were at biological risk, therefore they were not listed as either Threatened or Endangered internationally or domestically (C2.1). The clustering also showed that all these species either did not exhibit or exhibited only one of any inherent life characteristics that made it vulnerable to fishing pressure⁹ (C4.1). Lastly, the cluster analysis showed that current fishing practices do not threaten any of these species. The second group (red ellipse) contains only the linefish species: red stumpnose (*Chrysoblephus gibbiceps*) 2014 (and Control C2), which was positively correlated to NMDS1. Responses C2.3, C3.4, C4.4 and C5.3 were associated with this species and correlated positively to NMDS1. All responses in this group were the worst responses for their respective questions in this Track. Of these, the cluster analysis showed that red stumpnose scored only C3.4 and C5.3. This means that this species had at least two factors that make it highly vulnerable to fishing pressure¹⁰ (C3.4), and that target stock was threatened by current fishing practices (C5.3). The last group (orange ellipse) comprised inshore trawl species: St. Joseph's shark (*Callorhynchus capensis*) 2013, white stumpnose 2013, biscuit and twin-eye

⁹ These life history characteristics include schooling, other temporary aggregations, geographic distribution, diadromous, semelparous or viviparous reproduction and sequential hermaphrodite.

¹⁰ The factors that make species vulnerable to fishing pressure include growth rate, age at maturity, and maximum age.

skates (*Rajidae family*) 2013 and panga 2013; linefish panga 2013; East Coast spiny lobster (ECSL) (*Panulirus homarus rubellus*); hake longline's biscuit skates (*Raja straeleni*) 2014 and offshore demersal trawl biscuit skates 2014. These species were negatively correlated to NMDS2, along with the responses, C3.3 and C5.2, associated with them. The cluster analysis showed that these species either had at least one of the factors that make it highly vulnerable to fishing pressure, or information about these factors was not available (C3.3). St. Joseph's shark and ECSL were exceptions as they had at least two factors that made them moderately vulnerable to fishing pressure (C3.2), and cluster analysis also showed either that existing fishing practices might threaten target stock, or lack of information prevented an evaluation (C5.2) for all these species. Linefish black musselcarcker (*Cymatoceps nasutus*) was the only species outside the ellipses.

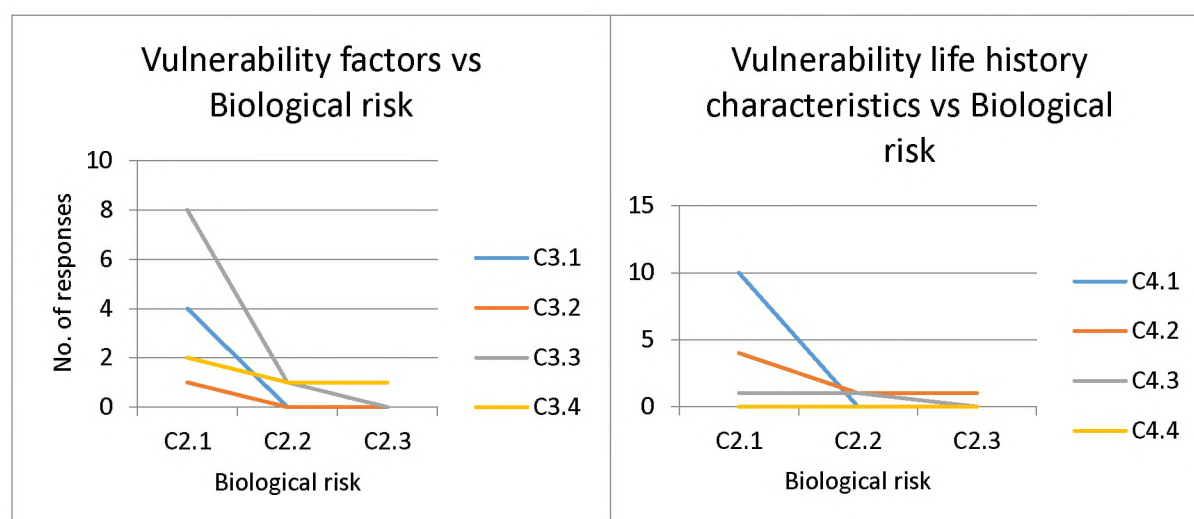


Figure 3.7c: Line plot showing the relationship of factors causing species vulnerability to fishing pressure (C3) against biological risk of the species and the possibility of it being listed as Threatened or Endangered (C2).

Figure 3.7d: Line plot demonstrating the influence of the vulnerability of species to fishing pressure because of life history characteristics (C4) on the biological risk of the species and the possibility of it being listed as Threatened or Endangered (C2).

It was expected that species that did not have a factor or factors that made them susceptible to fishing pressure were not likely to be at biological risk, therefore were not listed as either Threatened or Endangered (Fig. 3.7c). However, chi-square results showed there was no association between these responses (X-squared = 5.48, df = 6, p-value = 0.48). Jacopever (offshore trawl) and santer (linefish) were the exceptions;

they had at least two factors that indicated they were highly vulnerable to fishing pressure (C3.4). However, they are not at biological risk (C2.1). In the case of santer, the results of an IUCN Red List conducted in 2009 were awaiting review and publication.

Figure 3.7d shows the relationship between life history characteristics that make species vulnerable to fishing pressure and biological risk. Species that exhibit many life history characteristics that make them susceptible to fishing pressure were likely to be listed as either Threatened or Endangered but, as in the previous paragraph, there was no significant association between these responses (X-squared = NaN, df = 6, p-value = NA). There was insufficient evidence that biscuit and twin-eye skates exhibited any of the listed life history characteristics (C4.3) and were thus not at biological risk (C2.1).

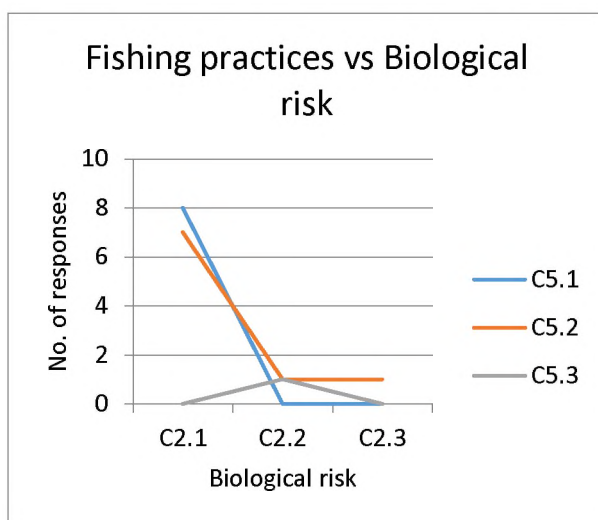


Figure 3.7e: Line plot demonstrating the influence of current fishing practices (C5) on the biological risk of the species (C2).

Figure 3.7e shows species not threatened by fishing practices were not likely to be at biological risk (Fig. 3.7e). There was an association between these responses (X-squared = 10.13, df = 4, p-value = 0.038). Black musselcracker was listed as an Endangered species (C2.3); however, there was not enough information to determine if the stock was threatened by fishing practices (C5.2).

Table 3.3: Track C species with colours of the ellipses from the NMDS plot and final SASSI colours obtained by those species.

		NMDS	SASSI
CD.4	Cape dory – offshore trawl	Green	Orange
GD.4	Gurnard – offshore trawl	Green	Orange
JP.4	Jacopever – offshore trawl	Green	Red
OP.4	Octopus – offshore trawl	Green	Orange
PG.4	Panga – offshore trawl	Green	Orange
DD.PL.4	Dorado – pelagic longline	Green	Orange
DD.LF.4	Dorado – line fishery	Green	Green
ST.4	Santer – linefish	Green	Orange
BS.HL.4	Biscuit skate – hake longline	Orange	Red
BS.OT.4	Biscuit skate – offshore trawl	Orange	Red
BTS.3	Biscuit & twin-eye skates – inshore trawl	Orange	Red
PG.IT.3	Panga – inshore demersal trawl	Orange	Red
PG.LF.3	Panga – line fishery	Orange	Orange
SJS.3	St. Joseph’s sharks – inshore trawl	Orange	Red
WS.3	White stumpnose – inshore trawl	Orange	Red
ECSL.3	East Coast spiny lobster	Orange	Orange
RS.4	Red stumpnose – linefish	Red	Red
BM.4	Black musselcracker – linefish	White	Red

Factors that cause species to be placed in the different NMDS ellipses were discussed in Table 3.1, and Table 3.3 is a similar case. As in Tables 3.1 and 3.2, species in the green ellipse are expected to be listed as either Green or Orange on the SASSI list; those in the orange ellipse listed as either Orange or Red and those in the red ellipse as Red. Jacopever was an exception. This species scored most of the best responses in Category 1; the exception was it contained at least two factors that made it vulnerable to fishing pressure (C3.4). It was in the green ellipse on the NMDS plot but was listed as a Red species on the SASSI list.

3.4. Discussion

These results show that there have been strides made in understanding problems that currently exist. Identifying these issues is paramount in ensuring progress of implementation for EAF. These can be used in determining milestones that will measure progress in implementation. In order to identify the issues that exist, it is useful to discuss the results of these categories separately.

Category 2: Ecological impacts

The offshore and inshore demersal trawls were at opposite ends of the NMDS plot (Fig. 3.3a). Although evidence is inconclusive, the SASSI assessments considered that the inshore trawl is likely to impact on benthic habitats (response 10.3). Other potential ecosystem impacts caused by the inshore trawl include damage to seabed habitats and vulnerable marine ecosystems; diverse and substantial bycatch, which includes over-exploited linefish species; high catches of juvenile silver kob and geelbek; chondrichthyan bycatch in the hake-directed fishery; discards of low-value and small fish. Response 7.4 indicates that this fishery negatively impacts species listed as over-exploited, collapsing or threatened. These include silver kob, smoothhound shark, geelbek, carpenter, and soupfin shark. All these are taken as bycatch. Evidence of ecosystem effects caused by the offshore trawl fishery is inconclusive because of insufficient information on offshore habitats.

The rest of the fisheries were clustered in between the offshore and inshore demersal trawl fisheries. The line fishery uses handlines and rod-and-reel (DAFF 2014), with minimal damage to habitat, and has a discard rate of less than 5%, with an unknown survival rate. Tuna pole uses pole and line, rod and reel, and trolling, which are not destructive to benthic habitat and species (Chuenpagdee, et al., 2003). Tuna pole also has a discard rate of less than 5%, but with a much better survival rate compared to the line fishery. According to the SASSI assessment, the mid-water trawl fishery operates in waters deeper than 110 m; the nets used are not believed to cause significant damage to benthic habitats. The discard and survival rate are similar to those of the line fishery.

The WCRL fishery was not associated with any other fisheries or responses. The fishery received favourable responses in this category. The exception was response 10.3, which indicates that this fishery was likely to cause substantial ecosystem changes. Ecosystem changes caused by this species include a shift in distribution of this species into productive abalone (*Haliotes midae*) areas, where the species is implicated in the disappearance of sea urchins (*Parechinus angulosus*) (Cockroft and Payne 1999; Cockroft et al. 2008). Juvenile abalone have a mutually beneficial relationship with sea urchins, the latter providing shelter from predation for the former (Cockroft and Payne 1999; Cockroft et al. 2008). This ecological impact caused by WCRL greatly affected recruitment of abalone species and resulted in severe outcomes for the abalone fishery (Cockroft et al. 2008). The abalone TAC was reduced by 80%, the recreational sector of the abalone fishery was suspended, and two previously productive abalone harvesting sites were closed (Cockroft et al. 2008). Another ecosystem change linked to WCRL is the significant impact on the numbers of breeding pairs of bank cormorants (*Phalacrocorax neglectus*) (Cockroft et al. 2008). The dramatic reduction in abundance of WCRL, which is a major prey species for bank cormorants, is reportedly the cause (Cockroft et al. 2008).

Category 3: Management measures

The factor that differentiated the two groups was the effectiveness of management measures for the different aspects of the fisheries. The first group, which includes linefish 2013 and 2014, pelagic longline 2013, offshore demersal trawl 2013, to name a few, had management measures that were more effective in managing ecosystem processes (ETP species, discards, bycatch and ecosystem effects) compared to the second group, which had management measures that were less effective on ecosystem processes. The second group, examples of which include demersal hake longline 2013 and 2014, mid-water trawl 2013, purse seine 2013, inshore demersal trawl 2013, had management measures that were more effective with regard to IUU, misreporting, compliance and enforcement, as well as transparency and participation, while the first group performed poorly in this regard.

Pelagic longline and offshore demersal trawl were observed in both groups, indicating that the effectiveness of their management measures changed from 2013 to 2014. For the offshore demersal trawl fishery, management of ecological impacts, discards, ecosystem effects and mixed fishery, changed from largely effective in 2013 to partly effective in 2014 and IUU; misreporting changed from fully effective in 2013 to largely effective in 2014. In the case of the pelagic longline fishery, management of ecological impacts, ETP species, discards, ecosystem effects and monitoring decreased from largely effective in 2013 to partly effective in 2014, while management of unwanted bycatch, compliance and enforcement and RFMO engagement increased from marginally effective, partly effective and marginally effective, respectively, in 2013, to partly effective, largely effective and partly effective, respectively, in 2014. Assessor bias (uncertainty) is another potential factor that may account for the change in management measures as these were conducted by two different teams over the two years.

The purse seine fishery, which has minimal bycatch because of its targeted fishing method, aggregated with fisheries in the second group. The fishery does however cause an ecological impact on the ecosystem, through interruption of the food-web chain. Sardine and Anchovy occupy mid-trophic level of 3.0 and 3.5, respectively, making them important predator species to the phytoplankton they feed on and prey species to larger fish and seabirds that feed on them (Shannon et al. 2003; McGregor 2015). This requires management intervention. Species in this fishery have experienced a distributional shift from the West Coast to the South Coast (McGregor 2015). This shift is reported to be due to environmental changes and localised overfishing (Coetzee et al. 2008; Watermeyer as cited by McGregor 2015). These ecological impacts require constant management attention, and may have a role in this fishery receiving a lower SASSI score in effectiveness of management measures from 2013 to 2014.

Category 1: State of target stock

Track A: Data rich species, scientific assessments are available and reference points defined.

The species present in Track A were identified as being of high commercial value. Because of their commercial importance, much research and monitoring has been undertaken for these species (Visser 2015). Deep- and shallow-water hake are South Africa's highest grossing species, with an annual landed value of ZAR2.87 billion, providing employment for 8355 (Lallemand et al. 2014). The hake caught by the offshore and inshore demersal trawl sectors, excluding the demersal longline sector, are MSC certified (Andrews et al. 2015). An MSC pre-assessment for the demersal longline sector was conducted by Japp (2011), but no action has been taken since. The small pelagics; anchovy and sardine, are the target stocks of the largest fishery in terms of landed mass, and the gross value of the small pelagic fishery is the second highest in the country (DAFF 2014). These species, which are all in the green ellipse, are offshore and require specialised and expensive vessels and equipment, so are not easily accessible to poachers. Fisheries that target these species have management measures that are largely and fully effective in managing illegal, unreported and unregulated fishing, as well as misreporting. This is a result of the high attention given to them by DAFF, probably because of their high social and economic value.

The status of a stock is influenced by different factors, such as fishing and ecological impacts. According to the DAFF 2014 report, stock status of shallow-water hake and anchovy were categorised as abundant, whereas stock status of deep-water hake and sardine were optimal. Fishing pressure relates to the amount of fishing exerted on the resources. Fishing pressure for sardine, deep- and shallow-water hake was optimal, while that of anchovy was light. This is consistent with the positive relationships that were observed between effectiveness of management measures vs fishing mortality (Fig. 3.5c) and management measures vs spawning stock biomass (Fig. 3.5d). All these factors explain the placement of these species in the green ellipse on the NMDS plot. Hake species from the demersal hake longline fishery were listed on the SASSI list as Orange, while the same species were listed as Green in the inshore and offshore trawl sectors (these were not part of the 2013 and 2014 assessments). The purse

seine species were listed as Green on the SASSI species list. The difference in the listing of these species, anchovy, sardine, shallow- and deep-water hake, lies in responses obtained in Categories 2 and 3. The purse seine fishery had negligible bycatch or discards compared to the hake longline fishery (DAFF 2014). The purse seine, however, was likely to have substantial ecosystem effects because of the important role of the target species as prey species. The assessments also show that the management measures of the purse seine fishery were more effective than the demersal longline fishery (Fig. 3.4a).

