TOWARDS OPERATIONALISING AN ECOSYSTEM APPROACH TO THE NAMIBIAN ROCK LOBSTER FISHERY: IDENTIFYING MANAGEMENT OBJECTIVES AND INDICATORS

Janine Basson

BSSJAN002

Submitted in partial fulfilment of the requirements
for the degree of Master of Science (by coursework and dissertation)
in Applied Marine Science

Department of Zoology

Faculty of Science

UNIVERSITY OF CAPE TOWN

October 2009

SUPERVISOR:

Associate Professor Astrid Jarre (University of Cape Town)

UT 590 BASS
868098

Declaration

1. I know that plagiarism is wrong. Plagiarism is to use another's work and to pretend that it is one's own. This includes copying phrases and sentences from another's writing, and inserting these into one's own work.
2. I have used a standard convention for citation and referencing. Each significant contribution to, and quotation in, this Report from the work, or works, of other people has been attributed, and has been cited and referenced. Where exact wording is used, this is placed in quotation marks, and the page number is included in the citation.
3. This Report is my own work.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

SIGNATURE Signed by candidate

DATE October 2009

NAME Janine Basson

STUDENT NUMBER BSSJAN002

ABSTRACT

The World Summit on Sustainable Development (WSSD) Plan of Implementation encourages the implementation of an Ecosystem Approach to Fisheries (EAF) management by 2010. Signatory countries, which include Namibia, have adopted this as being necessary for the sustainable use of their marine resources. However, there has been little progress made towards developing simple structured guidelines for implementing an EAF within fisheries management organisations. As part of an EAF project implemented by the BCLME (Benguela Current Large Marine Ecosystem) programme, a series of Ecological Risk Assessments (ERA) were conducted for selected fisheries, which focussed on identifying all major issues related to EAF that are not adequately addressed by present management strategies. This methodology was repeated for the Namibian Rock Lobster fishery. Highly prioritised issues from the workshop were used to construct causal maps and value trees, for which indicators were suggested in consultation with stakeholders. The results of the ERA confirmed that there is a severe lack of transparency and shared understanding among stakeholders in the Namibian Rock Lobster Fishery, which is causing high tension and user conflict within the fishery. However, the importance and strength of the ERA process was found to lie in the discussion that it facilitates amongst stakeholders. Causal maps proved very useful in placing perspective on the perceived problems associated with the current management of the Rock Lobster fishery and the hierarchical structuring of value trees proved extremely useful in facilitating the transparency of the process. A list of specific objectives and suggested indicators is presented here, but there remains paucity in the data that are needed to inform some of these suggested indicators. Thresholds for these suggested indicators are defined here and are needed for evaluating the indicators for combination into an overall evaluation of the implementation of an EAF in this fishery. Expert systems are suggested here as a good tool to do so through synthesizing information from a large number of indicators for the decision-making process and to readily incorporate updated information. The tentative set of indicators presented here needs further work. However, the results of the present thesis can be used in designing such a system, to the benefit of the Namibian Rock Lobster fishery and the ecosystem this fishery depends on.

Keywords

Ecosystem Approach to Fisheries; EAF; Ecological Risk Assessment; ERA; Indicators; Expert systems

TABLE OF CONTENTS

1. INTRODUCTION

1.1 A paradigm shift in fisheries management

Historically, fisheries have been managed in terms of their impact on target populations alone, with the long-term sustainability of the resource as the primary objective; fishery studies tended to assume that the fishery and the target species existed in isolation from the rest of the ecosystem. In industrialised countries, efforts have been towards establishing a biological knowledge base of fish stock dynamics on which to base predictions of the response of stocks to fishing, following what can be called the "modern fisheries management model", while in developing countries the emphasis has been on building up specialised research institutions that can produce this knowledge (Degnbol 2003, Degnbol and Jarre 2004). The major problem encountered by both developing and industrialised countries following this model has been shown to be the decoupling of, or contradiction between, the formalised research knowledge and the users' (the direct and indirect stakeholders) knowledge. There is a large discrepancy between how fisheries science and fishers observe management of fish stocks (Degnbol 2003), leading to loss of legitimacy, transparency and trust between stakeholders. Thus, a need was identified for new approaches to fisheries management that are cost-efficient and provide knowledge considered valid and deliverable by stakeholders (Degnbol and Jarre 2004). Recently there has been a shift towards a more holistic ecosystem approach to fisheries management (EAF), which has been adopted by many nations as being necessary for the sustainable use of their marine resources. Since the World Summit on Sustainable Development (WSSD[1]) in 2002, signatory countries, which include Namibia, are required to develop an ecosystem approach to fisheries (EAF) by 2010. Both internationally and in the Benguela region, this has resulted in much scientific activity and research aimed specifically at understanding complex marine ecosystems and the interactions occurring within, and how to use this knowledge for management (e.g. Shannon *et al.* 2004, Shannon *et al.* 2006).

Like any other management system, implementation of an EAF requires a policy, a strategy and an operational management plan (Garcia and Cochrane 2005). The policy outlines what the commitments of the EAF are, linking national and local developments with international

[1] www.un.org/jsummit/html/documents/summit_docs/2309_planfinal.htm

policy frameworks and agreements, as well as conceptual goals e.g. sustainable livelihoods, reducing uncertainty for industry etc. The strategy then takes these goals and turns them into operational objectives, ranking them and adding a timeframe within which they should be attained. Finally, the management plan provides details on what resources are available, the stakeholders involved, the measures specific to the different fisheries and the enforcement mechanisms available (Garcia and Cochrane 2005).

An EAF looks 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). In essence, an EAF approach looks to take existing management structures and improve their implementation to reinforce their ecological relevance (Garcia and Cochrane 2005). From this viewpoint, the major problem currently facing fisheries managers is how to incorporate ecosystem considerations into fisheries management in order to tackle new concerns about species interactions and spatial dynamics. Because the view towards societal objectives and ecosystem considerations has broadened, an ecosystem approach to management remains a confusing topic for many. Because of the complexity of the problems that need addressing, and the intrinsic absence of a general solution, learning by doing is viewed as the best way forward (e.g. Murawski 2007).

1.2 Will an ecosystem approach to management enhance sustainability?

As pressure on resources and ecosystems has increased, the shortcomings of the single-species approach to fisheries management have become abundantly clear; in assuming that the fishery and the target species exist in isolation, the fact that target stocks are affected by factors other than fishing – such as loss of critical habitat (e.g. through coastal zone development or pollution), changes in abundance of predators and prey (which could be caused by other fisheries), and climatic changes – is not considered (FAO 2003). In fact, this approach has not led to the sustainable use of biodiversity as it has failed to maximise the social, economic or ecological benefits of fisheries. Sustainable management of fisheries in the Benguela needs to take onboard considerations on long-term ecosystem change (Jarre *et al.* 2006) including the human factor and viewpoint (Morishita 2008). The key objective of EAF is the sustainable use of the whole system, not just targeted species. Furthermore, it recognizes humans as an integral component of the ecosystem, with sometimes competing interests in fisheries and marine ecosystems that need to be addressed. Ultimately, it provides a framework for incorporating a wide range of ecosystem conservation objectives into management plans (FAO 2003). There is a definite need to build a common understanding of an EAF with stakeholders, which should include what is required for an EAF, and the possible implications and benefits thereof for stakeholders. Indeed, if there is not a common understanding of where fisheries management is heading amongst stakeholders, is it unlikely to succeed. It has been shown that stakeholder participation and EAF benefit from each other (Degnbol 2003, Gray and Hatchard 2008) and thus management goals cannot and must not lose sight of the human perspective. Management goals must be operationalised i.e. specified to practical and understandable levels (FAO 2003, Morishita 2008) otherwise EAF will be impossible to implement. For effective fisheries management, good science (transparent and reliable data on the status of the target species, species belonging to the same ecosystem, associated or dependent species, and indicators of ecosystem changes – all of which must be explained to and communicated amongst stakeholders), identification of management goals (and the range of tools needed to achieve these goals) and the integration of the human factor into ecosystem management are needed (FAO 2003, Morishita 2008). Stakeholder involvement is imperative in the success of EAF (Berghöfer *et al.* 2008, Varjopuro 2008) and often management loses sight of the social and economic implications or even governance systems that may be required to implement recommendations. Including all stakeholders in the decision-making process, therefore, is imperative for the success of an EAF.

1.3 Ecological risk assessments (ERA) as a basis for an EAF

Globally, there has been little progress made towards developing simple structured guidelines for implementing an EAF within fisheries management organisations, with the exception of the FAO Code of Conduct for Responsible Fisheries (FAO 1995) and the Australian Ecological Sustainable Framework (Fletcher *et al.* 2002). With this challenge in mind, the BCLME (Benguela Current Large Marine Ecosystem program) implemented a regional EAF project in 2004 which included participation by researchers and managers from Angola, Namibia and

South Africa (Cochrane *et al.* 2004). Its objective was to evaluate the feasibility of an EAF in the region. As part of this project, a series of Ecological Risk Assessments (ERA) were conducted for selected fisheries (Nel 2007), which focussed on identification of all major issues related to EAF that are not adequately addressed by present management strategies.

An ERA is a tool used to identify and prioritise issues, building consensus amongst diverse stakeholder groups whilst defining the ecosystem in its broadest sense, including ecological, social and governance aspects. Issues pertaining to the ecosystem are listed and prioritised by stakeholders groups and those rated as 'Moderate' or higher are used to formulate (with agreement from all stakeholders) management objectives. Identified issues can thus be addressed in a specific ecosystem context with available scientific tools and/or monitoring techniques. Full performance reports (which involve setting an operational objective, the identification of suitable indicators, targets and milestones that allow for regular progress to measure against agreed targets) are developed for all issues of greater than 'Moderate' risk. Thus, as a solution to the complex problem of implementing an EAF that managers are faced with, ERAs provide a structured, transparent procedure, as a first step towards implementing an EAF. Time series behind indicators linked to the specific objectives (as identified through the ERA process) make it possible to evaluate a fishery and its status at a specific moment in time in an ecosystem perspective.

1.4 Moving from single species management to ecosystem management: the need for indicators

The implementation of an EAF is a process. Therefore, mechanisms need to be established in order to measure the *progress* towards an EAF. In other words, three main steps need to be established; (1) what are the desired goals, (2) what is the current state of the system relative to these goals, and (3) what mechanisms are available and/or necessary to enact the changes integral to reaching these goals (Link 2005).