An exception to the pattern of high-value fisheries being well managed is the West Coast rock lobster fishery. WCRL is a slow-growing, long-lived, high-value species which is important commercially, recreationally and also for small-scale fishing (DAFF 2014). The fishery is the third largest commercial fishery in the country, with an annual value of R260 million and 4200 employees (DAFF 2012b and DAFF 2014). This species was located in the red ellipse of the NMDS plot and was listed as orange in the SASSI species list. Target stock biomass of the WCRL is around 2.6% of pristine levels, and the DAFF 2014 report categorises the status of this species as both depleted and heavily depleted, with optimal fishing pressure (DAFF 2014). This species is easily accessible from the shore, making it vulnerable to poaching, and Category 3 shows that the authorities have only been marginally effective in combating IUU fishing and in enforcing compliance (Petersen et al. 2010b; DAFF 2012d). These factors explain its placement within the red ellipse on the NMDS plot. This species is listed as Orange however, on the SASSI species list, possibly because of the better responses obtained in Category 2: highly selective gear, low bycatch and limited damage to benthic habitats, as well as in Category 3 with regards to ecosystem effects and monitoring/data availability (Cochrane et al. 2004). SASSI noted that *“Since a decrease in Total Allowable Catch (TAC) was introduced stock levels have shown signs of rebuilding and recovery; however, recent TAC allocations were not set in accordance with the recovery targets and scientific recommendations, raising concerns about the future management of this stock”*.

Tuna and swordfish are a highly migratory, trans-boundary species distributed in the Atlantic, Indian and Pacific Oceans, in the case of swordfish (Cochrane et al. 2004, DAFF 2014). As such, they are managed by Regional Fisheries Management

Organisations such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) (DAFF 2014). These species are harvested in the pelagic longline and the tuna pole-line (formerly tuna pole), and rod and reel (DAFF 2014). All tuna and swordfish species in this track were in the orange ellipse on the NMDS plot (Fig. 3.5a), except albacore tuna, which was in the red ellipse because its spawning stock biomass was below the target reference point. The tuna and swordfish species in the orange ellipse for Track A, Category 1 were listed as Orange on the SASSI species list, except yellowfin tuna, which was listed as Green, while albacore tuna, in the red ellipse for Track A, Category 1, was listed as Orange on the SASSI species list. The yellowfin and albacore tuna assessed by SASSI were from the tuna pole-line sector. The tuna pole-line sector had fewer negative impacts on ETP species, less bycatch with a high survival rate, no significant negative ecosystem effects (Category 2) and management measures that were more effective (Category 3) when compared to the pelagic longline sector (SASSI).

The line fishery exploits over 200 species (Mann 2013; DAFF 2014). This fishery is very important for recreational fishing, as well as small-scale commercial fishing (Mann 2013). Estimates of the number of small-scale fishers varies between 30 000 and 100 000 (Cox 2013; DAFF 2014). This fishery is valued at R2.2 billion per year (DAFF 2014). The Track A line fishery species, such as hottentot, slinger and yellowtail, as well as two species targeted in the line fishery and caught as bycatch in the inshore demersal trawl fishery, carpenter and silver kob, were in the orange ellipse on the NMDS plot. Of these, the inshore trawl bycatch species, carpenter and silver kob, were listed as Red on the SASSI species list, while the same species, as well as slinger, were listed as Orange under the line fishery. Hottentot and yellowtail were listed as Green. The difference in listing of the same species targeted in both the inshore trawl and line fishery was possibly a result of the relatively high proportion of discards generated by the inshore trawl and retained juveniles or discards (see Category 2, Fig. 3.3a and b), as well as the better management in the line fishery (see Category 3 results, Fig. 3.4a and b). Hottentot and yellowtail were listed as Green because they obtained the best responses in Category 1 and the Category 2 and 3 results for the species did not result in downgrading.

Track B: Moderate data species, substantial fishery information but no reference points defined.

Track B contains a mixture of target and bycatch species. Most target species are from the line fishery and most bycatch species are from the demersal trawl fisheries, which are MSC certified. The green ellipse is dominated by species that are commercially important, such as kingklip, snoek and Cape horse mackerel, therefore their management is likely to receive more attention, and they are relatively inaccessible to illegal fishing activities. As previously mentioned, the line fishery is an important commercial and recreational fishery and provides a livelihood for small-scale fishers (Mann 2013). With over 200 species targeted in the line fishery, about 20 of those are of commercial importance and dominate catches by 90% (Mann 2013; DAFF 2014). Species in this fishery were heavily over-exploited to the point that the fishery was declared to be in a State of Emergency in 2000 (Cochrane et al. 2004; DAFF 2014). In an attempt to rebuild the stocks, a Total Allowable Effort (TAE) was set to reduce catches by 70% by reducing commercial fishing vessels from 755 to 450, and also reducing fishing pressure from the recreational sector (DAFF 2014). Although these regulations are in place, the actual fishing effort has consistently been above the set TAE, largely due to IUU fishing, exemptions for interim relief permits, and bycatch of linefish species from other fisheries, such as the inshore trawl, amongst others (DAFF 2014). Many linefish species are predatory species (Cochrane et al. 2004; DAFF 2014), and removing predatory species from an ecosystem has been documented as causing cascading effects, by releasing prey species, and affecting species diversity within that ecosystem (Pauly et al. 2002; Myers and Worm 2003). Management of resources in this fishery has been complicated, particularly for those species that are also caught as bycatch in other fisheries. This has created conflict between the line fishery and the inshore trawl fishery (Cochrane et al. 2004; Attwood et al. 2011).

The demersal trawl fisheries consist of the offshore demersal trawl and the inshore demersal trawl. These fisheries target deep-water hake, and shallow-water hake and East Coast sole (Agulhas sole), respectively. Catches from these fisheries include bycatch of commercial and non-commercial species (Cochrane et al. 2004; DAFF 2014). These bycatch species are, but are not limited to, monkfish, snoek, Cape horse mackerel, kingklip, silver kob, carpenter, smoothhound shark, soupfin shark and

geelbek (Cochrane et al. 2004; Attwood et al. 2011). The inshore trawl started as a multi-species fishery in 1898 but has since shifted to targeting only shallow-water hake and East Coast sole (Attwood et al. 2011). Even though this fishery targets two species, about 42% of the catch is from non-target species (Attwood et al. 2011). A substantial amount of the bycatch consists of marketable species (Attwood et al. 2011). Walmsley et al. (2007) estimate the bycatch species to be valued at 15–36% of the total product value (as cited by Attwood et al. 2011).

Track C: Data deficient species, very limited or no fishery specific data available on target stock, or non-target species that are retained.

Most of the species present in this track are bycatch species, many of them from the demersal trawl fisheries, as well as some linefish species and the East Coast Spiny Lobster (ECSL). It is not surprising this track is dominated by bycatch species as the track is for data-poor species. With the exception of the linefish species and the ECSL, most of these species are not of high commercial importance. Most of the offshore demersal trawl bycatch species were in the green ellipse on the Category 1, Track C NMDS plot and listed as Orange species on the SASSI list, and species from the inshore trawl were in the orange ellipse and listed as Red on the SASSI list (Fig. 3.7a; Table 3.3). As mentioned earlier, many of the inshore trawl bycatch species are targeted in other fisheries (Attwood et al. 2011), while most of the offshore trawl bycatch species are not targeted by other fisheries and are not abundant enough to sustain a separate fishery (Walmsley et al. 2007). There have been concerns about the sustainability of species targeted by the line fishery and caught as bycatch in the inshore trawl fishery, such as red stumpnose and panga (Attwood et al. 2011). This could be the reason these species were aggregated on the orange and red ellipse on the NMDS plot. The offshore trawl bycatch species, such as octopus and gurnard, are not targeted by other fisheries and their inaccessibility could be factors that contribute to their placement in the green ellipse on the NMDS plot. The offshore trawl has two bycatch species that are of commercial importance in this track: kingklip and monkfish (Walmsley et al. 2007). There is no way to target hake and avoid the bycatch of these

two species, and Walmsley et al. (2007) suggested the introduction of bycatch allocation.

Most of the linefish species, for example, black musselcracker and santer, present in this track are recreational species and few are of commercial value (Mann 2013). Although the recreational sector is importantly economically, especially with regard to tourism, this sector, along with some of its species, has not been afforded the same kind of attention as the commercial sector and its species (du Preez and Lee 2010). It is therefore not a surprise that the linefish species in this track are recreational species.

3.5. Conclusion

The picture painted by the SASSI assessments is that of a country moving towards implementation of EAF in practice, albeit slowly. These SASSI assessments act as indicators for sustainability of target stocks and ecological conditions. They also act as management performance indicators: through these assessments, effectiveness of management has been compared over the two years.

A major conclusion from this study is that species from larger commercial fisheries are more likely to be classified as green sustainable species compared to less financially significant fisheries. Category 1 showed that management measures influence the status of stock. A factor that influences good management measures is the amount of information available. Species from larger commercial fisheries are more researched and this information is used to improve management measures, thus ensuring these species are kept sustainable. Incentives seem to play a significant role in the overall conditions of the fishery. The largest commercial fishery in South Africa is certified by the most widely discussed eco-labelling body in the world (Jacquet and Pauly 2007).

Chapter 4: Assessment of progress in implementing the ecosystem approach to fisheries in practice, using the ecological risk assessments

4.1. Introduction

Principles of the ecosystem approach to fisheries (EAF) have been in existence for decades; their implementation, however, has proved to be challenging (FAO 2005). The World Summit on Sustainable Development Plan of Implementation called for the development of an institutional framework for implementation of EAF (Garcia and Cochrane 2005) and the Food and Agricultural Organisation (FAO) was mandated with the task of developing this framework, which resulted in the FAO Technical Guidelines for Responsible Fisheries (FAO 2003). There has also been a great deal of other work on the development of EAF frameworks including, for example, Ward et al.'s 'Policy proposals and operational guidance for ecosystem-based management of marine capture fisheries' (2002), Fletcher et al.'s 'National Ecological Sustainable Development Reporting Framework for Australian Fisheries' (2002), and Pitcher and Preikshot's 'RAPFISH: a rapid appraisal technique to evaluate the sustainability status of fisheries' (2001).

It has been over a decade since the first ERA was conducted in South Africa. The previous chapter showed a glimpse of what has been done, but was based on the SASSI assessments, which do not go into detail on the different issues covered by the questionnaires. The aim of this chapter is to assess, in detail, progress in implementation of EAF since the first ERAs were conducted and to assess obstacles preventing effective implementation of EAF. To achieve these two aims, four fisheries were chosen. These are the West Coast rock lobster fishery, the offshore trawl fishery, the inshore trawl, and the line fishery. The fisheries were chosen because they demonstrated different arrays of issues, from stock status to negative ecological impacts, and governance issues. The WCRL species is over-exploited, but the fishery causes negligible ecological impacts, while the inshore trawl fishery which targets stock in a fairly good condition, has negative ecological impacts. The line fishery, similar to the WCRL but with a diverse number of species, presents the most complex management system. Results from the previous chapter indicate that the offshore demersal trawl is the best fishery in terms of performance against the different criteria.

Economic importance and accessibility were also prominent factors in the previous chapter. The examples allowed for these different challenges to be explored in detail, to take note of improvements and assess how those improvements could potentially be used to assist other fisheries.

The West Coast rock lobster fishery

The West Coast rock lobster (WCRL), *Jasus lalandii*, is an economically and socially importance species. The full commercial sector of this fishery was reported at an estimated ZAR390 million commercial value in 2012, providing employment for over 1221 people, and the limited commercial sector contributed ZAR42 million with 825 rights holders (DAFF 2012b). Of the different fisheries issued limited rights, this fishery was the only one with a turnover that increased steadily against declining catches (DAFF 2012b). The distribution of this species is from north of Walvis Bay in Namibia, on the west coast of Africa, to East London on the south coast of South Africa (Cochrane et al. 2004; DAFF 2014). The fishery makes use of hoop nets and traps to catch males above 75 mm carapace length (CL) (DAFF 2014). In 1997, management adopted an operational management procedure (OMP) with the aim of rebuilding the severely depleted stocks. The current OMP aims to rebuild the stocks to 4.8% of their pristine levels by 2021, which are currently at 2.6% (DAFF 2014).

The demersal inshore trawl fishery

The inshore trawl fishery is situated on the south coast of South Africa and is split between two sub-sectors: one targets shallow-water Cape hake, *Merluccius capensis*, with East Coast (Agulhas) sole, *Austroglossus capensis*, as bycatch, and the other targets sole with shallow-water hake as bycatch. The fishery makes use of trawl nets which are dragged behind the boat along the ocean floor. The fishery is managed through an annual TAC for rights holders and employs in the region of 722 people. The landed catch value was estimated at ZAR100 million (DAFF 2014; Lallemand et al. 2014).

The demersal offshore trawl fishery

The offshore trawl fishery targets both hake species: shallow-water Cape hake, and deep-sea Cape hake, *M. paradoxus*. The shallow-water hake resources are shared with the inshore sector but uncertainty remains about the extent to which South African deep-water hake resources are shared with the Namibian Hake Fishery (Nel 2007; DAFF 2014). The offshore trawl is the largest grossing fishery in South Africa, with a landed value of about ZAR2.6 billion annually and over 6653 people employed in the sector (Lallemand et al. 2014). The hake fishery is export driven and is certified as sustainable by the Marine Stewardship Council (MSC) (Lallemand et al. 2014; Andrews et al. 2015).

The line fishery

Over 200 species are harvested in the line fishery, with only a few of those accounting for over 90% of the catch (Mann 2013). Resources are harvested by means of hook and line, excluding longline. The line fishery consists of three sectors: commercial, small-scale and recreational (DAFF 2014). The commercial sector is exclusively boat-based with many of its target species caught as bycatch in other fisheries (Petersen et al. 2010c). In 2000, the fishery was declared to be in a state of emergency. The commercial sector is managed through a total allowable effort system based on boat and crew numbers, while the recreational sector is managed through bag limits, closed areas and seasons, and the small-scale commercial sector is managed through a combination of these (DAFF 2014).

4.1.1. The ecological risk assessments (ERA)

The Benguela Current Large Marine Ecosystem (BCLME) programme, in conjunction with the FAO, initiated a project that would investigate the feasibility of implementing EAF in South Africa with the involvement of the Worldwide Fund for Nature (WWF) and the Department of Agriculture, Forestry and Fisheries (DAFF, formerly Marine and Coastal Management). This led to the development of the Ecological Risk

Assessments (ERAs) as the framework to aid implementation of EAF in South Africa (Nel et al. 2007). The ERAs were adapted from the National Ecological Sustainable Development Reporting Framework for Australian Fisheries (Fletcher et al. 2002). The goal of the ERA process was, *inter alia*, to assess each fishery, determine what management strategies exist, ecosystem concerns that stakeholders have, and issues impacting the fishery that are beyond management control, e.g. environmental impacts (Nel et al. 2007).

The ERA process involves participatory workshops with three objectives (*i*) to identify ecosystem issues, (*ii*) to prioritise these issues for management responses and (*iii*) to develop performance reports describing management responses for issues identified (Nel et al. 2007). Under the ERAs, the term ‘ecosystem’ encompasses biological, social, economic and governance (Nel et al. 2007).

i. Identification of issues

Stakeholders have to identify issues that affect the fishery under three categories: ecological wellbeing, human wellbeing and ability to achieve (Fig. 4.1). The nature of the process encourages stakeholder participation.

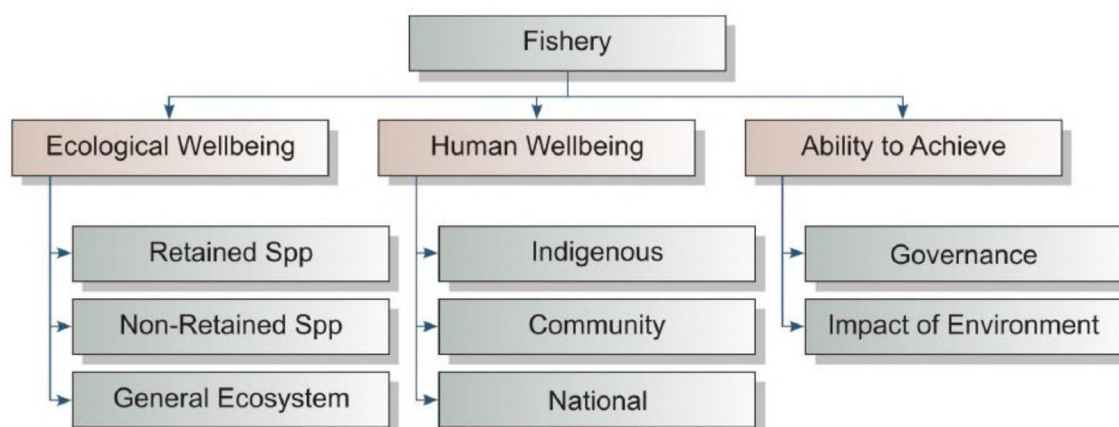


Figure 4.1: Schematic representation of the eight major components of the ERA process (Nel et al. 2007).

ii. Prioritisation of issues

The issues identified in the previous step differed in their levels of importance. They were therefore prioritised by allocating a risk score which is the consequence of the

occurrence of a particular issue (on a scale of 0–5) multiplied by the likelihood of it occurring (on a scale of 1–6). Issues were categorised as negligible (score of 0), low (score of 1–6), moderate (score of 7–12), high (score of 13–18) and extreme (score of 18 or greater) risk, according to their overall risk score. This process enables management to identify which issues are high risk and require immediate attention.

iii. Development of performance reports

Issues with a risk score of 7 and higher were identified as needing management attention. For these issues, performance reports requiring operational objectives, indicator identification, targets and milestones were developed. These, enabled regular progress to be measured against agreed targets. This process identified the need to continue with, or intensify actions already happening to address or mitigate the issues raised and also raise the need for action in neglected areas.