There is no general theory that can describe the whole functioning of marine ecosystems and so the management decision process must be based on several different tools (Jarre *et al.* 2006). Statistical methods and modelling have been shown to be effective in evaluating the effect of different management scenarios in the southern Benguela region, as well as in the development of indicators (Shannon *et al.* 2004, Shannon et al. 2009). However, sometimes the necessary input data are not available or the issues are not favourable to evaluation through modelling, in which case it may become necessary to use expert opinion (e.g. Paterson *et al.* 2007). Thus, the "hard predictability" that management has always been reliant on is now being replaced by a "soft predictability", which does not necessarily require the understanding of all the detailed processes or the churning out of quantitative predictions of outcomes (Degnbol and Jarre 2004). The knowledge base for EAF will need to be indicators and qualitative assessments rather than quantitative predictions based on analytical stock assessments (Degnbol and Jarre 2004).

Management plans must specify strategies for meeting their goals and objectives (Halliday *et al.* 2001) and good management decisions can only be reached when the knowledge on which they are based is clearly linked to management objectives (Degnbol and Jarre 2004). Indicators are central to how this can be done (Garcia and Cochrane 2005) as they permit assessment of the status of the system and form the basis for the development of reference values or reference directions (Link 2005, Rochet *et al.* 2005).

The identification of indicators can only take place after a number of other steps have occurred, i.e. setting of broad objectives, developing operational objectives from these broad objectives, and formulating operational objectives for specific issues. Within a particular context, the choice of indicator depends both on the specific objectives for management as well as the management institution that will be informed by the indicator. Furthermore, indicators must be accepted by at least a subset of stakeholders influential enough in the decision making process (Degnbol and Jarre 2004). Indicators can be used at various points in EAF implementation, e.g., they can provide a means of assessing EAF-related issues in a fishery, a means of tracking the implementation of certain management measures, or a means of tracking progress made towards an EAF. The DPSIR framework (Drivers-Pressures-State-Impacts-Responses) has proven useful to categorise such different uses. Indicators values, however still need to be translated into decision criteria depending on critical values, or thresholds (Link 2005).

Elements of fishing can be considered as having certain attributes (Halliday *et al.* 2001), which, for fish stocks, can include their biomass, growth rate, and mortality through fishing pressure. Socio-economic attributes can include revenues, employment and earnings (Halliday *et al.* 2001). Tracking these attributes (and consequently an EAF implementation into the fishery) can be done by way of indicators. Much research has been devoted to identifying such indicators (e.g. Daan *et al.* 2005 and contributions therein), and it is now generally agreed that a suite of indicators, operating in unison, will be needed to address the multivariate nature of and the complexity of issues within any specific EAF. It is in this way, through the potential use of a wide variety of indicators that can capture the effects of the interactions between resources, that an EAF out-performs the single species approach to fisheries management. Using only single species indicators, such as survey or catch records, cannot offer this level of detail as it may not necessarily reflect what is happening at the community or ecosystem level (Jarre *et al.* 2006). The properties of the indicators need to be described carefully and their relative responsiveness to management actions (in view of other drivers of ecosystem dynamics, such as environmental change) must be researched and known.

1.5 The Namibian West Coast Rock Lobster Fishery: An overview

The West Coast Rock Lobster (*Jasus lalandii*) is one of the primary products of the Namibian fishing industry and the resource has been heavily exploited over the last four decades (Grobler *pers. comm.*). The lobster are distributed throughout the inshore areas of Namibia between 24º57'03"S and 28º22'04"S and are commercially harvested south of Lüderitz between the Orange River border in the south and Easter Cliffs/Sylvia Hill north of Mercury Island (Grobler 2007, Currie and Grobler 2007).

Currently, Rock Lobsters are exploited both commercially and recreationally. The industry consists of 21 rightsholders who are all based in Lüderitz and the majority of the Rock Lobster companies are Namibian owned. During the 2007/2008 season, a Total Allowable Catch (TAC) of 350 tonnes was allocated among 19 rightsholders. The fishing fleet in 2007 consisted of 29 vessels, but most companies did not manage to fill their quota and less that 50% of the TAC was caught that season (Grobler 2007). The fishery is dominated by small quota holders and all the vessels used during the 2007/2008 season are owned by the rightsholders themselves. A total of four Rock Lobster commercial fishing areas are identified in Namibia, each consisting of one or more lobster grounds (Currie and Grobler 2007) (Figure 1).

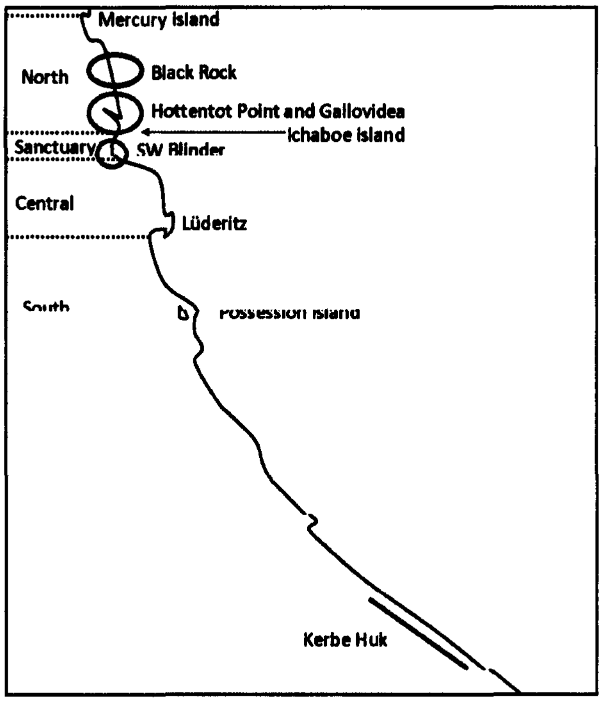


Figure 1: *South coast of Namibia showing the four important commercial fishing areas (Kerbe Huk, Black Rock, Hottentot Point and Gallovidea, and SW Blinder), each consisting of one or more lobster grounds*

All the catches are landed at one of two processing facilities in Lüderitz (MFMR 2008), where they are divided into one of three categories: quality, for the export market or on special request from the local market, catering or sub-standard, for the local market (MFMR 2008). There is currently not much value addition taking place in the Namibian Rock Lobster industry. According to rightsholders, the TAC is too small to produce certain value added products as it would require significant amounts of lobster to make enough value added products to penetrate global markets. Most of Namibia's competitors have TACs that are 8 to 10 times larger than those in Namibia. Namibian Rock Lobster is marketed internationally by Namibian Rock Lobster Packers (Pty) Ltd (NAMROCK). The two main forms in which lobster is exported are as either frozen whole cooked or as frozen tails. Around 95% of Namibian Rock

Lobster is exported to Japan and the majority of the tails are exported raw. In recent years, some Namibian Rock Lobster has been exported to the United States of America and Spain. Sizes 60 – 72cm fetch the highest prices and during the year 2008 this was around 2,980 Yen per 10kg box (equivalent to 32.09 USD, or 245.55 ZAR/Namibian dollar (NAD), at the time of writing) (MFMR 2008).

Employment in the Rock Lobster Fishery for 2007/2008 was 491 individuals, down slightly (2%) from the 2006/2007 season. Employment has stabilised over recent years as rightsholders have purchased vessels and been employing crew members on a seasonal basis. The employment within the fishery is 100% Namibian, with 335 persons employed offshore (71% of these employed on a temporary basis) and 156 persons employed onshore (96% of these employed on a temporary basis). Rightsholders within the industry have indicated that it is extremely difficult to sustain employment throughout the entire year. Most employees work for months before they receive payment from sales as sales are so unpredictable (MFMR 2008). As a result, most employees are only employed for six months of every year.

The Rock Lobster season is from the 1st of November to the 30th of April of the following year and the stock is believed to be shared with South Africa through a common larval pool (Grobler 2007). Commercial fishing occurs throughout the season with either rectangular traps that are soaked overnight or with ring nets, used off small dinghies, with the majority of the catch coming from the traps. Regulations on the fishery include a minimum size limit and not landing females-in-berry (females with eggs). Observers onboard these vessels collect length frequency data throughout the season (Grobler 2007).

There is a need for the practical implementation of EAF principles into the management protocols of the Rock Lobster fishery. However, the need for managers to prioritise resources and management actions complicates EAF implementation further. The Rock Lobster resource may be showing small signs of recovery (Maletzky 2008) but there is still concern regarding the management of the stock and the sustainability of its exploitation.

To date, six ERAs have been conducted in South Africa (hake, small pelagic, West Coast Rock Lobster, squid, large pelagic and linefish) and three in Namibia (hake, purse seine and midwater trawl) (Nel 2007), but none for the Namibian Rock Lobster Fishery. To attempt to address the management gaps that exist in this fishery, and provide building stones of an EAF in this fishery, this project aims to:

1. Together with stakeholders, identify all stakeholder issues of concern within the Namibian West Coast Rock Lobster Fishery and conduct a qualitative risk assessment for these issues;
2. Link all issues raised to management objectives and construct an objective hierarchy (value tree) of all issues raised, irrespective of the perceived severity of risk;
3. Identify potential indicators to address issues of high and extreme risk as a means to track the implementation efficacy of an EAF in this fishery, and collate data series for some of these suggested indicators; and
4. Outline how the indicators could be used in a tracking tool monitoring the implementation of an EAF into this fishery.

2. MATERIALS AND METHODS

2.1 Ecological Risk Assessment (ERA) Workshop

2.1.1 Stakeholders

In order to get a representative idea of the diversity of perception within the Rock Lobster fishery, invitations were widely distributed to members of the fishing industry, social scientists, research scientists, inspectorate, the parastatal Fisheries Observer Agency (FOA) and mining industry. It was expected that different stakeholder groups would have different perceptions of where management is failing to adequately mitigate impacts that are threatening the sustainability of the fishery. As the fishery is based in and operates out of Lüderitz, the workshop and interviews were held at the Lüderitz Marine Research (LMR) centre, which is part of the Namibian Ministry of Fisheries and Marine Resources (MFMR).

2.1.2 ERA methodology

The methodology used is based on the Australian and New Zealand Standard Risk Analysis which was adapted for use in a fisheries context (Fletcher *et al.* 2002, Fletcher 2005). It requires stakeholders to deliberate and agree upon a way forward, relying on the following three-step process:

1. Identification of issues
2. Prioritisation of these issues
3. Development of performance reports describing the management response most appropriate to address the issue

For the ERA for the Namibian Rock Lobster fishery, we followed the same procedure as implemented for other Benguela fisheries (Nel 2007).

2.1.2.1 Identification of issues

Following FAO 2003, issues pertaining to the Namibian Rock Lobster fishery were grouped into three categories: 'Ecological Wellbeing', 'Human Wellbeing' and 'Ability to Achieve'

(Figure 2). This allowed workshop participants to identify the main issues and concerns that face the fishing industry as a whole.

Each of these eight major components was further disaggregated into more detailed subcomponents for which operational objectives could be established. Issue identification involved group discussion and tailoring of these trees to fit the individual circumstances of the Namibian Rock Lobster fishery. Any issue identified by one or more participants was included in the list of issues, whether it was supported by other participants or not. In this way, a complete and comprehensive list of issues reflecting the concerns of all workshop participants was established.

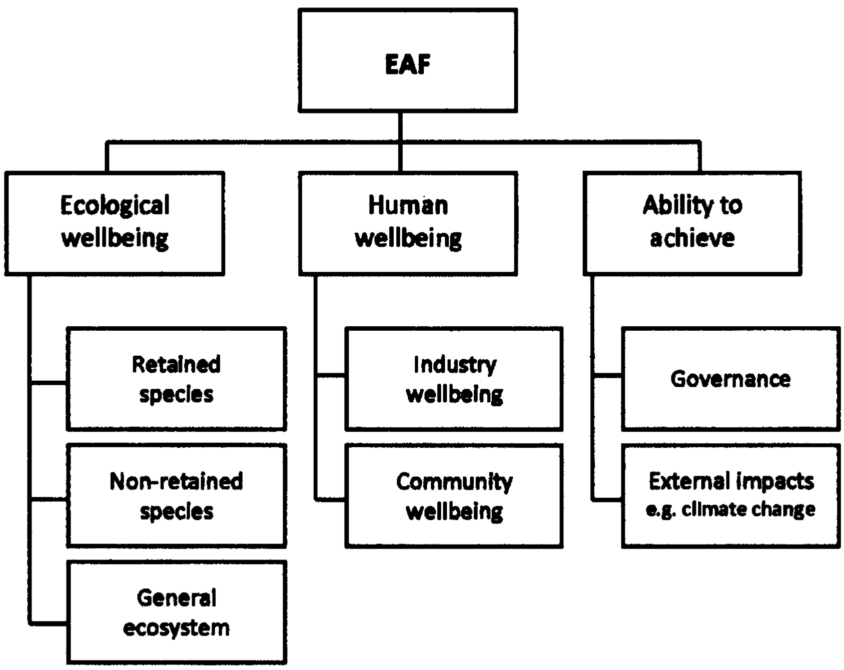


Figure 2: *Diagrammatic representation of the eight EAF major components included into the ERA process (adapted from FAO 2003).*

2.1.2.2 Prioritisation of Issues

An allocation of a 'risk value' provides a means of prioritising the issues. In order to do this, the risk assessment process uses a scoring system (according to explicit category guidelines available to all stakeholders in the ERA workshop) that measures the 'likelihood' of a negative issue occurring, and a second score that independently allocates the severity of the effects should the negative outcome come about ('consequence') (Fletcher *et al.* 2002, Shannon *et al.* 2006). The likelihood is scored on a scale of 1 to 6, and the consequence is scored on a scale of 0 to 5. The two scores are multiplied into a single risk score. Low risk issues require no immediate management action while high risk issues require management action (Nel *et al.* 2007).

Consensus is reached as far as possible in the workshop setting. In this case, consensus was reached on all consequences and likelihoods. Each issue was then categorised as a 'Negligible' (score of 0), 'Low' (score of 1 – 6), 'Moderate' (score of 7 – 12), 'High' (score of 13 – 18) or 'Extreme' (score of 18 or greater) risk according to their overall risk score.

The full ERA report is given in Appendix 2, including a complete list of all issues raised and their likelihood, consequence and risk ratings (page 38 of Appendix 2).

2.1.2.3 Development of Performance Reports and formulation of management objectives

After issues were prioritised, those rated as 'Moderate' or higher were used to develop (with agreement from stakeholders) performance reports according to the template in Table I, from which management objectives were formulated in the workshop. Due to time constraints, emphasis was placed on step 3 i.e. the fisheries management response.

***Table I**: Revised diagrammatic representation of the nine steps to developing the Performance Reports*

PERFORMANCE REPORT HEADING	DESCRIPTION
1) Operational objective (plus justification)	*What are you trying to achieve and why?*
2) Issue	*Which issue raised in the workshop is being addressed?*
3) Fisheries Management Response o Current o Future o Actions if performance limit is exceeded	o *What are the management actions currently being used to achieve acceptable performance?* o *What extra management is to be introduced?* o *What will happen if the indicator suggests that performance is not acceptable?*
4) Indicator	*What are you going to use to measure performance?*
5) Performance measure/limit (justification)	*What levels define acceptable and unacceptable levels of performance and why?*
6) External drivers	*What factors outside of the fisheries control may affect performance against objective?*

2.2 Further problem structuring: Causal maps and value trees

Further interviews were conducted after the ERA workshop, held on a one-to-one basis so participants felt free to express their views on the fishery without feeling pressured by other stakeholder views and/or prejudices. Participants were already familiar with the project, which was well received on the whole, and were thus invited to speak freely on issues they felt were important. All interviews were carried out by the same interviewer, with no pre-defined list of questions, and discussion was allowed to flow freely. Specific aspects of the interviews were followed up in subsequent email correspondence. The interviews were attended by two mining representatives (Namdeb), one representative from the Fisheries Observer Agency (FOA) based in Lüderitz and three research (Lüderitz

Marine Research – LMR) scientists. Regrettably, no representatives from the fishing industry were available for these additional interviews.

2.2.1 Causal maps

A causal map is a qualitative model of a system (Prigent *et al.* 2008) and consists of concepts and causal relationship between these concepts (Özesmi and Özesmi, 2004). A causal relationship such as "A → B" means A is the explanation of B or B is the consequence of A. The relationship can be either positive (an increase in A results in an increase in B or, alternatively, a decrease in A leads to a decrease in B) or negative (an increase in A results in a decrease of B) indicated by a "+" or "-" above the arrow (Prigent *et al.* 2008). The maps could also include the relative strength of the relationships (1: low, 2: medium or 3: high) and time scales (a: short term, b: medium term or c: long term).

Generic terms were defined and agreed upon to encompass all the issues identified in the ERA workshop as being of 'moderate' or greater risk. These were structured hierarchically (following Prigent *et al.* 2008) according to topics or categories e.g. 'food web implications of removing Rock Lobster' and 'entanglement of vulnerable species' at a lower level, are elements of the 'state of the general ecosystem', which in turn is an element of the 'general ecosystem' at the highest level. The final tree has eight 'branches' that formed the main concepts agreed upon by participants to encompass the main influences within the Namibian Rock Lobster fishery (see Appendix 3).

A smaller subset of workshop participants (interviewed post-ERA) were given these concepts and asked to draw links between those they believe influence each other, thus creating a causal map independently and without influence of the interviewer. Each participant drew their own causal map, which were combined to form an overall map for the fishery. Feedback was then solicited from the participants on the validity of the overall map.

2.2.2 A hierarchy of objectives in value trees

Following the tree-like approach to an EAF suggested by FAO (2003, and see Figure 2), the various objectives were structured into a hierarchy. This objective hierarchy is called a 'value tree' in the terminology of general Multi-Criteria Decision Analysis (MCDA). MCDA is a methodology designed for evaluating options taking into account decision-makers' multiple, and often conflictive, objectives (for an overview, see Belton & Stewart (2002) and Goodwin & Wright (2004)).

The performance reports and discussion from the ERA workshop provided the main foundation necessary for the structuring of the value trees. The intensive post-ERA interviews and causal maps further guided the construction of the hierarchy through teasing apart the ERA discussions in such a way as to grasp onto what the perceived central theme and driving forces behind the status of the Rock Lobster fishery is. The perceived central theme and driving forces then formed the basis for formulating seven generic operational objectives (Figure 3) which, through further consultation with experts from research, management and industry, were disaggregated into a hierarchy of increasingly specific operational objectives, for which potential specific indicators were identified. This was done in detail for the ecological branch of the EAF tree and in lesser detail for the other two branches i.e. human wellbeing and ability to achieve. In line with the MCDA theory, care was taken to disentangle related objectives so that the resulting twigs of the trees would largely represent independent aspects of the fishery.

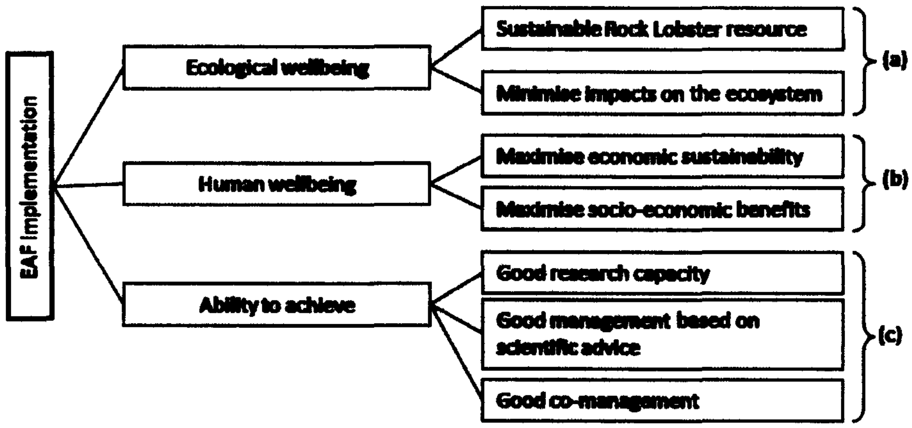


Figure 3: *Objective hierarchy (value tree) for the evaluation of the performance of the Namibian Rock Lobster fishery in an Ecosystem Approach to Fisheries; (a), (b) and (c) refer to Figures 10a, 10b and 10c, the details of which are further disaggregated in section 3.4.1.*

2.3 Identification of indicators

As a last step, a suite of potential indicators were identified to track the implementation of an EAF in the Namibian Rock Lobster fishery. Where indicators had already been outlined in the ERA workshop, these were reviewed for suitability to the specific management objective they were linked to. For all other specific objectives, key experts (MFMR scientists and colleagues at UCT and MCM) were consulted on possible indicators for use in the context of the Namibian Rock Lobster fishery.

After these indicators were identified, special attention was given to defining thresholds, such as is needed for categorical or semi-quantitative evaluation of indicator state ('good', 'medium', or 'bad) or, alternatively, for transformation into fuzzy variables, measuring the 'truth' value of an objective. Specifying threshold levels for indicators that can be used to define different ecosystem states is admittedly a very complex issue. In this case, the basis for threshold values were provided (as far as possible) through some consultation with relevant experts and extensive trawling of the available literature on the Rock Lobster in a Namibian context. Where data were found to be deficient for the West Coast Rock Lobster in particular, data on similar cold water species of Rock Lobster were used as a proxy. Properties of indicators include current practise for data collection, data gaps and perceived suitability of a particular suggested indicator towards understanding the resource. This evaluation of indicators, necessary for their combination into an overall evaluation of the implementation of an EAF in this fishery, was done for the 25 indicators for the ecological wellbeing of the fishery only, in line with the biological scope of this thesis.