Nel et al. (2007) synthesised those issues found to occur across all fisheries to form 10 generic EAF objectives:

1. The managing authority has a good understanding of the ecosystem impacts of fisheries, including target, non-target and general ecosystem impacts.
2. Ecosystem impacts of fisheries are included in management advice.
3. The social wellbeing of dependent fishing communities is accounted for in management advice.
4. The economic wellbeing of the fishing industry is maintained.
5. The managing authority has transparent and participatory management structures that ensure good communication and information shared locally and regionally.
6. Management plans incorporate EAF considerations.
7. Compliance with regulations reduces ecosystem impacts of fisheries.
8. Sufficient capacity, skills, equipment and funding exist to support the implementation of an EAF.

9. Good data procedures exist to support EAF implementation.
10. External impacts of fisheries are addressed (i.e. the effect of other sectors, other industries, climate change etc.).

4.1.2. The Ecological Risk Assessment Review process

A review process was undertaken every few years to track progress in implementation. This process included using the 10 generic EAF objectives and expanding them to 71 operational management objectives (Appendix A in Paterson and Petersen 2010). These operational objectives were created to address those issues requiring management attention identified through the ERA process, along with management indicators, which formed the basis of a framework for tracking the progress of EAF implementation. During the review process, the ERA process was conducted again as the old ERAs were presumed to be out of date.

An EAF implementation tracking tool was developed with NetWeaver knowledge base development software, using the hierarchical representation of the EAF management objectives as the knowledge base for the tracking tool. Participants were asked to identify a process step (current stage of implementation – Appendix B in Paterson and Petersen 2010) that described actions existing at the time that were taken towards achieving each operational objective. The fuzzy logic method was adopted as an inference mechanism that would lead to a degree of trueness between 1 (100% truth) and -1 (100% false). A fuzzy logic scale was applied to the process steps ultimately showing the degree to which a particular operational objective has been fulfilled, expressed as a percentage (Fig. 4.2a, 4.3a and 4.4). Participants also recorded progress, and prioritized actions required to move the implementation process forward and to record achievement or barriers hindering progress (Paterson and Petersen 2010).

4.2. Methods

Progress in implementation

The fuzzy logic results expressed as a percentage were plotted as a histogram to compare and demonstrate progress in implementing the EAF objectives during the period between the successive review processes. The process steps of 71 operational objectives were obtained from the first ERA review report, and the second ERA review report of each of the four selected fisheries. These two sets of results were compared to observe the status of the process step on each occasion and to check whether it had improved, stayed the same, or regressed since the first review; or if it was unaddressed, was fulfilled or was new in the second review report. The sum of the process steps for all operational objectives included in each EAF objective were entered on Excel and plotted as a histogram. Thereafter, a Wilcoxon signed rank test was conducted in the programme R to determine if there was a statistical difference between the fuzzy logic results of the second review and the first review. The null hypothesis was that the fuzzy logic results of the two sample years were identical populations. A Wilcoxon signed rank test is a non-parametric test that analyses matched-pair samples, or repeated measurements of a single sample based on differences (Woolson 2008). This was conducted for the WCRL and inshore and offshore hake fisheries combined (as had been done in the ERAs). The line fishery has only been reviewed once and therefore progress cannot be evaluated in this way for that fishery, but rather discussed using the single review information available.

Problems faced by the fishery

Results from the analysis of the SASSI assessments (Chapter 3) identified challenges that the above-mentioned fisheries are currently dealing with. These problems and their causes and reasons are explored in detail, using the ERAs, SASSI assessments together with other published literature.

Obstacles preventing effective EAF implementation

Results from the *progress in implementation* and the *problems faced by the fishery* sectors were consolidated to identify what overarching obstacles are possibly preventing effective implementation of EAF for each fishery.

4.3. Results and Discussion

4.3.1. The West Coast Rock Lobster fishery

Progress in implementation

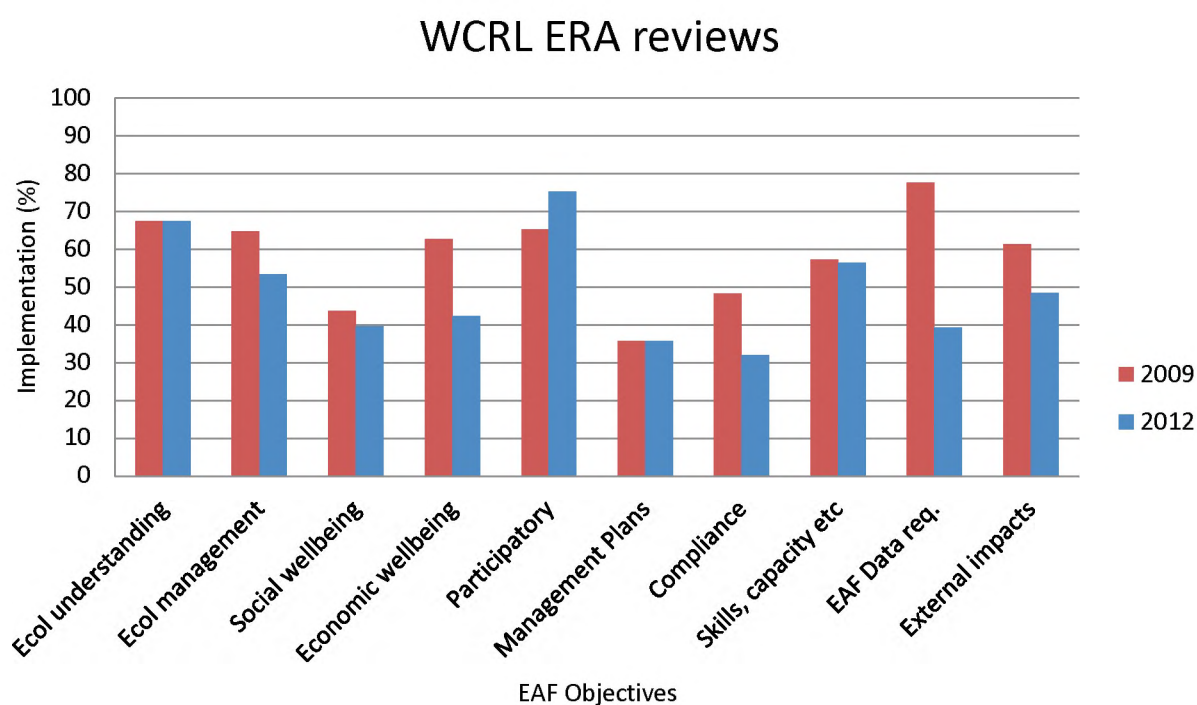


Figure 4.2a: Degree of implementation, expressed as a percentage, of EAF objectives from the 2009 and the 2012 ERA review process for the West Coast rock lobster fishery (DAFF 2012d).

The results show that in the West Coast rock lobster fishery, there has been limited progress in implementation, and for some EAF objectives, ground was lost between 2009 and 2012 (Fig. 4.2a). The histogram shows that implementation of most of the EAF objectives in fact declined over three years, decreasing from a mean of 58.4% in 2009 to 49% in 2012. Implementation of EAF data requirements, Economic wellbeing and Compliance declined by 38.4%, 20.3% and 16.2%, respectively. The Participatory EAF objective was the only one with improved implementation, increasing by 10.1%.

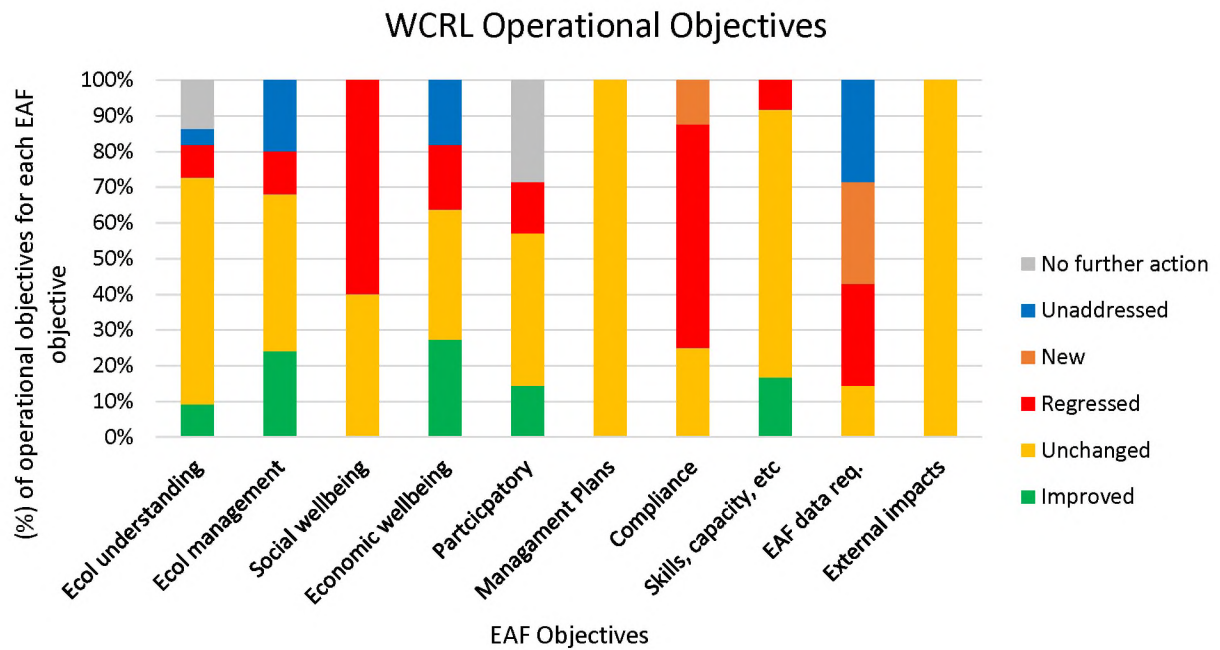


Figure 4.2b: Histogram showing operational objective process steps for the West Coast rock lobster fishery from the DAFF (2012d) ERA review process compared to the 2009 risk assessment. The legend shows the status of the process steps.

A breakdown of the operational objectives from the 2012 ERA report shows that many process steps remained the same as the 2009 ERA review (Fig. 4.2b). Of the process steps, 54.2% remained the same, 9.1% improved, 21.3% regressed, 4.1% comprised new operational objectives, and 4.2% required no further process steps. Economic wellbeing and Ecological management had the highest number of improved process steps at 27.3% and 24%, respectively. There was no change for the Management plans or for the External impacts objectives. The Compliance process steps had regressed most, 62.5%, followed by Social wellbeing with 60%. The extent of fulfilment of implementation of EAF in 2009 and 2012, as indicated by the process steps for all the operational objectives, was found to be significantly different (Wilcoxon test, $Z = 2.04$, $p = 0.04$), with 2012 lower than the initial extent of fulfilment in 2009 (Fig 4.2a).

Problems faced by the fishery

In the previous chapter, the results from the SASSI assessments showed that the WCRL target stock is over-exploited. The initial ERA process in 2004, under the Ecological wellbeing objective, categorised the priority allocated to abundance of the target stock as moderate. This oversight could possibly be attributed to the OMP that was in place with the aim of rebuilding stocks to 20% of 1996 levels. At the time, the target stock was estimated at 6% (Sauer et al. 2003). This aim was, however, not achieved. The 2012 ERA review changed the priority to high. Currently the target stock is at 2.6% of pristine levels (DAFF 2014). There are several issues that have contributed to the depleted stocks of WCRL and some that potentially prevent recovery of these stocks;

- The depleted status of the target stock is attributed to over-exploitation in the first half of the 20th century, as well as reduced somatic growth that affected recruitment in the late 1980s and early 1990s (Hazell et al. 2001; Sauer et al. 2003; DAFF 2014). As already mentioned above, catches of this species peaked in the 1950s, followed by a steady decline attributed to overfishing (DAFF 2014). The causes of the changes in somatic growth are unknown (Brandao et al. 2004), but have subsequently affected production and resulted in a low total allowable catch (TAC) being allocated for the fishery (Brandao et al. 2004). The average growth rate of the WCRL species from 1989–1992 was half the average growth rate recorded from 1987–1988, which is representative of normal growth rate for this species (Sauer et al. 2003). Somatic growth rate has since increased; annual growth increments of a 70mm male WCRL increased from 2.89mm in 1992 to 3.01mm in 2009 (Johnston et al. 2010). Between this period, the highest growth increment recorded was 4.90mm in 1996 (Johnston et al. 2010). Productivity changes in the southern Benguela region attributed to El Nino events have been theorised as the cause of the decrease in WCRL growth rate (Hazell et al. 2001). A study by Hazell et al. (2001) showed that food availability and temperature play a role in the growth rate of juvenile WCRL.

- The WCRL has high commercial value and it is relatively easily accessible, making it susceptible to illegal harvesting. DAFF estimated WCRL poaching to be at 565 t for the 2011 season (Statistics South Africa 2013). Other stakeholders argue that this is an understatement (Biyase 2011). There are a few factors that contribute to the high levels of illegal fishing. Prior to the promulgation of the Marine Living Resources Act (MLRA), small-scale fishers were not legally recognised as a sub-sector, resulting in small-scale fishers harvesting resources illegally for subsistence (Hauck et al. 2002; de Greef and Raemaekers 2013). The 1994 democratic elections brought little change; the promise of redistribution of wealth to those who were previously disadvantaged left many small-scale fishers frustrated and disgruntled after the slow process of transformation and what they deemed exclusion and denial of access to resources through the fishing rights allocation process, resulting in little compliance to regulations (Hauck et al. 2002; de Greef and Raemaekers 2013). The most important key driver of poaching is the high commercial value of this species. The fishery is export driven, and the exchange rate is currently at ZAR15.54 to USD1¹¹, making it a lucrative business for syndicates (Lallemant et al. 2014). The average price of WCRL species in 2014, for export in the Kleinemonde area is ZAR 225/kg (Jordan in prep).

Obstacles preventing effective EAF implementation

The Wilcoxon test showed that there was a significant difference between the degree of fulfilment of the EAF objectives between the 2009 ERA and the 2012 ERA reviews. The deconstruction of the Economic wellbeing, Compliance and EAF data requirements objectives in consideration of the above-mentioned challenges of this fishery shed light on the obstacles in the EAF implementation process;

- Within the economic wellbeing objective, the process of allocation of rights continues to fail to address the issues faced by fishing communities adequately. Recommendations by the Scientific Working Group to allocate quotas of at least

¹¹<http://www.xe.com/currencyconverter/convert/?Amount=1&From=USD&To=ZAR>

one ton per rights holder went ignored by the department in order to accommodate more participants. This subsequently made individual rights not economically viable. Also, new entrants were not provided with business and financial training. Long-term market security is cited as a serious concern as there are no strategies currently present that deal with this issue.

- The ERAs show that this fishery has a number of compliance issues. There seems to be a capacity problem within the managing body. The ERA reports stated that vessels larger than 5 m are fitted with a vessel monitoring system (VMS), but the operations room has limited functional hours, making it easier for smaller boats to abuse the system outside office hours. A few other problems connected to monitoring include lack of sufficient numbers of monitors to cover areas of exploitation, over-exploitation by interim relief permit holders often goes undetected, and the recreational sector does not have designated landing sites.
- Good data procedures that exist to support EAF include the use of logbooks, fisheries information management system (FIMS), as well as the land-based and sea observer programme for monitoring the resources. New operational objectives, however, indicate that log books for the interim relief sector are considered inadequate. Additionally, there are no logbooks for the recreational sector. Anderson (2011) notes that logbooks are important in communicating marine knowledge between fishers and fisheries researchers. Data contained in logbooks include kilograms caught per species, number of crew members, gear used, geographic location of catch as well as hours at sea (Anderson 2011), which data could be modified to suit the recreational sector. The suspension of the scientific observer programme creates gaps in the availability of information, disrupting long-term monitoring of the status of the resource. The absence of adequate logbook information leads to underestimates of fishing effort. This potentially affects the outcomes of the OMPs which use CPUE data to calculate TAC, ultimately tampering with the fisheries objective to rebuild the stocks. Information captured on logbooks is used for research purposes, research that informs policy (Anderson 2011).