3. RESULTS

3.1 Ecological risk assessment (ERA)

Most attendees of the ERA workshop were from the Namibian Ministry of Fisheries and Marine Resources (MFMR) (scientists, observers and inspectorate) with good representation from the Rock Lobster Fishery (both skippers and fishers) and the Mining sector (Namdeb Diamond Corporation (Pty) Limited) (Basson 2008). All participants agreed that the overriding objective that should govern management of the Namibian Rock Lobster is the rebuilding of the stock. All other management objectives are secondary to this.

During workshop discussions, a total of 91 issues were identified of which 81 (89%) were rated of 'moderate' risk or higher (Basson 2008). Most (49%) issues fell within the 'Ecological wellbeing' component, whilst 'Governance' issues (26 %) equalled those of 'Human wellbeing' (25 %) (Figure 4).

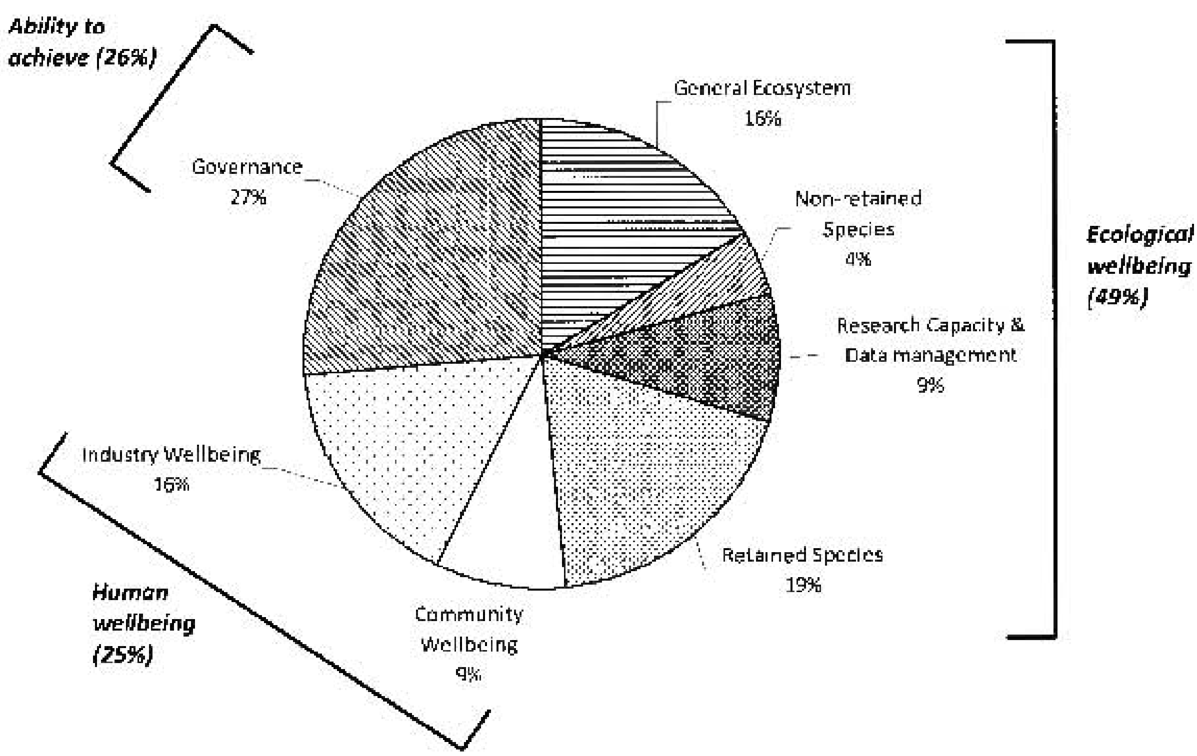


Figure 4: Issues in Namibian Rock Lobster fishery identified by ERA component and category

The prioritization process resulted in the majority of the issues falling into the 'Extreme' category (59%) (Figure 5). 'High' and 'Moderate' rated issues accounted for 14% and 16% respectively, with 'Low' and 'Negligible' issues respectively making up 7% and 4% respectively of the total number of issues. This seemingly biased result was noted during the workshop and thought to be valid as reflecting a fishery in crisis.

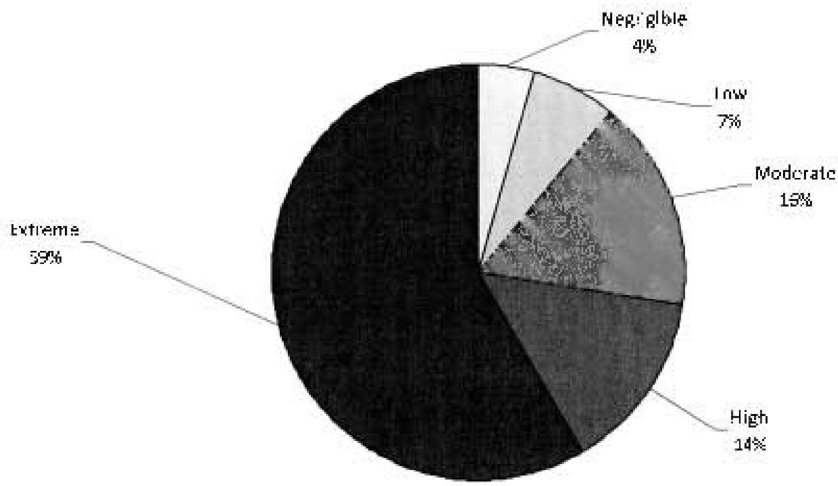


***Figure 5:** Issues in the Namibian Rock Lobster fishery identified in the ERA workshop by risk category*

When considering the spread of risk categories within each of the ERA components (Figure 6), the 'Ecological Wellbeing' component had the highest number of issues in total (44). The highest number of 'Extreme' issues fell into the 'Governance' category (18 out of a total of 24) within the 'Ability to Achieve' component, with the next highest number of 'Extreme' issues in the Industry Wellbeing (9) and Retained Species (8) categories of the 'Ecological Wellbeing' component. All issues raised within the 'Research Capacity and Data Management' category were prioritised as either of 'Moderate', 'High' or 'Extreme' risk.

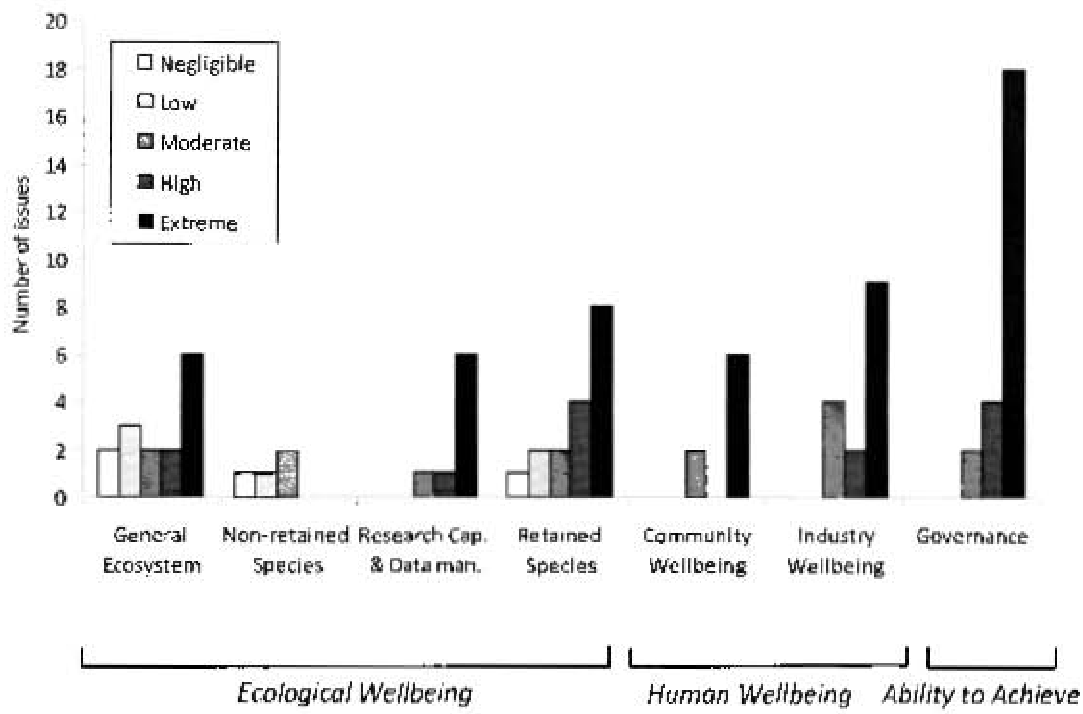


Figure 6: *Proportions of issues within given risk categories for each ERA component*

3.2 Causal maps

Causal (or cognitive) maps are usually used to structure a problem. In this case, they were used to establish what interrelationships may exist between issues raised in the ERA workshop by stakeholders that were prioritised as of 'high' or 'extreme' risk. Discussions tended to centre more on the conflicts and struggles that exist within the commercial fishery and not much was discussed regarding general ecosystem effects outside of the direct impacts of the fishery on the Rock Lobster resource. Thus, what follows is a diagrammatic representation and explanation of the discussion as it unfolded, but the reader should be aware that other influences on the resource exist, despite not being mentioned in detail here. These are expounded upon in Section 3.3.

The central theme in Figure 7, as discussed and decided on by the stakeholders, is the *'overexploitation of the Rock Lobster resource'*. The rest of the map provides possible and perceived causes of this central concept, with the overall driving force suggested to be the *'lack of stakeholder consultation in Rock Lobster management'*. "Tails" are described as those concepts with no incoming arcs, which may be associated with external driving forces and/or policy actions, and "heads" as those with no outgoing arcs, which could therefore be associated with consequences (Stewart *et al.* 2009). Following Stewart *et al.* (2009), interpretation of the map can be facilitated by classifying some of the concepts under the following headings:

3.2.1 Driving forces

These "tails" were seen to be the fundamental causes of the problems being experienced with the current management of the Rock Lobster fishery. *Lack of communication and transparency* between sectors (the mining and fishing industry; the commercial and recreational fishing industry; FOA and fishing industry; FOA and research; research and decision-makers/management etc.) is thought to be a result of there being no formal arena for stakeholder discussion and dissemination of information, which leads to conflict between these sectors. The antagonism and mistrust that exists specifically between the mining and fishing sectors was particularly evident in discussions. Even though studies are commissioned by the mining sector through independent consultants, it is still widely felt by participants that these studies are biased towards the mining sector and do not accurately reflect the effect, potential or otherwise, of mining on both the Rock Lobster resource and the general environment. Furthermore, the *lack of communication and transparency* that exists between the research component of governance and the decision-makers inevitably leads to a discrepancy between the scientific advice for and the ultimate TAC. Scientists feel their advice is often not taken as seriously as it should be and other factors (such as mining, which often takes precedence, or socio-economic factors such as potential unemployment) often carry more weight in the mind of the decision-maker, which can lead to the existing conflict between the recreational and commercial fisheries exacerbated, the TAC set too high and inevitable extra pressure placed upon the resource.