4.3.2. The Hake fishery

The ERAs for the hake fishery include all four sectors that target Cape hakes: offshore trawl, inshore trawl, hake longline and hake handline. As a result, Figure 4.3a below combines the *Progress in implementation* section for both the inshore and offshore trawl. *Problems faced by fishery* and the *Obstacles preventing effective implementation* sections are separated according to each sector.

Progress in implementation

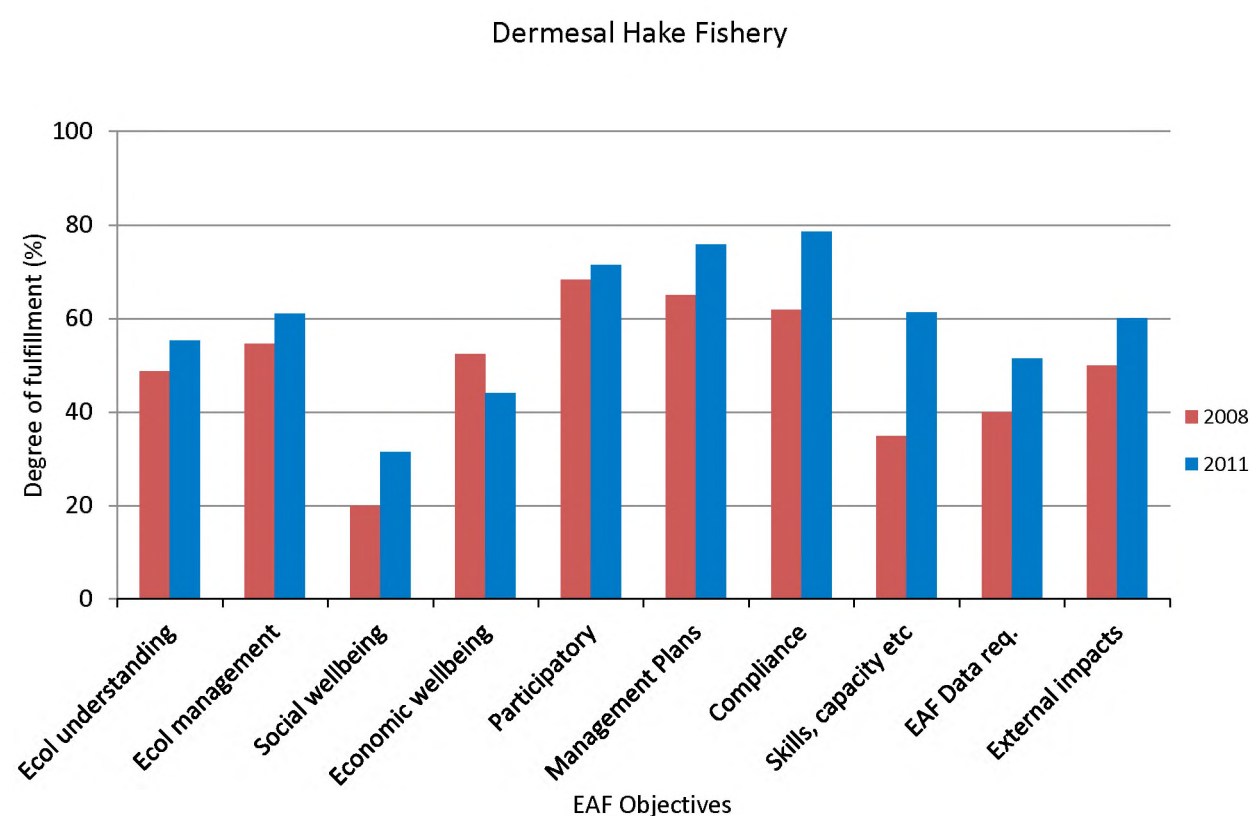


Figure 4.3a: Degree of implementation, expressed as a percentage, of the 10 generic EAF objectives in the demersal hake fishery for the 2008 and 2011 ERA reviews (DAFF 2011).

Unlike the WCRL fishery, there has been progress in implementing the 10 generic EAF objectives in the hake fishery, as Figure 4.3a shows. The average status of implementation increased from 49.6% in 2008 to 59.1% in three years, achieving a growth of almost 10%. Compliance, and Skills and capacity showed the biggest increases, with Compliance achieving a growth of 16.7%, and Skills and capacity 26.5%. Other objectives that achieved significant growth include Social wellbeing,

11.4%, Management plans, 10.7%, EAF data requirements, 11.4%, and External impacts, 10.2%. Economic wellbeing was the only objective to decline, decreasing by 8.4% in 2011.

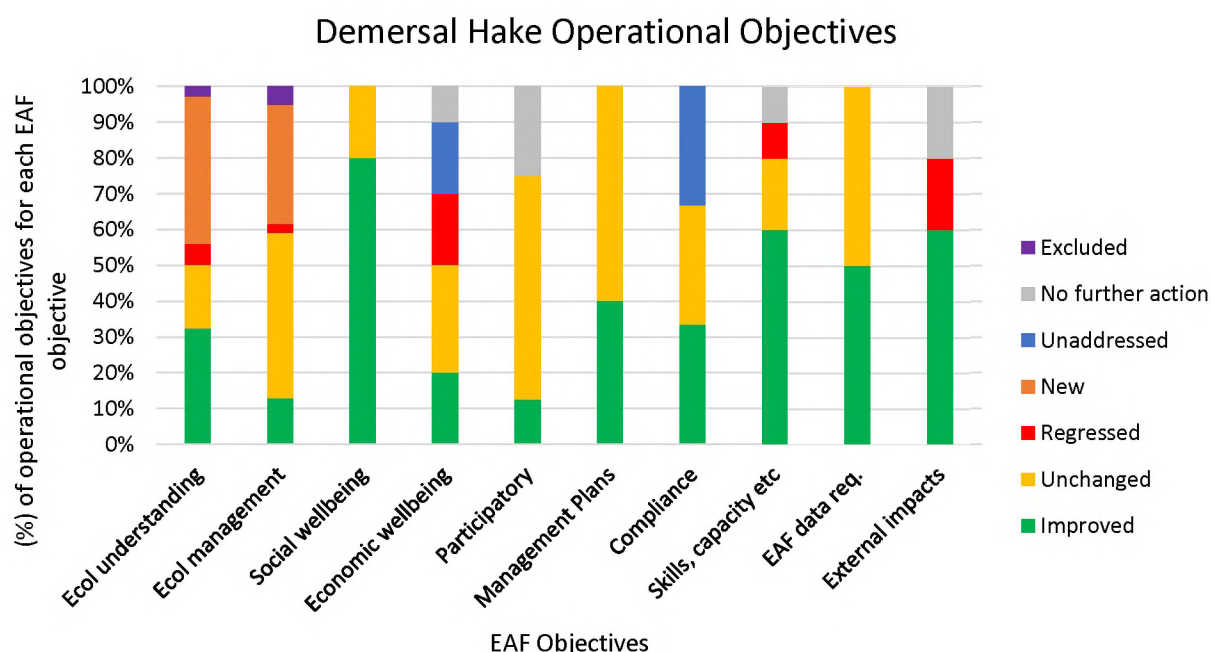


Figure 4.3b: Histogram demonstrating operational objectives, expressed as a percentage for each of the 10 generic EAF objectives, for the demersal hake fishery from the 2011 ERA review.

The overall process steps for the demersal hake fishery show that there were few process steps that regressed (Fig. 4.3b). Those that improved accounted for 40.1%, 34% remained unchanged, 6.1% regressed, 7.5% were new operational objectives, and 6.5% required no further process steps. Process steps for Social wellbeing, Skills and capacity, and External impacts objectives were the most improved, with 80% for the former and 60% for both the latter. Process steps for Economic wellbeing, and External impacts both declined by 20%. Implementation of EAF objectives in 2008 and 2011, as indicated by the process steps for all the operational objectives, was found to be significantly different (Wilcoxon test, $Z = -2.40$, $p = 0.01$), declining from 2008 to 2011 (Fig. 4.3a).

Problems faced by the inshore trawl fisheries

The 2013 SASSI species list listed all of the inshore trawl bycatch species as Red. East Coast sole was the only species listed as Orange. Chapter 3 showed that the ecological impacts caused by this fishery include a large number of non-target species, some of which are over-exploited, and affect the sustainability of these species.

- Trawling is a non-selective method (Andrews et al. 2015) resulting in the mortality of a substantial number of non-target species, most notably linefish species (Walmsley et al. 2007). Most of the inshore trawl activity is concentrated on the south coast at depths of less than 110 meters (Greenston and Attwood 2013). An estimated 42% of the fisheries catch composition consists of non-target species (Attwood et al. 2011; Andrews et al. 2015). The revenue generated by the inshore trawl from landed bycatch of non-target species is estimated at between 15 and 36%, and is referred to as 'joint product' (Walmsley et al. 2007; DAFF 2014). Bycatch species include over-exploited, SASSI red-listed species: silver kob (*Argyrosomus inodorus*), geelbek (*Atractoscion aequidens*), carpenter (*Argyrozona argyrozona*), smoothhound shark (*Mustelus mustelus*) and soupfin shark (*Galeorhinus galeus*) (SASSI assessment for inshore trawl). This fishery is working with the line fishery in order to develop a bycatch management strategy (DAFF 2014).

Problems faced by the offshore trawl fishery

Offshore (deep-sea) trawling is mostly active on the west coast at depths that exceed 110 m (Andrews et al. 2015). The minimum mesh size allowed is 110 mm for the offshore sector, compared to the hake-directed and sole-directed inshore sector of 90 mm and 75 mm, respectively (Andrews et al. 2015). A moderate number of non-target species are caught as bycatch. Bycatch is less than the inshore trawl sector and less diverse, with this sector generating 7% of its revenue from bycatch (Walmsley et al. 2007; Attwood et al. 2011). The NMDS plots from the previous chapter showed that the stock status of all the offshore trawl bycatch species assessed in 2013 and 2014 were in a good condition, with the exception of biscuit skates (*Raja straeleni*). Most of

these bycatch species were listed as Orange on the SASSI list, with jacobever (*Helicolenus dactylopterus*) and biscuit skates listed as Red. The 2014 SASSI assessments note that there is conflicting information on the effects of this fishery on listed, over-exploited or highly vulnerable species, particularly on elasmobranch species. However, the 2015 MSC report noted that seabirds were the only species affected by trawling. The 2014 SASSI assessments also noted that there is insufficient information to determine whether the fishery causes significant negative ecosystem impacts, while the 2015 MSC report gave potential effects in case of increased hake trawling.

Obstacles preventing effective implementation in the hake fishery

The Wilcoxon test shows there has been a significant improvement in implementation of EAF in the hake fishery from 2008 to 2011. Figure 4.3a demonstrates this improvement. Furthermore, this is supported by the operational objectives showing little regression of process steps (Fig. 4.3b). The only objective that declined was Economic wellbeing, largely due to uncertainty in the European markets for the hake longline sector. As a result, longline hake resources were sold locally for decreased prices and many vessels in the sector ceased fishing (DAFF 2011). The hake longline sector does not have MSC certification, however. An initial MSC pre-assessment was conducted in 2009, but there has been no further development since (Japp 2011). The MSC certification serves as a market incentive for the inshore and offshore trawl sectors (Lallemant et al. 2014).

4.3.3. The Line fishery

Progress in implementation

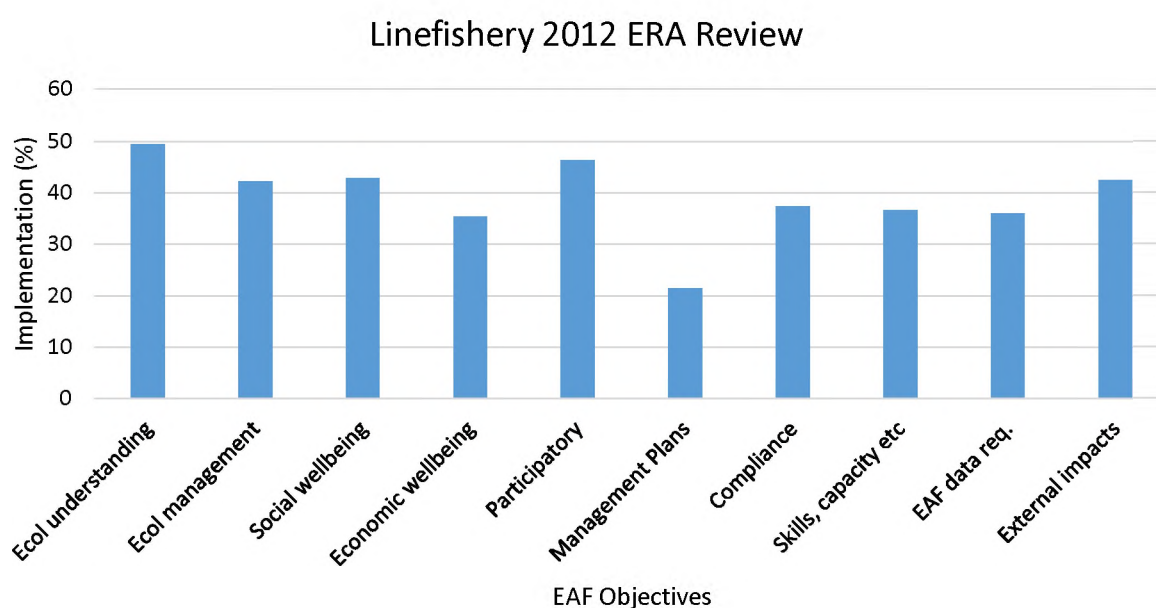


Figure 4.4: Histogram demonstrating the 10 EAF objectives for the 2012 linefish ERA review.

Results for the line fishery show cause for concern: implementation of EAF objectives all achieve less than 50%. Ecological understanding, followed by Participatory management, scored the highest with 49% and 46% respectively. Management plans performed worst, achieving only 21%.

Problems faced by the line fishery

The NMDS plots generated from analysis of SASSI assessments showed stock status of most linefish species to be poor. Of the 27 linefish species assessed, stock status of only six species was in a good condition, which amounts to a mere 22%. This is not new information; the over-exploitation and subsequent decline of stocks in this fishery has been documented for decades (Griffiths 2000). The fishery was declared to be in a state of emergency in 2000, the only fishery to experience this to date (DAFF 2014). The predicament facing this sector is that many of the species are caught by multiple fisheries; the same species is exploited by three different sectors within the line fishery: commercial, recreational and subsistence. Linefish species are also caught as bycatch

by trawlers, comprising up to 42% and 73% of the catch for the inshore and prawn trawls, respectively. This is due to the unselective nature of trawling and the fishing activity of these fisheries concentrated close to shore (Andrews et al. 2015). This multi-species fishery, spread across the entire South African coastline, is also particularly vulnerable to IUU fishing.

Obstacles preventing effective implementation in the line fishery

Existence of the line fishery can be traced back as early as the 1500s to the fishing activities of the indigenous Khoi people and the European settlers, making it South Africa's oldest fishery (DAFF 2014). The nature of this fishery presents a unique set of challenges that are not found in any other fishery. Early in the 20th century, management grappled with the challenges of managing this fishery, eventually choosing to focus on more organised fisheries which were easier to manage. Subsequently the fishery was left underdeveloped and openly accessible (Visser 2015). It was not until 1985 that the first comprehensive management measures were introduced (DAFF 2014). The 2012 ERA review shows that, in fact, little improvement from 1985 has been made, with Management plans scoring the lowest in terms of progress to implementation (Fig. 4.4). The fishery has long been described as a problem fishery and the 2012 ERA review echoes those sentiments (Visser 2015). This fishery is important from a livelihood perspective: an estimated 85% of the estimated 30 000 subsistence fishers depend on linefish resources, and reside in coastal communities that span the entire coastline (DAFF 2012d; DAFF 2014). In Kwa-Zulu Natal, the Eastern Cape and the Northern Cape, most small-scale fishers reside in rural communities, while, in the Western Cape, they reside in peri-urban and urban areas (DAFF 2012d). Rural communities in South Africa are often plagued with high unemployment and illiteracy rates, and are poverty stricken (Branch et al. 2002). The Policy for South African Small-scale Fisheries (SSFP), promulgated in 2012, aims to manage this fishery. The objectives of the policy are, *inter alia*, to create employment, provide livelihood and contribute to food security, while ensuring sustainability of natural resources (DAFF 2012c). This policy is yet to be implemented and the poor state of many linefish stocks will add to the challenges of implementation.

4.4. Conclusion

West Coast rock lobster

The large areas of exploitation, limited number of monitors and inability of management to enforce compliance effectively threatens the sustainability of this sector. In many cases, monitors are from the same communities as perpetrators, making it difficult for monitors to report offenders. The closure of the environmental court, which had a prosecution rate of 75% compared to the 10% achieved by traditional courts, makes the prosecution process lengthy and is, *inter alia*, a disincentive to compliance with regulations (de Greef and Raemaekers 2013). In one of the biggest poaching cases to affect rock lobsters in South Africa, a company, Hout Bay Fishing, was found have been under-reporting their catches of the South Coast Rock Lobster (SCRL) from 1987 to 2001 (Hauck and Kroese 2006), causing the CPUE to decline by over 50%. CPUE increased by 9% after the closure of Hout Bay Fishing. Even though the illegal sector of the WCRL has not reached the magnitude of the abalone illegal sector, sentiments are that, without urgent action, the same fate as the abalone fishery awaits the WCRL fishery (Brill and Raemaekers 2013).

Hake fishery

Of the four fisheries assessed, the hake fishery, particularly the offshore trawl hake fishery, is the best example of what sustainable development is. For the offshore trawl, status of the target stocks is in a good condition, most bycatch species are sustainable, management is functioning well and the fishery has managed to increase employment post-MSC certification (Lallemand et al. 2014). There are challenges that persist for the other sub-sectors: the longline and the handline sub-sectors are excluded from the MSC certification, and the inshore trawl bycatch species are not in a sustainable condition. Although the hake trawl sectors have problems with bycatch, a number of strides have been taken to mitigate and manage bycatch of non-target species, as one of the conditions for their MSC certification.

Additionally, the offshore trawl sector has significantly reduced incidental mortality of seabirds by using bird-scaring lines and continues to monitor impacts on

elasmobranchs. This was one of the conditions of the second period of the certification and has managed to decrease mortality of seabirds drastically from 18 000 birds in 2004 to 9900 birds in 2010 (Andrews et al. 2015). The certification scheme serves as a positive economic incentive for the producers in the form of access to high-end markets in Northern Europe. The fishery has increased its work force since its certification, thus creating employment (Lallemant et al. 2014).

Line fishery

The line fishery is a particularly complex fishery. The complexity of this fishery is the result of a multiple issues, *inter alia*: (1) this fishery targets multiple species, (2) it is shore-based, making it accessible throughout the entire South African coastline, (3) it comprises all three fishing sectors: subsistence, commercial and recreational, (4) the exact number of participants is unknown, (5) most of the participants are poor with no alternative livelihood, (6) target species are caught as bycatch in other fisheries, and (7) it requires interaction with more government departments. The complexity of this fishery makes it a social and legislative issue where not all interests of stakeholders are met (Sowman 2011). The SSFP aims to address and meet the needs of these stakeholders, although not all stakeholders. The policy will award fishing rights to communities rather than individuals. The rights will include communities sharing a basket of species. The policy is currently under implementation and it remains to be seen whether it will be possible to achieve its objectives. The proposed plan of organising fishing communities into co-operatives is similar to the plan that was abandoned in the early 20th century (Visser 2015).

In closing, the ERAs show there has been progress in the implementation of EAF in practice. This progress, however, varies from fishery to fishery. It is clear the larger commercial offshore fisheries have made much more progress, compared to the others. These fisheries are more organised, with fewer rights holders, which makes them easier to manage. A large portion of the hake fishery target market is the European Union where consumers are often interested in the sustainability of the

products they are consuming, and sustainability labels exist to fill the gap for this niche market. These large fisheries therefore stand to benefit from working together to ensure the sustainability of the fishery, and to protect their investments while increasing their market share.

The WCRL and the line fishery share similar attributes: as inshore fisheries, they are utilised by all three fishing sectors: commercial, recreational and subsistence. This has placed an enormous strain on the resources. These fisheries are also easily accessible with little compliance from stakeholders. The large number of participants, who, unlike the larger fisheries do not have shared interests, present another stumbling block preventing proper management of these fisheries. The economic capital of these participants is also different from their counterparts in larger fisheries: they have limited alternative livelihoods. Allison and Ellis (2001) speak of 'livelihood diversification', that is, the creation and encouragement of alternative livelihoods for communities who are dependent of marine resources. This has the potential to conserve these resources, and encourage compliance.

Progress also varies between data-rich and data-poor fisheries. Visser (2015) noted the bias shown by government as well as fisheries scientists early in the 20th century towards trawl fisheries and the side-lining of the small-scale fisheries sector. This means these large fisheries received all the resources and constant monitoring that small-scale fisheries were not afforded.

Chapter 5: Synthesis and Conclusion

The importance of the ecosystem approach to fisheries (EAF) has long been documented (FAO 2003; Garcia and Cochrane 2005) and is reiterated through this study. South Africa's commitment to implement EAF fully by 2015 (Veitch et al. 2012), while not successfully achieved, is recognition of its importance. The fundamental of any democratic state is its ability to be accountable to the commitments it makes. The aim of this study was to assess the progress made in implementing an ecosystem approach to fisheries in South Africa in both principle and practice. Its objectives were to evaluate the progress made in the implementation of the ecosystem approach to fisheries in South Africa's marine fisheries policies and legislation, to assess the extent to which an ecosystem approach to fisheries is being implemented in management of South African fisheries, and to consider any obstacles that may have hindered better progress and factors that have contributed to advancing it. These objectives have been addressed at length in previous chapters.

Progress in implementation of EAF in principle

The review in Chapter 2 reiterates for South Africa what the FAO (2005) already stated for the world as a whole: that translation of international legal instruments into national and regional legislation and policies has been slow around the world. The new commitment by South Africa and other countries to implement EAF fully by 2015 has reached its 'sell by date', and South African legislation has shown a lack of adherence to its commitment. The findings of this study contradict those of the Pitcher et al. (2009) study that found implementation of EAF in principle to be better than in practice in South Africa. Although the Marine Living Resources Act No 18 of 1998 (MLRA) contains some principles of EAF (DEAT 1998), and while the Policy for the Small-scale Fisheries Sector (SSFP) recognises EAF as the appropriate approach for management of small-scale fisheries (DAFF 2012c), the current laws governing marine resources in South Africa have not adequately addressed implementation of EAF. This could be attributed to several factors, such as uncertainty and confusion among stakeholders about what the terms of implementation are (Christensen 2011;

Petersen et al. 2015). Another factor could be the slow pace of policy change (Jacquet and Pauly 2008). Cochrane et al. (2015) noted that implementation of EAF in practice is occurring at a faster pace than implementation in law, creating the illusion that policies are working. The existence of the Benguela Current Commission (BCC), which was stimulated by the results of the ecosystem research conducted in the Benguela Current region, is an advantage that could be used to fast track the slow pace of policy changes. The BCC is a multi-sectoral inter-governmental initiative between the three Benguela region countries; Angola, Namibia and South Africa (BCC; www.benguelacc.org). The role of this organisation is to promote sustainable management of the BCLME. *“The BCC provides a vehicle for the three countries to introduce an ecosystem approach to ocean governance”* (BCC; www.benguelacc.org).

Progress of EAF implementation in practice

The assessments by the Southern African Sustainable Seafood Initiative (SASSI) are an indication that there has been progress in the implementation of EAF in practice, although not fully. The conceptual framework of EAF (Fig. 1.9) requires continuous evaluation of management of resources through a set of indicators (FAO 2005; FAO 2009). While implemented primarily by an NGO rather than government and the fishing sector itself, these assessments serve such a requirement. The SASSI assessments (response 14.2, Chapter 2) taken in combination with the ERAs for those fisheries examined here showed that there is currently no fishery in South Africa that has implemented EAF fully. This is supported by the results of the Pitcher et al. (2009) study, which showed that many countries, including South Africa, are still far from fully implementing EAF; in fact, no country scored 100% for full implementation. Hilborn and Ovango (2014) noted the importance of making fisheries management more widespread to include previously unmanaged species, and the SASSI assessments have succeeded in showing this to be the case in some sectors. One of the most important lessons to come from the SASSI assessments, one that has continuously been reiterated in literature (Cochrane et al. 2015), is the importance of effective management plans. Category 1 showed that when management measures are present and are effective, target stocks, or even bycatch species, were likely to do

well. These assessments, along with the ecological risk assessments (ERAs) were instrumental in bringing to the surface the numerous challenges to, and the successes in implementing EAF. The results from the SASSI assessments showed that implementation of EAF was highly variable between fishery sectors.

The goal of the ecosystem approach to fisheries management is to provide for the needs of humans from current to future generations without compromising the integrity of marine ecosystems (FAO 2003). South Africa has consistently been identified as one of the most unequal societies in the world (The World Bank 2014). The picture painted by the ERAs and the SASSI assessments, to some extent, reflects the challenges the country continues to face regarding class differences. Economic gain and poverty both appear to play an important role in the management of South Africa's fisheries. The large commercial fisheries with large financial muscle get most of the management and research attention, while the small-scale fisheries with many participants traditionally get less attention and are often seen as a 'problem' (Visser 2015). Partly as a result of this disparity, the large commercial fisheries are doing better in implementing EAF in all aspects than the fisheries of lower economic value, with many participants.

Although EAF is said to take into account human social and economic needs as well as governance, its discussions and processes are still dominated by natural sciences (Cochrane et al. 2008). The SASSI assessments currently focus on ecological and management processes, excluding human dimensions. These assessments were therefore limited in scope and only show certain aspects of the EAF implementation process in South Africa. The ERAs on the other hand, attempted to make the process inclusive of all stakeholders and to cover all aspects of EAF, but the reports by Nel et al. (2007) and Petersen et al. (2010a) show that social scientists, economists and representatives of fishers and/or fishing communities were still largely missing from the action. Sauer et al. (2003) conducted the last in-depth report on the social and economic aspects of fisheries, including transformation of South Africa's fishing industry, although some aspects were addressed in the 2010 DAFF performance review. A possible danger that could arise from the lack of participation by fishers and

fishing communities is that those contributing to the ERAs might act as ‘self-appointed’ representatives of resources users. Scientists, managers, NGOs and other stakeholders must be careful not to ‘think’ for resource users.

Factors influencing progress

The assessments also showed that many challenges still persist. This was highlighted by the high number of Orange and Red listed species coupled with the low number of species classified as Green. Assessments reveal challenges of sustainability from both biological and ecological aspects. Furthermore, both progress and challenges appeared to be largely influenced by a few common factors, amongst others, the presence or absence of positive incentives, co-management, management plans, accessibility of species from the shore, compliance, economic importance, capacity and interests of rights holders and other stakeholders. These factors have largely been addressed in previous chapters. In Chapter 2, the importance of creating incentives was a key result, as well as the lack of emphasis on incentives in the MLRA. As an example, the process of implementing EAF in the offshore and inshore trawl is largely driven by the incentive of accessing niche markets in Europe (Lallemand et al. 2014). The offshore trawl, and the inshore trawl to some extent, are good examples of fisheries with substantial progress in implementing EAF. Locally, the SASSI assessments also serve as an incentive to market sustainably produced products (Landey 2013), with negative publicity through a bad assessment likely to influence sales. Here, social media has put pressure on producers and retailers to follow the SASSI assessment process, by fuelling public outrage and subsequent calls for public boycott of those who do not follow that process. One such outlet to make headlines was Fruit and Veg City, who sold red steenbras (*Petrus rupestris*); a red-listed, no-sale species as santer (*Cheimerius nufar*) (Barichiev 2012). Upon discovery, there was public outcry which led to the retailers issuing a public apology. The company has since become part of the WWF-SASSI Retailer/Supplier Participation Scheme. The negative incentives currently in existence have not been sufficient to encourage high levels of compliance in the WCRL and linefish fisheries (de Greef and Raemaekers).

Other measures and more positive incentives are needed, including alternative livelihoods, as indicated by the SSFP.

EAF recognises that human dimensions form an important part in the health of an ecosystem (FAO 2009). Good understanding of these dimensions is imperative for the success of EAF. Hersoug (p. 83, 2014) notes that *“If we accept that the ecosystem also includes human beings, the challenge of EAF is how to regulate the interaction between the natural and the social system, that is, the institutions involved. And if institutions are central parts of the social dimension, so are participation and democracy”*. South African fisheries are faced with diverse objectives which include equity, sustainability of resources, and stability within the industry (Witbooi 2006). Chapters 3 and 4 showed the challenges faced by fisheries with diverse stakeholder interests; these fisheries are harder to manage. Shore-based fisheries are particularly challenging. These fisheries consist of fishers with varying interests that include commercial, livelihood and recreational. Also, many of the fishers participating in these fisheries have very few alternative livelihood options. The large number of participants, coupled with their diverse interests, makes it difficult for these fisheries to organise and co-operate in managing resources. On the contrary, it is easier for larger fisheries to organise because there are fewer rights holders and the interests of the rights holders are, in general, not very different from each other. Adding to the diverse interests of the fishing industry, the ocean’s economy consists of numerous other industries, with their own objectives (DEA 2014). Managing all these different objectives is important for the success of EAF.

Co-management is currently recognised for the small-scale sector; however, a co-management system can also be created for the largely commercial fisheries as well, some of which, albeit unofficially, already have some form of co-management system in place. An example of co-management in large commercial fisheries is the Responsible Fisheries Alliance¹², in the hake fishery, which allocates resources, skills, competencies and equipment to contribute to the effective management of this sector. Distributing the responsibility of managing resources through a co-management system could possibly help the managing authority with their capacity issue and also

¹² www.rfalliance.org.za

could help in regard to compliance, to steal from the African National Congress's (ANC) slogan, "*Together we can do more*".

Limitations of study

Shortcomings of this study include the limited legislation and policies evaluated. There are around 50 legal instruments regulating marine governance in South Africa (DEA 2014). It was not possible to examine all of that information in the time available and this study focused on only the major legislation and policy under the jurisdiction of the Department of Agriculture, Forestry and Fisheries, which are the key laws for fisheries governance (Witbooi 2006). Other marine legal instruments, especially conservation legislation which are under the jurisdiction of the Department of Environmental Affairs, were left out of this study, and it is noted that conservation is of key importance to implementation of EAF.

In addition to the lack of human dimensions, another limitation of this study was due to the SASSI procedure. The SASSI assessments were conducted by two different teams over the 2013–2014 period. It was outside the scope of this study to measure uncertainty resulting from observer bias. Another limitation includes the limited sensitivity analysis of the scoring of SASSI assessments. These limitations in the SASSI assessments, which formed a major source of information for this study, mean that the outcomes from this study will have suffered from similar limitations. This needs to be taken into account in interpreting the results, but the overall results and conclusions are considered to be a reasonable reflection of the progress being made and the obstacles being encountered.

Conclusion

The progress in implementation of EAF in practice, while slow, has superseded that of legislation (this study; Cochrane et al. 2015). International legal instruments and treaties show South Africa's commitment to implementing EAF; however, the process of updating national legislation is slow and the MLRA does not fully reflect those commitments. South African legislation does acknowledge the importance of EAF; however, there seems to be a lack of political will to implement it across all fisheries,

and a lack of guidance on how EAF should be implemented. Petersen et al. (2015) observed that EAF continues to be seen as 'add-on', rather than an approach from which to develop management plans and objectives. A possible explanation for this could be that EAF is an evolving process that can be built on existing management measures. This could be perceived to be 'add-on' rather than working to make EAF central to the management system. Despite the progress that has been made, this study has demonstrated that much still remains to be done across all fishery types.

In light of the findings of this study, there are several recommendations to pave the way forward. The ERAs are a good place to start and can serve as a basis for developing, in consultation with all relevant stakeholders, an enabling legal framework (FAO 2009). Cochrane et al. (2015) stressed the importance of management plans and also outlined all the information that needs to be contained for such plans. Immediate formation of such management plans for all fisheries is advised. Involvement of stakeholders in the formation of these management plans is crucial, as it has been reported that this process assists in improving compliance (FAO 2009).

The managing authority could use the opportunity presented to it by the large commercial fisheries by formalising a co-management approach that will spread responsibility across all stakeholders. This would help to reduce their capacity issues. Stern (2013) reported that resource users welcome a co-management approach with government. The successful implementation of a co-management approach through the SSFP in the small-scale fisheries sector could serve as a point of departure. Another recommendation from this study is that the managing authority, in consultation with stakeholders, must look into creating positive incentives that take into consideration the different interests of resource users. This includes providing social, institutional, economic, and market incentives, among others.

Most importantly without the political will to move EAF forward, the WSSD promise will never be realised. The BCC could play a crucial role in this regard. Coupled with the political will is the capacity to drive EAF. The managing authority lacks this fundamental aspect.