Limited scientific capacity and resources (in terms of funding) is also seen to be a strong driving force behind the overexploitation of the resource. Limited research capacity means that insufficient and incomplete data is collected regarding the resource, leading to a lack of understanding of the population dynamics and distribution of the resource. Because of the limitations in data on which management advice can be based, the relevance and quality of the advice is subsequently also limited, and the risk of over-estimating how much fishing pressure the resource can withstand thus increases. Poor management advice leads to poor management, and can be a cause of overexploitation of the resource. Limited data can also feed into the user conflict that exists between the recreational and commercial fisheries. Currently, no data is available or collected for the recreational fishery, limiting knowledge not only on how the fishery impacts on the resource but also on how an overexploited fishery can potentially impact on its users, in terms of socio-economics. Discussions clearly reflected that such data would aid in better management decisions, which would lead to a smaller discrepancy between the TAC and research advice.

The *remote location of Lüderitz*, with only one small airport and several hours by road to the next international airport are seen as a strong driving force behind the limited number of markets open to the commercial fishery. Currently, there is no value added to the Rock Lobster product as the TAC is too small to produce certain products that require significant amounts of lobster to penetrate global markets. In recent seasons, fishers have not managed to fill their individual quotas or the TAC. This combined with the limited market options and low sales prices on the product has often led to pressure on decision-makers to extend the fishing season, leading to increased pressure on the resource. The intricacy of the relationships is especially manifested when considering the direct and indirect causes for overexploitation of the resource. The problem of poaching and increased crime rates (within both the recreational and commercial fisheries) is exacerbated not only by the unfeasibility of individual quotas, but also by the extension of the fishing season. There is a direct and indirect relationship between the unfeasibility of individual quotas, the periods of unemployment within the fishery, increased poaching and crime rates, and a decreased CPUE. Industry members indicated that it is extremely difficult to sustain employment throughout the entire year, with most employees employed for only six months of the year. Decreased CPUE would aggravate this further as fishers decide to put their efforts into more guaranteed employment opportunities. This can also lead to increased poaching efforts as fishers disregard legal size limits or numbers for catches allowed per permit in favour of that insufficient and incomplete data is collected regarding the resource, leading to a lack of understanding of the population dynamics and distribution of the resource. Because of the limitations in data on which management advice can be based, the relevance and quality of the advice is subsequently also limited, and the risk of over-estimating how much fishing pressure the resource can withstand thus increases. Poor management advice leads to poor management, and can be a cause of overexploitation of the resource. Limited data can also feed into the user conflict that exists between the recreational and commercial fisheries. Currently, no data is available or collected for the recreational fishery, limiting knowledge not only on how the fishery impacts on the resource but also on how an overexploited fishery can potentially impact on its users, in terms of socio-economics. Discussions clearly reflected that such data would aid in better management decisions, which would lead to a smaller discrepancy between the TAC and research advice.

The *remote location of Lüderitz*, with only one small airport and several hours by road to the next international airport are seen as a strong driving force behind the limited number of markets open to the commercial fishery. Currently, there is no value added to the Rock Lobster product as the TAC is too small to produce certain products that require significant amounts of lobster to penetrate global markets. In recent seasons, fishers have not managed to fill their individual quotas or the TAC. This combined with the limited market options and low sales prices on the product has often led to pressure on decision-makers to extend the fishing season, leading to increased pressure on the resource. The intricacy of the relationships is especially manifested when considering the direct and indirect causes for overexploitation of the resource. The problem of poaching and increased crime rates (within both the recreational and commercial fisheries) is exacerbated not only by the unfeasibility of individual quotas, but also by the extension of the fishing season. There is a direct and indirect relationship between the unfeasibility of individual quotas, the periods of unemployment within the fishery, increased poaching and crime rates, and a decreased CPUE. Industry members indicated that it is extremely difficult to sustain employment throughout the entire year, with most employees employed for only six months of the year. Decreased CPUE would aggravate this further as fishers decide to put their efforts into more guaranteed employment opportunities. This can also lead to increased poaching efforts as fishers disregard legal size limits or numbers for catches allowed per permit in favour of

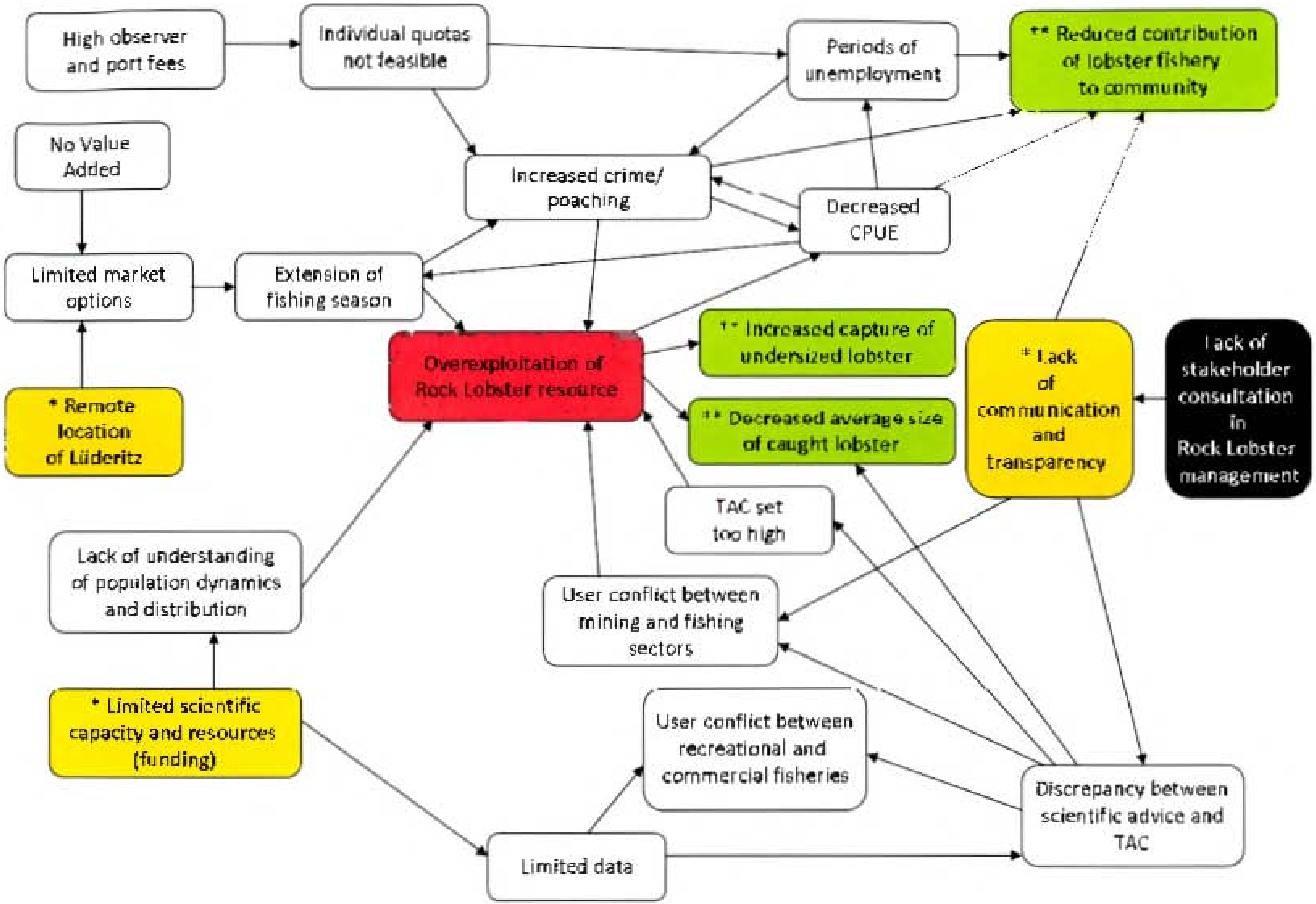


Figure 7: *Causal map showing interrelationships that may exist between issues raised in the ERA workshop that were prioritised as of 'high' or 'extreme' risk. The central theme, as decided on by participants, is the 'overexploitation of the Rock Lobster resource' ('heads', or consequences, are denoted by ** and 'tails', or external driving forces, denoted by *).*

3.2.3 Self-reinforcing feedback loops

There are a number of complex self-reinforcing feedback loops, or "vicious circles", which became increasingly evident during the mapping process, all of which involve poaching: Firstly, the *extension of the fishing season* could lead to *overexploitation of the Rock Lobster resource* (through more opportunity afforded to potential poaching) which could lead to a *decreased CPUE*, which could lead to *increased poaching*; secondly, a *decreased CPUE* could lead to increased *poaching*, which could lead to a further *decreased CPUE*; and lastly, a *decreased CPUE* could lead to *poaching*, which could lead to *overexploitation of the Rock Lobster resource*. Though these loops represent only one perception of the discussions that ensued during the ERA workshop, this is still very indicative of the intricacy of trying to manage a fishery whilst keeping the socio-economic aspect firmly in mind – any management decision taken will have knock-on effects on the Lüderitz community. Poaching will often be an issue with high value resources in many developing countries. Avenues towards solutions include an effective system of monitoring, control and surveillance (MCS), and consideration of alternative livelihoods. These "vicious circles" are at the heart of what needs to be addressed in the management of this fishery; workshop discussions concur that the sustainable utilisation of the resource is unattainable without keeping the human considerations in mind.

These discussions, and the subsequent causal map, resulted in expounding upon issues fundamental to the EAF process, namely the ecological wellbeing (increasing the average sizes of caught lobster and limited capture of undersized lobster), human wellbeing (from the community point of view; addressing the reduced contribution of the Rock Lobster fishery, and from the industry's point of view; addressing limited market options, user conflicts and the decreased CPUE) and governance issues (the discrepancy which exists between scientific advice and TAC, user conflicts between sectors etc.). Further discussion was however necessary to tease apart these issues. The one-on-one interview process proved exceedingly useful in this respect.

3.3 Factors affecting the Rock Lobster resource

Following these discussions, a smaller sub-set of the participants (interviewed post-ERA workshop) were asked to draw their own causal maps using the concepts agreed upon to encompass the main influences within the Rock Lobster fishery (see Appendix 3). Owing to the difference in experience and knowledge of the participants, the factors believed to be affecting the Rock Lobster fishery are very diverse. The causal maps are aggregated by stakeholder group (Figure 8).

Stakeholders agreed that different industries will inevitably impact upon each other and perception rather than fact plays an important role. Most stakeholders believed that the main impact on the Namibian Rock Lobster resource is diamond mining as the areas in which the mining takes place coincides with known lobster distribution. The effects of land based mining cannot be denied or refuted but Namdeb pointed out their regular independent studies monitoring fine tailings, beach accretion and impacts on macrofauna (fauna >5mm) (C. Gomez *pers. comm.*), in both mined and undisturbed areas (Elizabeth Bay and Grosse Bucht) as evidence for environmental consciousness even in mining operations. These monitoring reports, with recommendations for Namdeb's attention, are distributed upon request to interested parties. Despite this, there is no formal mechanism by which other stakeholders can comment on these reports or on the monitoring procedures undertaken by the consultants.

Scientists felt strongly that the rebuilding of the Rock Lobster stock should take precedence over maximum utilisation of the stock, which is also supported by the principles underpinning EAF (FAO 2003) and was agreed among all stakeholders. They felt that the current method of stock assessment (DeLury[2] 1947) is biased towards the fishing sector and needs to be improved through incorporating all known life history traits of the Rock Lobster into the assessment. The general opinion was that recreational fishing did not impact upon

---

[2] DeLury models for estimating population size rely on the fact that removing individuals from a population often has a noticeable effect on some observable index of abundance.The modified DeLury model is used to estimate fishable biomass for Namibian Rock Lobster. Input data for the model include the commercial catch and effort time series since 1971, natural mortality (estimate), catch selectivity and the number of new recruits (defined as the lobsters in the smallest size class, i.e. 65-69 mm CL) and full recruits (all lobsters above 69 mm CL) (Maletzky 2008).

the resource very heavily as diving for Rock Lobster is very dependent on conditions i.e. swell, sea water temperature. The need to understand the combined effect of the recreational and commercial fisheries was also identified. Scientists felt that the impact of the Rock Lobster fishery on non-retained species, such as cetaceans, seabirds and turtles, needs to be addressed.

Observers (a broad category used for the purposes of this thesis including fisheries inspectors as well as fisheries observers from the FOA) felt they are sometimes excluded from official channels of communication. They felt they don't receive feedback often enough on what the data they must collect is required for and therefore do not feel part of the process i.e. of managing the resource. They strongly felt that safety standards onboard vessels should be adhered to and that living conditions onboard vessels were unacceptably poor.

Overall poor communication (between scientists and the fishing industry; between management and scientists; between the mining industry and the fishing industry; between the FOA and MFMR) was highlighted by participants as one of the main issues for concern.

Most participants felt that overall improved marine environmental policy would decrease the overall negative effect on the Rock Lobster resource as the policy would set the guiding principles for the protection of the general ecosystem and outline regulations for both commercial and recreational fishing, as well as guidelines for mining operations.

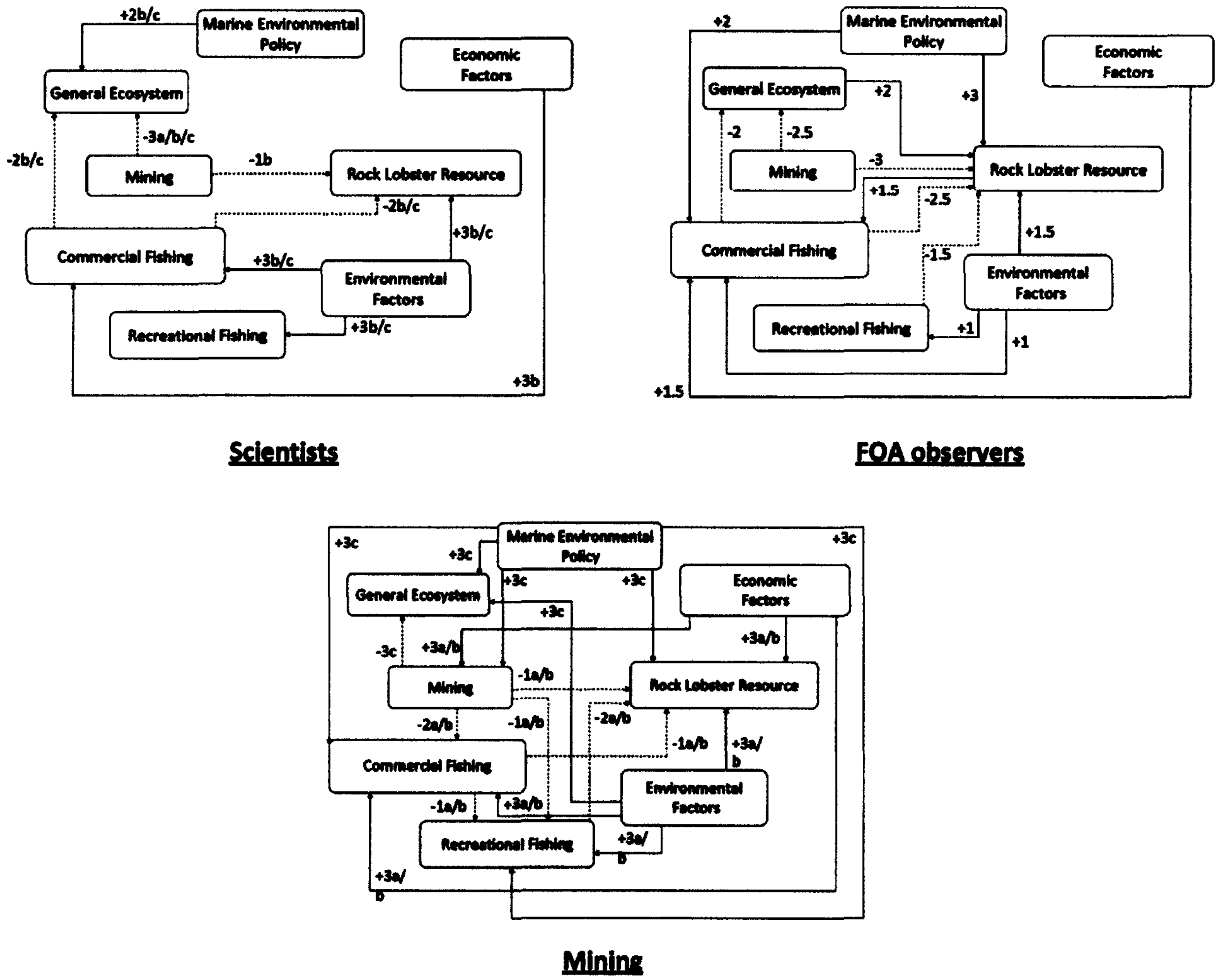


Figure 8: Average causal maps per stakeholder group (scientists, observers and mining representatives), showing the strengths (1: low, 2: medium, 3: high – shown by all stakeholder groups) and time-scales (a: short term, b: medium term, c: long term – shown by the mining and scientist groups) of the relationships between concepts

The general consensus amongst participants, however, was that the Rock Lobster resource is mainly influenced by mining, commercial fishing, environmental factors and recreational fishing (Figure 9) based on the average strength of relationships.

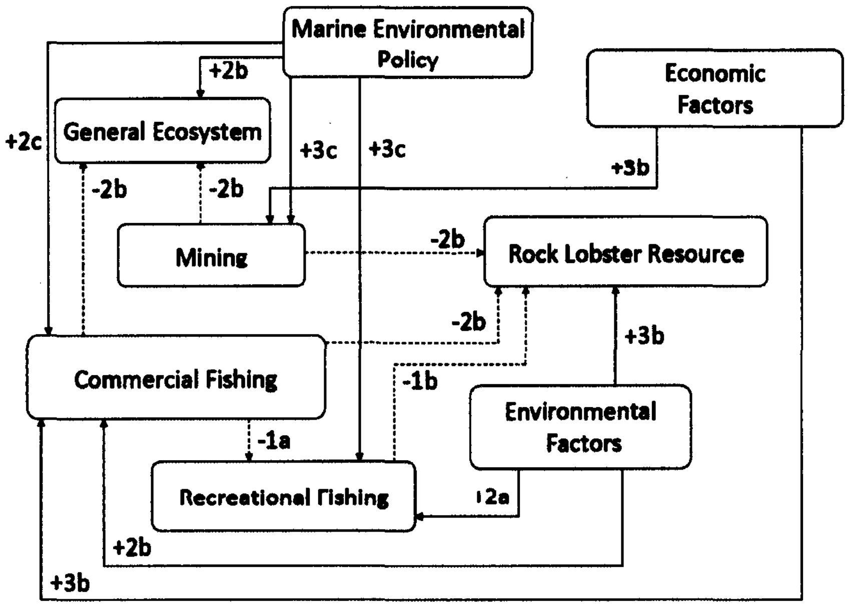


***Figure 9:** Combined causal map, averaged across stakeholder groups, showing the strengths (1: low, 2: medium, 3: high) and time-scales (a: short term, b: medium term, c: long term) of the relationships between concepts*

3.3.1 Mining

Most stakeholders perceive a negative impact of mining on the Rock Lobster resource directly through the accidental take of lobsters during mining operations and also possibly indirectly through noise (produced through mining operations) affecting the behaviour of the lobsters. The possible food web implications of removing Rock Lobster as both predator and prey were also noted in workshop discussions, but not identified by participants on their maps as it was felt that this impact is small in comparison to removal of lobster by the fishery. Some participants felt that mining did not affect the Rock Lobster resource directly, but instead influenced only the general environment by smothering Rock Lobster prey through sedimentation. The interaction between mining and the general environment was felt to be stronger than between mining and the resource itself in most cases. Mining activities are also thought to directly interfere with the migration patterns and distribution of the Rock Lobster (e.g. Pulfrich 2006) and indirectly through noise generated by mining operations.

The strength of and time scales on which the relationships act also differed greatly between stakeholder groups. Observers showed mining as having a weaker effect on the general ecosystem than on the resource itself, possibly because observers are more directly involved with fishing practices than either scientists or mining and therefore witness the effect of mining on the resource more directly. Scientists and mining perceived the effect of mining to be stronger directly on the general ecosystem than on the Rock Lobster resource, through degradation of habitat suitable for Rock Lobster settlement as discussed above.

3.3.2 Commercial fishing

Commercial fishing was noted by all participants as having a negative effect on the Rock Lobster resource. Poor fishing practices through the capture of undersized lobsters and of females-in-berry, as well as localised overfishing, was believed by most participants to negatively impact the Rock Lobster resource. Through improved stock assessment and understanding of the combined effect of the commercial and recreational fishery, it was generally felt that the use of the resource could be optimised.

The fishers themselves agreed that current fishing practices negatively impact on the resource and on the general ecosystem. They however thought it important to mention how strongly economic factors drive the industry through the lack of access to international market options because of the remote location and nature of Lüderitz. They also mentioned the conflict that exists within the commercial fishing industry itself through poor relations between skippers and their crew; crew complain of poor living conditions onboard vessels and skippers complain of crew striking as the Rock Lobster season starts, which in turn influences the profitability of the industry. Furthermore, the socio-economic knock-on effect due to the seasonality of employment within the industry (possibly leading to poaching to supplement either income or diet) was raised by participants as an influence on the commercial fishery.