References:

- Allison EH, Ellis F. 2001. The livelihood approach and management of small-scale fisheries. *Marine Policy* 25(5): 377–388.
- Anderson MJ. 2001. A new method for non-parametric multivariate analysis of variance. *Australian Ecology* 26: 32–46.
- Anderson T. 2011. *Tracking the movement of fish, skipper's logbooks and marine knowledges in fisheries management*. M.Sc thesis, University of Cape Town. 73pp.
- Andrews J, Groeneveld J, Pawson M. 2015. Intertek fisheries certification: South African hake trawl fishery. Derby, UK: Intertek Fisheries Certification (IFC). 335pp.
- Attwood CG, Petersen SL, Kerwath SE. 2011. Bycatch in South Africa's inshore trawl fishery as determined from observer records. *ICES Journal of Marine Science: Journal du Conseil* 68(10): 2163–2174.
- Barichievy A. 2012. Something Stinks At Fruit And Veg City. Cape Town: News 24. Available from: <http://www.news24.com/MyNews24/Something-Stinks-At-Fruit-And-Veg-City-20120615>. [29 January 2016].
- Basson J. 2011. Not all seafood is equal. *South African Journal of Science* 107(5/6): 3p.
- Bergman MJ, van Santbrink JW. 2000. Fishing mortality of populations of megafauna in sandy sediments. In: Kaiser MJ; de Groot SJ (eds.), *Effects of fishing on non-target species and habitats*. Oxford: Blackwell Science. Pp 49–68.
- Bianchi G. 2008. The concept of the ecosystem approach to fisheries in FAO. In: Bianchi G, Skjoldal HR (eds), *The ecosystem approach to fisheries*. Rome: FAO Fisheries Department. Pp 20–38.
- Biyase L. 2011. Poaching rocks lobster trade. Times Live. Available from: <http://www.timeslive.co.za/business/2011/01/15/poaching-rocks-lobster-trade>. [23 September 2015].
- Bjorndal A. 2009. Regulation of fishing gears and methods. In: Cochrane KL, Garcia SM (eds), *A fishery manager's guidebook*. Rome: FAO and Wiley-Blackwell. Pp 176–195.

- Branch GM, May J, Roberts B, Russell E, Clark BM. 2002. Case study on the socio-economic characteristics and lifestyles of subsistence and informal fishers in South Africa. *South African Journal of Marine Science* 24(1): 439–462.
- Brandao A, Butterworth DS, Johnston SJ, Glazer JP. 2004. Using a GLMM to estimate the somatic growth rate trend for male South African West Coast rock lobster, *Jasus lalandii*. *Fisheries Research* 70: 339–349.
- Brill GC, Raemaekers SJP. 2013. A decade of illegal fishing in Table Mountain National Park (2000–2009): trends in the illicit harvest of abalone *Haliotis midae* and West Coast rock lobster *Jasus lalandii*. *African Journal of Marine Science* 35(4): 491–500.
- Cawthorn DM, Steinman HA, Witthuhn RC. 2011. Evaluating the availability of fish species on the South African market and the factors undermining sustainability and consumer choice. *Food Control* 22: 1748–1759.
- CBD (Convention on Biological Diversity). 1992. The Convention on Biological Diversity, UN Conference on Environment and Development, Rio de Janeiro, <https://www.cbd.int/doc/legal/cbd-en.pdf> [26 September 2014].
- Christensen V. 2011. Introduction: toward ecosystem-based management of fisheries. In: Christensen V, Maclean J (eds), *Ecosystem approaches to fisheries*. Cambridge, New York. Pp 1–8.
- Chuenpagdee R, Morgan LE, Maxwell SM, Norse EA, Pauly D. 2003. Shifting gears: assessing collateral impacts of fishing methods in US waters. *Frontiers in Ecology and the Environment* 1(10): 517–524.
- Clarke KR, Warwick RM. 2001. *Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition*. Plymouth: PRIMER-E. 176p.
- Cochrane KL, Payne AIL. 1998. People, purses and power: developing fisheries policy for the review South Africa. In: Pitcher TJ, Hart PJB, Pauly D (eds), *Reinventing fisheries management*. London: Kluwer Academic Publishers. Pp 73–99.
- Cochrane KL, Augustyn CJ, Cockcroft AC, David JHM, Griffiths MH, Groeneveld JC, Lipiński MR, Smale MJ, Smith CD, Tarr RJQ. 2004. An ecosystem approach to fisheries in the southern Benguela context. *African Journal of Marine Science* 26: 19–35.

- Cochrane KL. 2008. What should we care about when attempting to reconcile fisheries with conservation? In: Nielson J, Dodson JJ, Friedland K, Hamon TR, Musick J, Verspoor E (eds), *Reconciling Fisheries with Conservation: Proceedings of the 4th World Fisheries Congress*. Bethesda, MD: American Fisheries Society. 1: 5–24.
- Cochrane KL, Augustyn CJ, O'Toole MJ. 2008. The implementation of the ecosystem approach to fisheries management in the Benguela region: experiences, advances and problems. In: Bianchi G, Skjoldal HR (eds), *The ecosystem approach to fisheries*. Rome: FAO Fisheries Department. Pp 262–292.
- Cochrane KL, Augustyn CJ, Fairweather T, Japp D, Kilongo K, Litembu J, Moroff N, Roux JP, Shannon L, Van Zyl B, Vaz Velho F. 2009. Benguela Current Large Marine Ecosystem—Governance and Management for an Ecosystem Approach to Fisheries in the Region. *Coastal Management* 37: 235–254.
- Cochrane KL, Bianchi G, Fletcher W, Fluharty D, Mahon R, Misund OA. 2014. Regulatory and governance frameworks. In: Fogarty MJ, McCarthy JJ (eds), *The Sea* 16. Cambridge: Harvard University Press. Pp 77–119.
- Cochrane KL, Joyner J, Sauer WHH, Swan J. 2015. An evaluation of the Marine Living Resources Act and supporting legal instruments as a framework for implementation of an ecosystem approach to fisheries in South Africa. *African Journal of Marine Science* 37(4): 437–456.
- Cockcroft AC, Payne AIL. 1999. A cautious fisheries management policy in South Africa: the fisheries for rock lobster. *Marine Policy* 23(6): 587–600.
- Cockcroft AC, Griffiths MH, Tarr RJQ. 1999. Marine recreational fisheries in South Africa: status and challenges. In: Pitcher TJ (ed), *Evaluating the benefits of recreational fishing*. Vancouver: The Fisheries Centre, University of British Columbia. Pp 64–70.
- Cockcroft AC, van Zyl D, Hutchings L. 2008. Large-scale changes in the spatial distribution of South African West Coast rock lobsters: an overview. *African Journal of Marine Science* 30(1): 149–159.
- Cox J. 2013. *Assessment report on small-scale fisheries in Africa*. Prepared behalf of Masifundise Development Trust for AU-IBAR. Cape Town: Masifundise Development Organisation. 9p.

- Crawley MJ (ed). 2007. *The R book*. England: John Wiley & Sons.
- Crosoera D, van Sitterta L, Ponte S. 2006. The integration of South African fisheries into the global economy: past, present and future. *Marine Policy* 30: 18–29.
- Cury PM, Mullon C, Garcia SM, Shannon LJ. 2005. Viability theory for an ecosystem approach to fisheries. *ICES Journal of Marine Science: Journal du Conseil* 62(3): 577–584.
- DAFF (Department of Agriculture, Forestry and Fisheries). 2011. *Ecological risk assessment review of the South African hake fishery, 21-22 July 2011*. Cape Town: DAFF. 67pp.
- DAFF (Department of Agriculture, Forestry and Fisheries). 2012a. *Integrated growth and development plan*. Pretoria: DAFF 84pp.
- DAFF (Department of Agriculture, Forestry and Fisheries). 2012b. *2009/10 Performance review of fishing rights holders. Overall report/summary: limited commercial and full commercial rights holders*. Cape Town: DAFF Fisheries Management Branch 89pp.
- DAFF (Department of Agriculture, Forestry and Fisheries). 2012c. *Policy for the small-scale fisheries sector in South Africa. Government Gazette No. 35455 20 June 2012*. Cape Town: DAFF Fisheries Management Branch. 56pp.
- DAFF (Department of Agriculture, Forestry and Fisheries). 2012d. *Ecological risk assessment review for the South African West Coast Rock Lobster fishery*. Cape Town: Fisheries Management Branch 60pp.
- DAFF (Department of Agriculture, Forestry and Fisheries). 2014. *Status of the South African marine fishery resources 2014*. Cape Town: DAFF Fisheries Management Branch 84pp.
- DEA (Department of Environmental Affairs). 2014. *Unlocking the economic potential of South Africa's oceans: marine protection services and governance*. Cape Town: DEA. 55pp.
- DEAT (Department of Environmental Affairs and Tourism). 1998. *The Marine Living Resources Act No. 18 of 1998*. Government Gazette No. 18930. Pp 34.

- de Greef K, Raemaekers S. 2013. South Africa's illicit abalone trade: an updated overview and knowledge gap analysis. Report prepared for TRAFFIC /The Wildlife TRAPS project. Cape Town: Environmental Evaluation Unit, University of Cape Town. 30pp.
- du Preez M, Lee DE. 2010. The contribution of trout fly fishing to the economy of Rhodes, North Eastern Cape, South Africa. *Development Southern Africa* 27(2): 241–253.
- FAO (Food and Agricultural Organisation). 1995. *Code of conduct for responsible fisheries*. Rome: FAO Fisheries Department. 49p.
- FAO (Food and Agricultural Organisation). 1997. *Technical Guidelines for Responsible Fisheries*. Rome: FAO Fisheries Department. 82p.
- FAO (Food and Agricultural Organisation). 2001. *The Reykjavik declaration on responsible fisheries in the marine ecosystem*. Rome: FAO Fisheries Department. 12pp.
- FAO (Food and Agricultural Organisation). 2003. *The ecosystem approach to fisheries. FAO Technical Guidelines for Responsible Fisheries*. Rome: FAO Fisheries Department. 112pp.
- FAO (Food and Agricultural Organisation). 2005. *Putting into practice the ecosystem approach to fisheries*. Rome: FAO Fisheries Department. 76pp.
- FAO (Food and Agricultural Organisation). 2009. Fisheries management. 2. The ecosystem approach to fisheries. 2.2 Human dimensions of the ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries*. Rome: FAO fisheries Department. 88pp.
- FAO (Food and Agricultural Organisation). 2010. *The State of World Fisheries and Aquaculture 2010*. Rome: FAO Fisheries Department. 197pp.
- FAO (Food and Agricultural Organisation). 2012. *The state of world fisheries and aquaculture 2012*. Rome: FAO Fisheries Department. 209pp.
- FAO (Food and Agricultural Organisation). 2014. *The state of the world fisheries and aquaculture 2014*. Rome: FAO Fisheries Department. 243pp.

- Fletcher WJ, Chesson J, Fisher M, Sainsbury KJ, Hundloe T, Smith ADM, Whitworth B. 2002. *National ESD Reporting Framework for Australian Fisheries: The 'How To' Guide for Wild Capture Fisheries*. FRDC Project 2000/145, Canberra, Australia.
- Fletcher WJ. 2008. Implementing an ecosystem approach to fisheries management: lessons learnt from applying a practical EAFM framework in Australia. In: Bianchi G, Skjoldal (eds), *The ecosystem approach to fisheries*. Rome: FAO. Pp 112–124.
- Fuchs D, Kalfagianni A, Havinga T. 2011. Actors in private food governance: the legitimacy of retail standards and multi-stakeholder initiatives with civil society participation. *Agriculture Human Values* 28: 353–367.
- Garcia SM, Zerbi A, Aliaume C, Do Chi T, Lasserre G. 2003. *The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook*. FAO Fisheries Technical Paper. No. 443. Rome: FAO Fisheries Department. 2003. 71p.
- Garcia SM, Cochrane KL. 2005. Ecosystem approach to fisheries: a review of implementation guidelines. *ICES Journal of Marine Science: Journal du Conseil* 62(3): 311–318.
- Goby G, Schwarz AM, Pomeroy R, Knight M. 2012. *Ecosystem Approach to Fisheries Management (EAFM): A Solomon Islands Policy Review*. Honolulu, Hawaii: The USAID Coral Triangle Support Partnership. Pp48.
- Greenston JD, Attwood CG. 2013. *Assessing the feasibility of a bycatch co-management programme in South Africa's inshore trawl fishery*. Prepared for The Responsible Fisheries Alliance. Cape Town: University of Cape Town. 53pp.
- Griffiths MH. 2000. Long-term trends in catch and effort of commercial linefish off South Africa's Cape Province: snapshots of the 20th century. *South African Journal of Marine Science* 22: 81–110.
- Hara M, de Wit M, Crookes D, Jayiya T. 2008. Socio-economic contribution of South African Fisheries and their current legal Policy and Management Frameworks. *Plaas* 18: 1–75.
- Hauck M, Sowman M. 2001. Coastal and fisheries co-management in South Africa: an overview and analysis. *Marine Policy* 25: 173–185.

- Hauck M, Sowman M, Russell E, Clark BM, Harris JM, Venter A, Beaumont J, Maseko Z. 2002. Perceptions of subsistence and informal fishers in South Africa regarding the management of marine living resources. *South African Journal of Marine Science* 24: 463–474.
- Hauck M, Kroese M. 2006. Fisheries compliance in South Africa: A decade of challenges and reform 1994–2004. *Marine Policy* 30: 74–83.
- Hazell RWA, Cockcroft AC, Mayfield S, Noffke M. 2001. Factors influencing the growth rate of juvenile rock lobsters, *Jasus lalandii*. *Marine Freshwater Research* 52: 1367–1373.
- Hersoug B. 2014. The social dimension: The challenge of dealing with equity. In: Garcia SM, Rice J, Charles A (eds), *Governance of marine fisheries and biodiversity conservation: interaction and co-evolution*. New York City: John Wiley & Sons. Pp 82–95.
- Hilborn R, Ovando D. 2014. Reflections on the success of traditional fisheries management. *ICES Journal of Marine Science: Journal du Conseil* 71(5): 1040–1046.
- Hutchings L, Roberts MR, Verheye HM. 2009. Marine environmental monitoring programmes in South Africa: a review. *South African Journal of Science* 105: 94–102.
- Isaacs M. 2011. Individual transferable quotas, poverty alleviation and challenges for small-country fisheries policy in South Africa. *Mast* 10(2): 63–84.
- Jacquet JL, Pauly D. 2007. The rise of seafood awareness campaigns in an era of collapsing fisheries. *Marine Policy* 31: 308–313.
- Jacquet JL, Pauly D. 2008. Funding priorities: big barriers to small-scale fisheries. *Conservation Biology* 22(4): 832–835.
- Jacquet J, Hoen J, Lai S, Majluf P, Pelletier N, Pitcher T, Sala E, Sumaila R, Pauly D. 2009. Conserving wild fish in a sea of market-based efforts. *Oryx* 44(1): 45–56.
- Japp, DW. 2011. *Pre-Assessment Report for the South African Longline Fishery for Hake*. Unpublished document, compiled by Capricorn Fisheries Monitoring cc for WWF-SA and Ocean Fresh. 30pp.

- Jennings S, Reynolds JD. 2000. Impacts of fishing on diversity: from pattern to process. In: Kaiser MJ; de Groot SJ (eds.), *Effects of fishing on non-target species and habitats*. Oxford: Blackwell Science. Pp 235–250.
- Johnston SJ, Butterworth DS, Glazer JP. 2010. *TAC 2010 for West Coast rock lobster using OMP 2007 re-cast*. FISHERIES/2010/AUG/SWG-WCRL/21. 15pp.
- Joyner J. 2013. An evaluation of the changing policy environment for fisheries in South Africa. Honours Thesis, Rhodes University, South Africa.
- Konefal J. 2012. Environmental movements, market-based approaches, and neoliberalization: a case study of the sustainable seafood movement. *Organisation & Environment* 26(3): 336–352.
- Kuemlangan B, Sanders J, Deupmann P, De Young C. 2014. Integrative policy and legal instruments, approaches and tools: fisheries and biodiversity conservation. In: Garcia SM, Rice J, Charles A (eds), *Governance of marine fisheries and biodiversity conservation: interaction and co-evolution*. New York City: John Wiley & Sons. Pp 166–180.
- Lallemant P, Berg M, Hansen H, Venter C, Purves M. 2014. *An analysis of the economic benefits of MSC certification for the South African hake trawl fishery*. IIFET 2014 Australia Proceedings. 12p.
- Landey D. 2013. SASSI and the MSC: how effective have they been with reaching consumers in Cape Town and raising their awareness? M.Sc. thesis, University of Cape Town, South Africa.
- Mather D, Britz PJ, Hecht T, Sauer WHH. 2003. *An economic and sectoral study of the South Africa fishing industry. Volume 1: Economic and regulatory principles, survey results, transformation and socio-economic impact*. Report prepared for Marine and Coastal Management. Grahamstown: Rhodes University 300pp.
- Mann BQ (ed). 2013. *Southern African linefish species profiles*. Durban: Oceanographic Research Institute. 357p.
- McGovern D. 2005. The sustainable seafood movement: transforming the global seafood industry. *IntraFish Industry Report*.