There is a strong influence on commercial fishing through marine environmental policy, which was not indicated by all participants and thus does not appear as a strong relationship on the combined map. The influence of marine environmental policy on the fishing industry cannot be ignored and was raised in the workshop as a point of concern. Improved stock assessment and understanding the combined effect of the commercial and recreational fisheries is essential to rebuilding the stock. The current model used for stock assessment (DeLury 1947) is felt by scientists to be biased towards the fishing sector, as it only uses commercial fishing data and does not incorporate all necessary parameters needed to be representative of all components of the Rock Lobster fishery (J-P Roux *pers. comm.*). Management advice based on this incomplete model is thus weak and can lead to poor management decisions. The issue of stock assessment is expounded upon in Section 3.4 (and Appendix 4).

3.3.3 Environmental factors

Participants felt that environmental factors have a strong influence on the availability of the Rock Lobster resource for catching, through influencing conditions and catch rates for commercial and recreational fishers, and through determining the location and density of lobsters available for catching.

Studies undertaken by the MFMR have shown that high swell conditions can be a major contributor to poor catch rates (e.g. Grobler 2007) through preventing fishermen from hauling their traps and preventing lobsters from feeding (due to strong bottom surges), which can in turn negatively affect lobster growth. These effects on the lobster stock are, however, difficult to measure directly.

High bottom dissolved oxygen conditions can play a major role in the availability of lobsters to the fishing fleet, as high dissolved oxygen levels on the deeper seabed areas can enable lobster stock to remain on their winter grounds in deeper waters (K. Grobler *pers. comm.*). However, because the lobsters would not need to move inshore under conditions of high oxygen, they could be thinly distributed, and could result in a lower CPUE for the commercial fishery (Grobler 2007).

3.3.4 Recreational fishing

The effect of the recreational fishery on the Rock Lobster resource was felt by most participants to be much less than that of the commercial fishery but, due to its nature, it is very difficult to monitor and thus difficult to quantify. Poaching of Rock Lobster within the recreational fishery was also noted by all as negatively impacting on the resource.

Recreational fishing for Rock Lobster is permitted every day and most participants felt that environmental factors are the main influences on the recreational fishery. Participation in the recreational fishery is by permit only and lobsters must be caught by free diving. Thus, environmental conditions such as swell and the temperature of the water greatly influence the frequency and occurrence of diving for lobster.

3.3.5 Conflicting views

As would be expected, there were conflicting views between stakeholders about the main influences (both positive and negative) on the Rock Lobster fishery (Figure 8). Scientists felt the environment has the most positive effect on the Rock Lobster resource, whereas observers believed Marine Environmental Policy to have the most positive affect on the resource. Mining stakeholders agreed on both fronts that, in the short term, the environment would have the most positive effect on the resource, but that, in the long term, Marine Environmental Policy would have more of an influence. In terms of negative influences on the resource, scientists believe commercial fisheries devastate Rock Lobster populations more severely than any other concept, whereas observers maintained that mining has the most detrimental effect on the resource, overall. Mining stakeholders agreed but felt that commercial fishing has as much of a detrimental effect on the resource as mining does. Though there were conflicting views, the stakeholders showed willingness to set these aside in lieu of a more important goal i.e. rebuilding the Rock Lobster resource.

3.4 Value trees and indicators

Value trees compiled in consultation with stakeholders show the hierarchy of objectives under the overarching objectives of an EAF (ecological, human wellbeing, or socio-economic, and ability to achieve) (Figure 10a-c). Based on the performance reports and discussion from the ERA workshop and guided by the intensive post-ERA interviews and causal maps, the hierarchy was constructed through teasing apart the ERA discussions in such a way as to grasp onto what the perceived central theme and driving forces behind the status of the Rock Lobster fishery is. For example, the central theme from the causal map (Figure 7), the *'overexploitation of the Rock Lobster resource'*, was used to construct the two operational objectives under ecological wellbeing i.e. if the central concern is the overexploitation of the Rock Lobster stock, then, in answer to this, an overarching objective should be a sustainable Rock Lobster resource. The second overarching ecological objective, 'Minimise impacts on the ecosystem' will also contribute to a sustainable Rock Lobster resource when considering an EAF i.e. a healthy ecosystem supports a healthy resource. Equally, if a driving force is thought to be *'Lack of communication and transparency'* on all levels (Figure 7), an answer to this would be 'Good co-management' between industry and management, and 'Good management based on scientific advice', thus formulated into separate overarching objectives under 'ability to achieve'. Some suggested indicators linked to the 'branches' of increasingly specific operational objectives, as well as some specific objectives, are shown in dashed boxes as 'leaves'.

More emphasis is placed on the Ecological Wellbeing branch in this thesis, in line with its biological scope (Figure 10a). Thus, the following is meant only as an overview. More discussion and thought resulted in the detailed descriptions for this branch of suggested indicators, which are given in Appendix 4, for which indicator description guidelines provided by Halliday *et al.* (2001) were followed. The detail in Appendix 4 also includes suggestions of thresholds for most of these suggested indicators.

Indicators for the Human Wellbeing and Ability to Achieve, or Governance, aspects of the fishery were discussed in the workshop with stakeholders. There were not many specific objectives agreed upon due to time constraints. Thus, many 'indicators' shown in Figures

10b and 10c are, in fact, specific management objectives and most of these cannot at present be measured as they currently represent vague concepts rather than actual tangible indicators, and thus require much more thought. Formulation of these into specific indicators will rely specifically on expert scientific opinion. The end suite of indicators will need to include properties of the indicators and suggested reference (or boundary) points or at least reference directions. The context of these indicators as well as comments pertaining to the time series behind these is given in Appendix 5.

3.4.1 Ecological Wellbeing

Overarching objectives from the ERA workshop that were decided on by all stakeholders were disaggregated into more specific objectives through simply asking 'How?' e.g. 'a sustainable Rock Lobster resource' (a general objective) is attained *how;* through 'good productivity' and 'low mortality' of the resource (more specific objectives); 'Good productivity' of the resource is attained *how*; through a 'good habitat' (most specific objective). To suggest possible indicators, questions were asked regarding how the most specific objectives could be measured e.g. how can a 'good habitat' be measured? These were answered in terms of what influences the resource in terms of abundance, productivity and distribution i.e. 'sea surface temperature (SST)', 'dissolved oxygen (DO)', 'swell' and 'wind' (speed and direction), all of which influence the abundance and productivity of the resource, albeit indirectly. Following this example, the following specific objectives were decided on through consultation with stakeholders, and corresponding potential indicators derived, after which value trees were circulated to stakeholders for comments and/or critiques.

SUSTAINABLE ROCK LOBSTER RESOURCE

- *Good productivity: Good habitat*

Specific objective(s): Tracking favourable environmental conditions

Indicator(s): Composite indicator (still to be defined and tested), including sea surface temperature (SST), bottom dissolved oxygen (DO), wind and swell

The literature extensively documents how environmental conditions can influence the distribution and abundance of Rock Lobster (e.g. Beyers and Wilke 1990, Hazell *et al.* 2001, Pulfrich *et al.* 2006), thus the parameters discussed in these papers are the indicators decided upon here to measure good productivity. The biology and ecology of, and fishery for the Rock Lobster if strongly influenced by environmental factors, hence the choice of SST, wind, DO and swell. However, emphasis should again be made that many of these cannot be used as 'stand-alone' indicators and must be used in conjunction with each other to be useful in assessing the wellbeing of the resource.

Temperature has been identified as one of the primary factors influencing somatic growth rate in spiny lobster (Hazell *et al.* 2001) and is one of the environmental factors influencing the duration and frequency of recreational lobster dives. In some cases though, such as wind (direction and speed), no significant correlation to lobster abundance has been shown (Grobler and Noli-Peard 1997). However, wind is known to influence the advection of water; on days of northerly winds, inshore advection of warmer offshore surface water down-welled against the coast, resulting in increased bottom DO (Louw 2008). DO is known to directly influence the distribution of lobsters; Newman and Pollock (1971) found that *J. lalandii* tended to avoid water with dissolved oxygen below 2 ml/L. Grobler and Noli-Peard (1997) showed that lobsters were abundant at bottom DO concentrations of above 3ml/L.

- *Good productivity: Good food*

Specific objective(s): Favourable benthic community structure

Indicator(s): Still to be defined and tested; possibly densities of different mussel species

Mayfield *et al.* (2000) established that the growth rate of lobsters, which show strong dietary preferences, is related to the availability of preferred prey on the seabed (the main food choice for *Jasus lalandii* being ribbed (*Aulacomya ater*) and black (*Choromytilus meridionalis*) mussels). Thus, the benthic community structure, and particularly the density of mussels, is thought to be a suitable indication of 'good food'. (Benthic community in itself is however not an indicator, but a *group* of potential indicators. Indicators of benthic community structure could be ratios of different feeding guilds or species in terms of biomass or the relative contribution of different prey species for Rock Lobster, as examples.) Knowing the benthic community structure in lobster areas would also aid in understanding the trophic role of lobster in the food web, an issue, albeit of lesser importance, also raised in the ERA workshop (Basson 2008).

- *Low mortality: Low fishing mortality: Good assessment: Good data: Combined effect of recreational and commercial fishery understood:*

Specific objective(s): Combined catch of recreational and commercial fisheries is sustainable

Indicator(s): Still to be defined and tested, but suggested to be based on the following data categories:

(1) Recreational pressure (recreational data information)

(2) Potential contribution to the fishery (commercial data information)

(3) Extent of poaching (illegally harvested/poached lobsters

These suggested data categories should be further discussed and formalised through intensive stakeholder consultation beyond the scope of this thesis. It should be kept in mind though that the rating of these suggested indicator categories and subsequent indicators should relate to how accurately these data were collected and the trends in the results of each sub-component over time.

Potential indicators and boundary points for the recreational and commercial fisheries specifically are suggested and outlined below:

- *Low mortality: Low fishing mortality: Good assessment: Good data: Recreational fishery quantified:*

Specific objective(s): Size distribution in catch reflects size distribution of rock lobsters in nature (which can be caught legally)

Indicator(s): Size distribution of confiscated catch (i.e. poached); Catch by area and size distribution: Median & suitable percentile to represent central tendency and spread

Rock Lobsters are a high-value resource and the financial incentive to operate illegally is very great. In the recreational fishery, illegal activities comprise the occasional disregard of bag limits and selling of catch. Shannon *et al.* (2006) suggest using the size frequency of confiscated illegal catch as indicators in addressing the illegal catch i.e. poaching of Rock Lobster in South Africa, which can also be done for Namibia. Currently, there is paucity in data available for the Namibian recreational fishery that needs to be addressed. Cockcroft and Mackenzie (1997) demonstrated that permit sales and estimates of total recreational catch (based on these sales and the average number of lobsters caught per permit holder over these seasons) could be ascertained through using telephone interviews of permit holders over the 1991/92 to 1994/94 fishing seasons. This information could also be collected in Namibia and would be relevant in understanding the distribution of catch within the recreational fishery. Attaining this indicator will however require collaboration between the research and inspectorate sectors.