- McGregor ES. 2015. *Assessing the implementation efficacy of an ecosystem approach to fisheries management in the South African sardine fishery*. PhD thesis, University of Cape Town. 290pp.
- McLoughlin R, Rayns N, Smith A, Johnson D, Hobday A, Smith T. 2008. Implementing the ecosystem approach in Australian Commonwealth (Federally) – managed fisheries. In: Bianchi G, Skjoldal HR (eds), *The ecosystem approach to fisheries*. Rome: FAO Fisheries Department. Pp 293–300.
- Myers RA, Worm B. 2003. Rapid worldwide depletion of predatory fish communities. *Nature* 423: 280–283.
- Mullon C, Pierre F, Cury P. 2005. The dynamics of collapse in world fisheries. *Fish and Fisheries* 6: 111–120.
- Murawski SL. 2007. Ten myths concerning ecosystem approaches to marine resource management. *Marine Policy* 31: 681–690.
- Nel DC. 2007. Ecological risk assessment (ERA) for the South African demersal hake fishery. In: Nel DC, Cochrane KL, Petersen SL, Shannon LJ, van Zyl B, Honig MB (eds), *Ecological risk assessments: a tool for implementing an ecosystem approach for South African Fisheries*. WWF Report series – 2007/Marine/002. Pp 8–37.
- Nel DC, Cochrane KL, Petersen SL, Shannon LJ, van Zyl B, Honig MB (eds). 2007. *Ecological risk assessments: a tool for implementing an ecosystem approach for South African Fisheries*. WWF Report series – 2007/Marine/002. 225 pp.
- Nielsen JR, Hara M. 2006. Transformation of South African industrial fisheries. *Marine Policy* 30: 43–50.
- Office of Parliamentary Counsel. 2014. *Amendment Act No. 31, 2014 of the Fisheries Management Act No. 162, 1991*. 448pp.
- Oksanen J. 2013. *Multivariate Analysis of Ecological Communities in R: vegan tutorial*. 43pp.
- Paterson B, Petersen S. 2010. EAF implementation in Southern Africa: lessons learnt. *Marine Policy* 34: 276–292.

- Pauly D, Christensen V, Gu  nette S, Pitcher TJ, Sumaila UR, Walters CR, Watson R, Zeller D. 2002. Towards sustainability in world fisheries. *Nature* 418: 689–695.
- Perez-Ram  rez M, Phillips B, Lluch-Belda D, Lluch-Cota S. 2012. Perspectives for implementing fisheries certification in developing countries. *Marine Policy* 36: 297–302.
- Petersen SL, Paterson B, Basson J, Moroff N, Roux J-P, Augustyn J, D’Almeida G (eds). 2010a. *Tracking the Implementation of an Ecosystem Approach to Fisheries in Southern Africa*. WWF South Africa Report Series – 2010/Marine/001. 276pp.
- Petersen SL, Okes N, Basson J, Paterson B, Cockcroft A. 2012b. Ecological risk assessment review for the South African West Coast rock lobster fishery. In: Petersen SL, Paterson B, Basson J, Moroff N, Roux J-P, Augustyn J, D’Almeida G (eds), *Tracking the Implementation of an Ecosystem Approach to Fisheries in Southern Africa*. WWF South Africa Report Series – 2010/Marine/001. Pp 251–302.
- Petersen SL, Kerwath S, Paterson B, Okes N. 2010c. Ecological risk assessment for the South African line fishery. In: Petersen SL, Paterson B, Basson J, Moroff N, Roux J-P, Augustyn J, D’Almeida G (eds), *Tracking the Implementation of an Ecosystem Approach to Fisheries in Southern Africa*. WWF South Africa Report Series – 2010/Marine/001. Pp 77–133.
- Petersen SL, Duncan JA, Omardien A, Betts M, Johnson A. (eds). 2015. *A decade of implementing an Ecosystem Approach to Fisheries for Southern African fisheries*. WWF South Africa Report Series – 2015/Marine/001.
- Pikitch EK, Santora C, Babcock EA, Bakun A, Bonfil R, Conover DO, Dayton P, Doukakis P, Fluharty D, Heneman B, Houde ED, Link J, Livingston PA, Mangel M, McAllister MK, Pope J, Sainsbury KJ. 2004. Ecosystem-based fishery management. *Science* 305: 346–347.
- Pitcher TJ. 1999. *Rapfish: a rapid appraisal technique for fisheries, and its application to the code of conduct for responsible fisheries*. FAO Fisheries Circular No. 947. 47 pp.
- Pitcher J, Preikshot D. 2001. Rapfish: a rapid appraisal technique to evaluate the sustainability status of fisheries. *Fisheries Research* 49: 255–270.

- Pitcher TJ, Kalikoski D, Short K, Varkey D, Pramoda G. 2009. An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. *Marine Policy* 33: 223–232.
- Roheim CA. 2009. An evaluation of sustainable seafood guides: implications for environmental groups and the seafood industry. *Marine Resource Economics* 24: 301–310.
- Sainsbury KJ, Punt AE, Smith ADM. 2000. Design of operational management strategies for achieving fishery ecosystem objectives. *ICES Journal of Marine Science: Journal du Conseil* 57(3): 731–741.
- SASSI (Southern African Sustainable Seafood Initiative). *The common wild capture fishery methodology*. Cape Town: WWF-SASSI. 5pp.
- Sauer WHH, Hecht T, Britz PJ, Mather D. 2003. *An economic and sectoral study of the South African Fishing Industry. Volume 2: Fishery profiles*. Report prepared for Marine and Coastal Management. Grahamstown: Rhodes University 308pp.
- Sigurjónsson J. 2008. Ecosystem-based fisheries management in Iceland: implementation and some practical considerations. In: Bianchi G, Skjoldal HR (eds), *The ecosystem approach to fisheries*. Rome: FAO Fisheries Department. Pp247–261.
- Shannon LJ, Moloney CL Jarre A, Field JG. 2003. Trophic flows in the southern Benguela during the 1980s and 1990s. *Journal of Marine Systems* 39: 83–116.
- Shannon LJ, Cochrane KL, Moloney CL, Fréon P. 2004. Ecosystem approach to fisheries management in the southern Benguela: a workshop overview. *African Journal of Marine Science* 26: 1–8.
- Short K, Graham A, Grieve C. 2008. Ecosystem-based management of marine capture fisheries: not a theoretical concept but useful operational reality. In: Bianchi G, Skjoldal HR (eds), *The ecosystem approach to fisheries*. Rome: FAO. Pp 76–85.
- Sowman M. 2011. New perspectives in small-scale fisheries management: challenges and prospects for implementation in South Africa. *African Journal of Marine Science* 33(2): 297–311.

- Statistics South Africa. 2013. *National accounts: environmental economic account, fishery accounts for South Africa: 1990–2011*. Discussion document D0405.0. Johannesburg: Statistics South Africa. 29pp.
- Statistics South Africa. 2014. *National accounts: environmental economic account compendium*. Report number: 04-05-20. Johannesburg: Statistics South Africa. 71p.
- Statutes of the Republic of South Africa – Constitutional Law. 1996. *Constitution of the Republic of South Africa Act No. 108 of 1996*. Pp 1241.
- Stern M. 2013. *Sustainable livelihoods and marine resources: how does South Africa's policy for the small-scale fisheries sector consider current challenges on the ground?* SAlIA occasional paper no 166. Pp 20.
- Symes D. 2000. Integrated management: the implication of an ecosystem approach to fisheries management. In: Kaiser JK, Groot SB (eds), *Effect of fishing on non-target species and habitats. Biological, conservation and socio-economic issues*. Oxford: Blackwell Science. Pp366–380.
- The World Bank. 2014. *South Africa economic update, fiscal policy and redistribution in an unequal society*. Washington: The World Bank. 59pp.
- Tromble GR. 2008. The ecosystem approach to fisheries management in the USA. In: Bianchi G, Skjoldal HR (eds), *The ecosystem approach to fisheries*. Rome: FAO Fisheries Department. Pp 301–308.
- UN (United Nations). 1972. *United Nations Conference on Human Environment*. New York: UN. 202pp.
- UN (United Nations). 1982. *United Nations Convention on the Law of the Sea*. New York: UN.
- UN (United Nations). 1992a. *United Nations Conference on Environment and Development*. New York: UN. pp.
- UN (United Nations). 1992b. The Rio declaration on environment and development. *United Nations Conference on Environment and Development*. New York: UN. 5pp.
- UN (United Nations). 1992c. Agenda 21. *United Nations Conference on Environment and Development*. New York: UN. 251pp.

- UN (United Nations). 1995. *United Nations conference on straddling fish stocks and highly migratory fish stocks*. New York: UN.
- van Marlen B. 2000. Technical modification to reduce the bycatches and impacts of bottom-fishing gears. In: Kaiser JK, Groot SB (eds), *Effect of fishing on non-target species and habitats. Biological, conservation and socio-economic issues*. Oxford: Blackwell Science. Pp 253–268.
- Veitch L, Dulvy NK, Koldewey H, Lieberman S, Pauly D, Roberts CM, Rogers AD, Baillie JEM. 2012. Avoiding empty ocean commitments at Rio+20. *Science* 336: 1383–1385.
- Visser N. 2015. The origins of the present: economic conflicts in the fisheries of the South African south coast, circa 1910 to 1950. *Maritime Studies* 14(9): 1–31.
- Walmsley SA, Leslie RW, Sauer WHH. 2007. Managing South Africa's trawl bycatch. *ICES Journal of Marine Science* 64: 405–412.
- Ward T, Tarte D, Hegerl E, Short K. 2002. *Policy proposals and operational guidance for ecosystem-based management of marine capture fisheries*. Australia: World Wild Fund for Nature Australia. 80p.
- Wilkinson L, Friendly M. 2009. The history of the cluster heat maps. *The American Statistician* 63(2): 179-184.
- Wilson DC, Raakjær J, Degnbol P. 2006. Local ecological knowledge and practical fisheries management in the tropics: a policy brief. *Marine Policy* 30: 794–801.
- Witbooi E. 2006. Law and fisheries reform: Legislative and policy developments in South African fisheries over the decade 1994–2004. *Marine Policy* 30: 30–42.
- Woolson RF. 2008. *Wilcoxon Signed-Rank Test*. Wiley Encyclopaedia of Clinical Trials. Pp 1–3.
- WCED (World Commission on Environment and Development). 1987. *Our Common Future*. Oxford: Oxford University Press.
- WSSD (World Summit on Sustainable Development). 2002a. Report on the World Summit on Sustainable Development. New York: United Nations. 176pp.

WSSD (World Summit on Sustainable Development). 2002b. Plan of Implementation of the World Summit on Sustainable Development. New York: United Nations. 62pp.

WWF-SA (Worldwide Fund for Nature – South Africa). 2013. *Small-scale fisheries improvement project business case*. Cape Town: WWF-SA. 31pp.

WWF-SA (Worldwide Fund for Nature – South Africa). 2014a. *Ten years of being SASSI, a documentation of the sustainable seafood movement in South Africa*. Cape Town: WWF-SA. 68pp.

WWF-SA (Worldwide Fund for Nature – South Africa). 2014b. *State of management of South Africa's marine protected areas*. Cape Town: WWF-SA. 160pp.

Appendices:

Appendix 1: The SASSI Common Wild Capture Fishery assessment questionnaire.

The Common Wild Capture Fishery Methodology¹

Methodology developed with scientific advice from Thünen Institute of Baltic Sea Fisheries
Version 4.01

Unit of Assessment

Scientific Name
English Name
(FAO) Area of capture
Country, Province, State (within EEZ)
Stock, ICES Area
Capture method
Management authority

Picture [place for species picture]

Score: Total Assessment Score*:
*Scoring guidepost: see APPENDIX. Please insert scoring points and corresponding colour in the respective boxes

Individual Category Score*:

1. Target Stock		2. Ecological Effects of Fishery:		3. Management:	
MSC available?	Yes/No/in certification	Details			
FIP available?	Yes/No	Details			

Assessment Details

Current Assessment	Status	DRAFT / FINAL	Date
Assessor (Name/Organisation)			
Cross-checker (Name/Organisation)			
Previous Assessment	Date:	Score:	
Assessor (Name/Organisation)			
Cross-checker (Name/Organisation)			

Wild Capture Fishery

1. Please note this is a version of the methodology where the scoring has been removed.
CommonMethodology_WildCaptureFisheries_v4_01_publ_page 1

Summary [place for summary / text must comply with master list]

Main references [place for references which are cited in more than one question]

Disclaimer

This assessment is carried out by a qualified assessment team composed of experienced fisheries biologists from the nature conservation organizations WWF, NSF, and associated institutions. The information provided in this assessment has been collected according to high scientific standards. All judgments are delivered independently of commercial interests. This is an assessment methodology to indicate the relative sustainability of a fishery. This methodology is not a certification of sustainability, nor does it allow the fishery or retailer to make any claims about the species or stock or a certain product. This is a desk-based assessment. Each assessment undergoes a quality control (cross-check) regarding consistency by a member of the assessment team. However, no rights whatsoever can be based upon the advice. This methodology is not to be used by third parties without consulting the WWF Global Seafood Coordinator.

Note to assessor: Place for background information on Unit of Assessment you might want to add, like biology, stock status, fishery, catches/landings

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CATEGORY 1: STOCK STATUS AND BIOLOGY

Depending on the available amount of information, there are 3 possible tracks on which the stock status is rated. Question 1 sets the course which track is applicable.

Q1 Are adequate* stock assessments of the target stock available?

*Adequate = State of the art stock assessment not older than 3 years
If the current assessment is older than 3 years, go to Track B.

Detailed fishery data is available AND a reliable quantitative stock assessment is conducted on a regular basis AND reference points are defined → **Track A** (QA2-A6)

Substantial fishery data is available, but no reference points are defined OR reference points are defined but a recent quantitative stock assessment is lacking → **Track B** (QB2-B5)

Little or no fisheries data AND no stock assessment AND no reference points are available OR [Bycatch]: Species is not targeted directly - it is taken as bycatch which is retained/landed** → **Track C** (QC2-C5)

**Bycatch species which are not appropriately managed in a species-specific manner. If fishery data is available, go to track A or B, respectively.

Annotations

References

TRACK A/data-rich. Scientific assessments available and reference points defined.

QA2 Are limit AND target reference points for fishing mortality (F) and spawning stock biomass (SSB) implemented by the responsible management authority?

YES - Limit reference points (LRPs)* AND target reference points (TRPs)** or proxies for these are implemented

NO - Either target OR limit reference points are not implemented

*e.g. Bmsy-trigger, Fmsy OR Bpa, Blim, Fpa, Flim

**e.g. Bmsy, Fmgt, Ftarget

Annotations

References

QA3 Is the target species' spawning stock biomass (SSB) above reference points?

Spawning stock biomass is above target level: $SSB > B_{msy}$

Spawning stock biomass is above trigger (ICES sense): $SSB > B_{msy-trigger}$

Spawning stock biomass is above precautionary reference point: $SSB > B_{pa}$

Spawning stock biomass is below trigger ($SSB < B_{msy-trigger}$) if no precautionary reference points are defined, OR between limit and precautionary reference points ($Blim < SSB < B_{pa}$) [At increased risk*]

Spawning stock biomass is below limit reference point: $SSB < Blim$ OR $SSB < 0,5 B_{msy}$ as a proxy if $Blim$ is not defined [Suffering reduced reproductive capacity*]

* According to ICES definition

Annotations

References

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QA4 Is the fishing mortality (F) of the target stock below reference points?

Fishing mortality is around F target (if that is lower than Fmsy)

Fishing mortality is below Fmsy OR - if Fmsy is not defined or equal to Fpa - below precautionary reference point: $F < F_{pa}$ [Harvested sustainably*]

Fishing mortality is above Fmsy but well below limit reference point (if no Fpa is defined): $F_{msy} < F < F_{lim}$ OR: $F = F_{pa}$

Fishing mortality is between limit and precautionary reference points (ICES sense) ($F_{pa} < F < F_{lim}$) [At increased risk*]

Fishing mortality is above limit reference point: $F > F_{lim}$ [Harvested unsustainably*, overfishing occurring]

* According to ICES definition

Annotations

References

QA5 Is the scientific advice adequately defined and, if implemented, will likely ensure to maintain the long-term productivity and/or the recovery of the stock?

YES - The scientific advice is adequately defined → Proceed to QA6

NO - The scientific advice is not adequately defined and/or will likely lead to stock decline → Do not continue with other questions in Category 1

Annotations

References

QA6 Are the regulatory measures to control fishing mortality or stock size* determined in accordance with the corresponding scientific advice** AND met by the current catches?

* This may be either TAC/quota or an effort management system of temporal and/or spatial closures, effort restrictions, etc. Consider existing long term management plans (LTMP) and/or Harvest Control Rules (HCR)

**State of the art scientific advice not older than 3 years.

YES - Measures are in accordance with the scientific advice AND effectively implemented AND compliance is evidenced

Measures are in accordance with the scientific advice AND will likely ensure to maintain the long-term productivity and/or the recovery of the stock

Regulatory measures to control stock size are not defined OR measures are implemented but effectiveness is uncertain OR stock status is healthy despite the absence of specific management measures

NO - Measures are not in accordance with the scientific advice but effectively implemented, OR measures are in accordance with the scientific advice but not effectively implemented, OR a LTMP is in place but is unlikely to ensure the long-term productivity of the stock, OR catches in relation to regulatory measures and/or scientific advice are unknown

NO - Measures are not in accordance with the scientific advice AND measures are not effectively implemented (e.g. target values are exceeded by the fishery)

Annotations

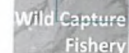
References

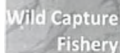
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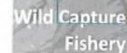


TRACK B/data-moderate. Substantial fishery data available, but no reference points defined.	
TRACK B	QB2 How precise is the available fishery-specific information*? *E.g. landings, total catch (including CPUE), fishing effort, size/age distribution. <u>Note to assessor:</u> Consider only data sources that are relevant for the UoA (e.g. no CPUE for pelagic stocks)
	☐ The available data is detailed enough to allow for a solid and comprehensive description of the stock
	☐ Not all of the above mentioned parameters can be described with sufficient accuracy
	Annotations
	References
TRACK B	QB3 Do fishery-specific data indicate that the target stock is in good condition with regard to biomass?
	☐ YES - Stock is in good condition or underfished
	☐ YES - Stock is appropriately used or fully fished
	☐ Stock size is uncertain OR unknown
	☐ NO - Stock is overfished
Annotations	
References	
TRACK B	QB4 Do fishery-specific data indicate that the fishing rate is appropriate to sustain the long-term yield in the future?
	☐ YES – Stock is fished at a rate likely to maintain stock at, or increase stock towards, good condition [overfishing is not occurring]
	☐ Stock is fished at a rate that risks maintaining stock at, or decreasing stock towards unsustainable levels [at risk of overfishing] OR fishing rate on the target stock is unknown
	☐ NO – Stock is fished at a rate that is reducing stock to unsustainable levels, OR is preventing recovery of depleted stock [overfishing is occurring]
	Annotations
References	
TRACK B	QB5 Do management measures* exist that will likely ensure the long-term productivity and/or the recovery of the stock? *Management measures could be e.g. Total allowable catch (TAC), fishing effort, technical measures <u>Note to assessor:</u> Please account for Table 7/Guidance Document
	☐ Management of target stock is fully effective
	☐ Management of target stock is partly effective OR stock status is healthy despite the absence of specific management measures
	☐ Management of target stock is marginally effective OR: Effectiveness of management of target stock is unknown
	☐ Management of target stock does not exist OR is not effective





References



QC2

References

QC3

References

Q4

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YES - The species exhibits more than 3 of the listed parameters
[Species is particular vulnerable to fishing pressure]

Annotations

References

QC5 Will the current fishing practice likely reduce the stock to unsafe levels*?

NO - Current fishing practice is likely to maintain maximum productivity of the stock

NO - Current fishing practice does not threaten the target stock

YES - There are indications that current fishing practice might threaten the target stock OR not enough information for evaluation

YES - Current fishing practice threatens the target stock

* E.g. due to the gear used or the range or the coverage of the fishing activity.

Annotations

References

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CATEGORY 2: ECOLOGICAL EFFECTS OF THE FISHERY

Q7 Does the fishery negatively impact* any species (fish and non-fish) that is listed** as threatened, endangered or protected (ETP) OR overfished OR biologically highly vulnerable***?

* Impacts only to be considered on population level

** List examples as of QC2

*** Highly vulnerable species: e.g. selected species of elasmobranchs, demersal deep sea finfish (e.g. of the families Macrouridae, Sebastidae, Trachichthyidae)

NO - The fishery under assessment does not cause significant damage to any listed, overfished, or highly vulnerable species

NO - The fishery under assessment is not likely to cause significant damage to any listed, overfished, or highly vulnerable species

There is no OR conflicting information concerning the effects on listed, overfished, or highly vulnerable species

YES - The fishery under assessment is likely to cause significant damage to some listed, overfished, or highly vulnerable species

YES - The fishery under assessment causes significant damage to any listed, overfished, or highly vulnerable species

Annotations

References

Q8 Does the fishery generate discards?

Note to assessor: Only use the categories "low", "moderate" or "high" when no other information is available

... by weight	<5%	5-15%	15-30%	>30%	unknown
...referenced in a scientific report as:	low	moderate	high	very high	
High survival rate*					
Low** or unknown survival rate					

* High survival rate: over 75% of each discarded species survive

** Low survival rate: less than 75% of discarded species survive

Annotations

References

Q9 Does the retained catch contain juveniles* or non-target species?

*Juveniles = individuals (target AND non-target species) which are smaller or younger than the length or age where 50% of the individuals of that specific stock are considered mature.

Percentage of catch is by weight. Assessors should be conservative when looking at juveniles given low weight relative to adults.

NO - The retained catch contains no (or <5%) juveniles AND no (or <5%) non-target species [selective catch method]

YES - The retained catch contains 5-30% juveniles AND no (or <5%) non-target species OR the landed catch contains 5-30% non-target species AND no (or <5%) juveniles

YES - The retained catch contains 5-30% juveniles AND 5-30% non-target species OR there is not enough information for evaluation

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YES - The retained catch contains >30% juveniles AND/OR non- target species
[non-selective catch method, e.g. trawling, dredging, FAD associated seine]

Annotations

References

Q10 Does the intensity of the fishery result in significant negative ecosystem changes*, such as cascade effects, major food chain effects, or community changes? [Ecosystem Effect]

*Examples of significant ecosystem changes: Significantly increased abundance of species with a low trophic level caused by depletion of predators. OR Depletion of top predators as a result of the decrease of key prey species. OR Truncated size composition of the ecological community. OR Major changes in the species biodiversity of the ecological community. OR Changes in the genetic diversity of a stock that lead to changes of e.g. growth or reproduction of the species. OR Destruction of key biogenic/habitat-forming species.

- ☐ NO - The fishery is not causing significant negative ecosystem changes
- ☐ Negative ecosystem changes caused by the fishery are unlikely OR the likelihood of impact cannot be determined because there is conflicting, inconclusive, or insufficient information
- ☐ YES - Significant negative ecosystem changes are likely [circumstantial evidence]
- ☐ YES - The fishery is causing significant negative ecosystem changes [direct evidence]

Annotations

References

Q11 Is the fishing method destructive to particular benthic habitats or habitat forming species within the benthic habitat? [Habitat Effect]

Notes to assessor: Provide references for definition of habitat type.
In case the habitat types are mixed, scores are to be averaged.
In case the fishing grounds are known to include at least one sensitive habitat, score accordingly.

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Habitat type	Sand/ gravel/ mud	Rocky	Biogenic reefs, sponge- beds, seagrass	Seamounts, cold water corals, hydrothermal vents
Capture method				
Pelagic (midwater) trawl, pelagic long-line, spear, harpoon, purse seine, midwater gillnet, pole & line, trolling, hook-and-line				
Hand-picking				
Hand raking				
Pots, traps				
Bottom long-line, bottom set gillnet				
Danish seine, demersal seine, fly-shooting				
Beam trawl/beam trawl rollers, demersal otter trawl				
Beam trawl/tickler chains or chain mats				
Dredge				
Explosives, chemicals & other illegal operations				
Annotations				
References				

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Fishery

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CATEGORY 3: MANAGEMENT

Q12 Is there a management system* in place for the fishery under assessment?

*A management system may be anything ranging from fully regulated to completely voluntary and/or small scale.

- ☐ YES - A management system is in place → Proceed to Q13
- ☐ NO - A management system is not in place OR a management system is in place, but the details are not available → Do not continue with other questions in Category 3
- ☐ NO - A management system is not in place but there are indications that it would be urgently required → Do not continue with other questions in Category 3

Annotations

References

Q13 Are the established management measures for the fishery under assessment effective in maintaining the integrity of the habitat and ecosystem AND in maintaining the long-term productivity of all impacted species?

Procedure: Highlight the appropriate box for each issue. The points don't go directly in the total assessment score, but they are aggregated in the "score" section below.

ISSUE	1. Relevance		2. Effectiveness				
	Is this issue relevant to the fishery under assessment?		Fully effective	Largely effective	Partly effective	Marginally effective OR effectiveness unknown	Not effective
	No (Do not continue in this row)	Yes (Proceed to column 2)					
(Q no. relates to question above)							
ETP species* (Q7)			100	75	50	25	0
Discard (Q8)			100	75	50	25	0
Unwanted bycatch (Q9)			100	75	50	25	0
Ecosystem effect** (Q10)			100	75	50	25	0
Habitat effect*** (Q11)			100	75	50	25	0
Monitoring/data availability****		X	100	75	50	25	0
Mixed fishery			100	75	50	25	0
IUU, misreporting			100	75	50	25	0
Compliance, enforcement			100	75	50	25	0
Transparency, participation			100	75	50	25	0
Others (please specify)			100	75	50	25	0

* Endangered, threatened or protected OR overfished OR biologically highly vulnerable species

** Ecosystem effect: refer to definition given in Q10

*** Habitat effect = Impact on habitat and habitat forming animals, e.g. corals

**** Issue must be rated mandatorily

SCORE: Notes to Assessor: Determine the score by calculating the arithmetic mean (i.e. add the points from above and divide the sum by the number of relevant issues chosen. [Example: 4 issues chosen with 75+75+75+25=250 points. 250/4=62.5 → SCORE 0]. Insert the result in the respective box below.

SCORE 90-100: Management is effective

SCORE 65-89: Management is largely effective

SCORE 40-64: Management is partly effective

SCORE 15-39: Management is marginally effective
OR there is insufficient information to assess effectiveness

SCORE 0-14: Management is not effective

Annotations

References

Q14 Is there an ecosystem-based management (EBM)* plan or approach in place?

* For the definition of EBM, please refer to the Guidance document.

- ☐ YES - An EBM is implemented effectively
- ☐ YES - An EBM is currently at the state of implementation OR singular measures aiming specifically at the integrity of the ecosystem are in place and effective
- ☐ NO - Steps have not been taken to implement an EBM

Annotations

References

FISHERY IMPROVEMENT MEASURES

The following questions do not count to the overall scoring. Data are needed for informational purposes only.

FIP Is the fishery under assessment taking part in a Fishery Improvement Program (FIP)?²

- ☐ YES - The fishery/a part of the fishery is taking part in a FIP Indicate share of the fishery in FIP (e.g. as percentage of the total landings or number of vessels)
- ☐ NO - The fishery is not taking part in a FIP

Annotations

References

MSC Is the fishery under assessment applying for MSC certification?²

- ☐ YES - The fishery/a part of the fishery is MSC certified Indicate landings of the certified fishery as percentage of the total landings in the UoA
- ☐ The fishery/a part of the fishery is in the full assessment process for MSC certification
- ☐ NO - Efforts to apply for MSC-certification have not been taken OR a pre-assessment has been undertaken, but no further steps have been taken

Annotations

References

The questions FIP and MSC are indicator questions only and do not count towards the final score.

Appendix 2: A copy of a script used in the ordination analysis in the programme R.

```
setwd("e:\\From ru comp - data2\\Data3\\Combined2")
sassi <- read.csv("TrackA.csv",row.names=1, header=T)
sassi2 <- read.csv("TA.csv", header=T)
attach(sassi2)

library(vegan)
library(MASS)
library(cluster)
library(gclus)
library(RColorBrewer)

#ord <- rda(sassi)
ord <- metaMDS(sassi, distance = "binomial", binary=TRUE)
#####
dev.new()
plot(ord, type="n")
points(ord, display = "spec", col="black", bg="red", pch=21)
text(ord, display = "spec", col="blue", pos=3)
points(ord, display = "sites", col="black", bg="yellow", pch=22)
text(ord, display = "sites", col="black", pos=4)
abline(h=0, lty="dotted")
abline(v=0, lty="dotted")
#####

plot(ord, type="t")
```

```
points(ord, display = "sites", cex = 0.8, pch=21, col="red", bg="yellow")
text(ord, display = "spec", cex=0.7, col="blue")
```

```
dev.new()
plot(ord, type="n")
plot(ord, disp="sites", type="t")
ordihull(ord, sassi2$Question, col="blue")
ordiellipse(ord, sassi2$Question, col=3,lwd=2)
ordispider(ord, sassi2$Question, col="red", label = TRUE)
points(ord, disp="sites", pch=21, col="red", bg="yellow", cex=1.3)
```

```
ord.fit <- envfit(ord ~ Response, data=sassi2, perm=1000)
plot(ord, dis="site")
plot(ord.fit)
ordisurf(ord, sassi2$Response, add=TRUE)
```

```
dev.new()
plot(ord, type="n")
plot(ord, disp="sites", type="t")
ordihull(ord, sassi2$Category, col="blue")
ordispider(ord, sassi2$Category, col="red", label = TRUE)
points(ord, disp="sites", pch=21, col="red", bg="yellow", cex=1.3)
```

```
par(mfrow=c(1,2))
stressplot(ord, main="Shepard plot")
gof<-goodness(ord)
plot(ord, type="t", main = "Goodness of fit")
```

```

points(ord, display="sites", cex=gof*100)

dev.new()

sp.n<-vegdist(sassi, method="binomial")
sp.cl<-hclust(sp.n, method = "single")
plot(sp.cl)

sp.comp<-hclust(sp.n, method="complete")
plot(sp.comp)

#Cluster based on ward's classification
sp.ward<-hclust(sp.n, method="ward")
plot(sp.ward)

#selecting optimum number of clusters
grp<-function(X)
{
  require(cluster)
  gr<-as.data.frame(as.factor(X))
  distgr<-daisy(gr,"gower")
  distgr
}

kt<-data.frame(k=1:nrow(sassi), r=0)
for (i in 2:(nrow(sassi)-1)){
  gr<-cutree(sp.ward,i)
  distgr<-grp(gr)
  mt<-cor(sp.n, distgr, method="pearson")
  kt[i,2]<-mt
}

```

```

    }

kt

k.best<-which.max(kt$r)

plot(kt$k,kt$r, type="h", main="Mantel optimum number of clusters - Ward",
      xlab="k (number of groups)", ylab="Pearson's correlation")
axis(1, k.best, paste("optimum",k.best, sep="\n"),col="red",font = 2, col.axis="red")
points(k.best, max(kt$r), pch=16, col="red", cex=1.5)

#Silhouette plot

k<-4

cutg<-cutree(sp.ward, k=k)
sil<-silhouette(cutg, sp.n)
silo<-sortSilhouette(sil)
rownames(silo)<-rownames(sassi)[attr(silo,"iOrd")]
plot(silo, main="Silhouette plot - Chord - Ward",
      cex.names=0.8, col=cutg+1, nmax.lab=100)

sp.wo<-reorder.hclust(sp.ward, sp.n)
plot(sp.wo,hang=-1,xlab="4 groups", sub="", ylab="Height",
      main="Chord-Ward (reordered)",labe_s=cutree(sp.wo, k=k))
rect.hclust(sp.wo, k=k)

#heat map

dev.new()

dend<-as.dendrogram(sp.wo)

heatmap(as.matrix(sp.n), Rowv=dend, symm=TRUE, margin=c(3,3))

```

```
#ordered community table
dev.new()
or<-vegemite(sassi, sp.wo)
heatmap(t(sassi[rev(or$species)]), Rowv=NA, Colv=dend,
        col=c("white", brewer.pal(5,"Greens")), scale="none",
        margin=c(4,4), ylab=".")
```

```
#k-means partitioning
sp.kmeans<-kmeans(sp.n, centers=4, nstart=100)
sp.kmcas<-cascadeKM(sp.n, inf.gr=2, sup.gr=10, iter=100, criterion="calinski")
plot(sp.kmcas, sortg=TRUE)
summary(sp.kmcas)
sp.kmcas$results
sp.kmcas$partition
sassi[order(sp.kmeans$cluster),1]
ord.KM<-vegemite(sassi, sp.kmeans$cluster)
sassi[ord.KM$sites, ord.KM$species]
```

```
boxplot(sassi2$Response~sp.kmeans$cluster, col=2:5, varwidth=TRUE)
```

```
#####
```

```
dev.new()
plot(sp.ward)
rect.hclust(sp.ward, 4)
grp2 <- cutree(sp.ward, 4)
ordihull(ord, grp2, lty = 2, col = "red")
```