- *Low mortality: Low fishing mortality: Good assessment: Good data: Commercial fishery quantified:*

Specific objective(s): Reduction in fraction of juveniles in confiscated catch i.e. poached lobsters; Size distribution in catch reflects size distribution of rock lobsters in nature (which can be caught legally)

Indicator(s): Fraction of juveniles in confiscated catch by area; Catch by area and size distribution: Median & suitable percentile to represent central tendency and spread

Current regulations for the commercial fishery include a minimum size limit of 65mm CL (based on the length of sexual maturity) and a mesh size limit for commercial traps of 65mm, with some vessels using 70mm mesh size. In this fishery, because there is not 100% observer coverage, the prevalence of poaching is very difficult to quantify. Together with suggestions made by Shannon *et al.* (2006) for quantifying poaching (i.e. using the size frequency of confiscated illegal catch as indicators in addressing the illegal catch of Rock Lobster in South Africa), socio-economic studies would also aid in understanding the incentives for poaching and to assess the economic forces possibly driving the larger-scale commercial illegal catching. The distribution of catches for each fishing ground gives a good indication of where the most effort has been placed amongst all fishing grounds while the average length of unsorted Rock Lobster i.e. including undersized lobster, gives a good indication of the status of the stock.

- *Low mortality: Low fishing mortality: Good assessment: Good data: Good model:*

Specific objective (s): High quality stock assessment model

Indicator(s): Categorical classification of the quality of the stock assessment model

Input data for the current model (DeLury) are commercial catch and effort since 1971, estimates of natural mortality, catch selectivity, and number of new recruits (65-69mm carapace length, or CL) and fully grown recruits (>69mm CL). Fisheries Independent Monitoring Surveys (FIMS) used to be undertaken but these only monitored the commercial fishing grounds and should incorporate data regarding the whole coastline). Because of a lack of research capacity and funding, it was discontinued (C. Grobler *pers. comm.*). The current model is felt to be very biased towards the fishing sector as it uses only commercial fishing data (J-P Roux *pers. comm.*). Workshop participants felt that current stock assessment can be improved by incorporating additional data, such as environmental factors e.g. wind, SST, DO and swell, as well as recruitment, growth and distribution data etc. The stock assessment should use data from fisheries research, observer logbooks as well as industry logbooks. Suggested covariates for the model are suggested here (Appendix 4) but these would still need to be reworked to be combined appropriately.

- *Low mortality: Low fishing mortality: Low exploitation rate:*

Specific objective(s): Low interannual variability in commercial catch per unit effort (CPUE)

Indicator(s): Interannual differences in CPUE

The declining CPUE for the fishery (Maletzky 2008) is cause for concern regarding the state of the resource and industry wellbeing. The natural predation on a healthy resource, one with a favourable environment for growth and good productivity and enough good prey items, combined with the fishing pressure should not have a negative impact on the stock. Thus, a stable CPUE, a CPUE with low interannual variability, would be beneficial to both resource and fishery.

- *Low mortality: Low fishing mortality: Good fishing practice:*

Specific objective(s): Reduction in the fraction of undersized specimens in commercial catch; Good compliance with seasonal closure for Female Rock Lobsters-in-berry in the catch

Indicator(s): <u>% undersized specimens in commercial catch; % compliance with seasonal closure for Female Rock Lobsters-in-berry in commercial catch</u>

Poor boat-based sorting techniques are thought to negatively impact on the resource, in particular females-in-berry. Lobster caught in traps are more prone to the loss of appendages which Melville-Smith and de Lestang (2007) showed can be associated with the reduced probability of females (of the Australian west coast rock lobster *Panulirus cygnus*) developing ovigerous setae. If fewer females consequently produce setae, there will most likely be a reduced probability that these females would produce more than one batch of eggs within a season. Contact with gear and handling by fishers also increases the chances of appendage loss (Brouwer *et al.* 2006). Surviving lobsters typically can and do regenerate lost limbs, but at a long-term functional cost, such as reduced foraging efficiency, mating success, and increased vulnerability to predation (Juanes and Smith 1995). The suggested indicator 'Good compliance with seasonal closure for Female Rock Lobsters-in-berry in the catch' may not be a direct indicator of ecological wellbeing. However, it has been included here as it would be indicative of good fishing practise, which is integral to 'low fishing mortality'. If so decided through stakeholder consultation, this indicator could be more suited to the 'ability to achieve' branch and ultimately moved under that branch.

- *Low mortality: Low mining mortality:*

Specific objective(s): Low direct and indirect mortality of Rock Lobsters through mining-related activities i.e. mining effects on Rock Lobster quantified

Indicator(s): <u>To be identified, defined and tested</u>

Declining Rock Lobster catches after 1980 and the associated development of coastal and marine diamond mining has resulted in concern about the sustainability of the stocks and suspicions that marine mining must at least be partially responsible for these declines. To quantify the effects of mining on the lobster stock is however a large and dire task and the obvious weakness of this suggested category is exacerbated by the severe lack of knowledge needed to propose possible indicators for the impacts of mining on the resource. Scientific studies were undertaken regarding possible impacts of mining Rock Lobster but these studies are seen as biased by stakeholders as the consultants are paid by companies operating within the mining sector. Information regarding the effect of diamond mining on the resource is very limited and thus much more discussion and collaboration with stakeholders will be necessary to reach consensus on indicators for this objective.

- *Low mortality: Level of natural predation (i.e. direct predation of Rock Lobster):*

Specific objective(s): Healthy predator populations e.g. bank cormorant

Indicator(s): The IUCN status of the bank cormorant (*Phalacrocorax neglectus*) populations

The bank cormorant is classified as endangered (IUCN 2008) and is endemic to both Namibia and South Africa. They feed inshore where their main prey items include pelagic Goby and Rock Lobster (Kemper *et al.* 2007). According to the final report of the BCLME project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME, the main threats to the bank cormorant population includes a lack of prey items, such as Rock Lobster. Crawford *et al.* (2008) found that the reduction of bank cormorants in the north of the Western Cape and increases in the south are consistent with recent changes in the production and distribution in the province of Rock Lobster. In an ecosystems approach to fisheries management, there needs to be a balance reached between the human induced impact on the resource and the natural predators of the resource. The IUCN status, which is a summary of expert understanding of bird populations dependent on the lobster stock, gives an indication of whether this balance has been reached. If there are good data available on trends in the Namibian bank cormorant population, this would ultimately be the best supplementation for this indicator.

MINIMISE IMPACTS ON THE ECOSYSTEM

- *Minimise impacts on non-retained species: Minimal gear entanglement:*

Specific objective(s): Reduction in the number of incidences of vulnerable species entanglement reported and recorded

Indicator(s): Number of incidences of vulnerable species entanglement reported and recorded

The Rock Lobster fishery does incur detrimental effects upon the general ecosystem. This includes damage to benthic community structure and entanglement of vulnerable species (such as seabirds, sea turtles, cetaceans and seals) in gear and bait box strapping. There are also incidences of bycatch (of small demersal sharks, crabs and klipfish). There is a need for spatially referenced baseline information. Observer forms can and should be expanded upon to include information about entanglements.

- *Minimise impacts on non-retained species: Minimal ghost fishing:*

Specific objective(s): Reduction in the number of Rock Lobster traps lost; Decreased discrepancy between numbers of traps lost and those recovered

Indicator(s): Interannual differences in numbers of Rock Lobster traps lost

In recent times, there have been some changes in fishing practices that have resulted in fishermen no longer tending their lobster traps, which leaves them vulnerable to storm conditions. Concern was raised in the workshop about the potential for ghost fishing with these discarded traps when swell increases and traps roll around on the benthos, sometimes fatally trapping animals. Each vessel should have a tracking system for their gear. There should be penalties and/or fines for gear loss, to be enforced by the Inspectorate, which would minimise the potential impact on non-retained species.

➢ *Minimise impacts on non-retained species: No negative impact of using gurnard as bait:*

Specific objective(s): Decreased catch of gurnard, Good compliance with regulations in gurnard bait fishery

Indicator(s): Catch size and size distribution of gurnard (Median & suitable percentile to represent central tendency and spread)

Currently, there is no baseline data regarding gurnard stocks and nothing is known about the biology of the species. Fishing for gurnard *Chelidonichthys capensis* as bait for the Rock Lobster fishery is experimental for this season and will be re-evaluated after the season. If the gurnard fishery becomes established, regulations will need to be set up and enforced. The catch distribution and quantity of gurnard would give a good indicator of the abundance and productivity of the gurnard resource, as well whether regulations within the fishery are being adhered to.

➢ *Minimise damage to lobster habitat: Low pollution:*

Specific objective(s): Effective penalties in place for vessels leaking oil through and operational Oil Spill Contingency Plan (OSCP); Decrease in the amount of litter reported upon docking; Good compliance with marine protected area (MPA)

Indicator(s): Interannual differences in the number of pollution-related penalties through the OSCP; database of litter (per vessel) recorded upon docking; Record of VMS plots of Rock Lobster fishing trips

Oil leaked from Rock Lobster fishing vessels during fishing operations can have far reaching consequences on the wider ecosystem through e.g. damaging reef habitats or immobilising vulnerable species. A Namibian oil spill contingency plan (OSCP) already exists but is outdated. It should be updated and should stipulate that waste incurred through fishing operations (besides offal) must be brought back to harbour in order for the vessel to be cleared for the next trip. Furthermore, according to the Namibian Marine Resources Act of 2000 (MFMR 2000), it is illegal to leave or dump any gear at sea. Skippers report of bait box strapping tossed overboard during fishing operations, which could lead to the entanglement of vulnerable species. Keeping a record of what vessels take onboard for trips and what they bring back will give a good indication of the pollution contribution of each vessel. This should be mandatory for vessels to be cleared for their next trips. Namibia's coastline provides important retention areas and nursery grounds for juvenile and larval stages of Rock Lobster. Because lobsters are slow-growing and have low natural mortality, they are very susceptible to overfishing and need to be managed carefully. Namibia's first MPA was recently declared at the end of 2008 (H. Currie *pers. comm.*) and covers many important lobster areas (Currie and Grobler 2007). A record of the VMA plots for each vessel would show compliance with this MPA. All these indicators combined would decrease the pollution contribution by the fishery.

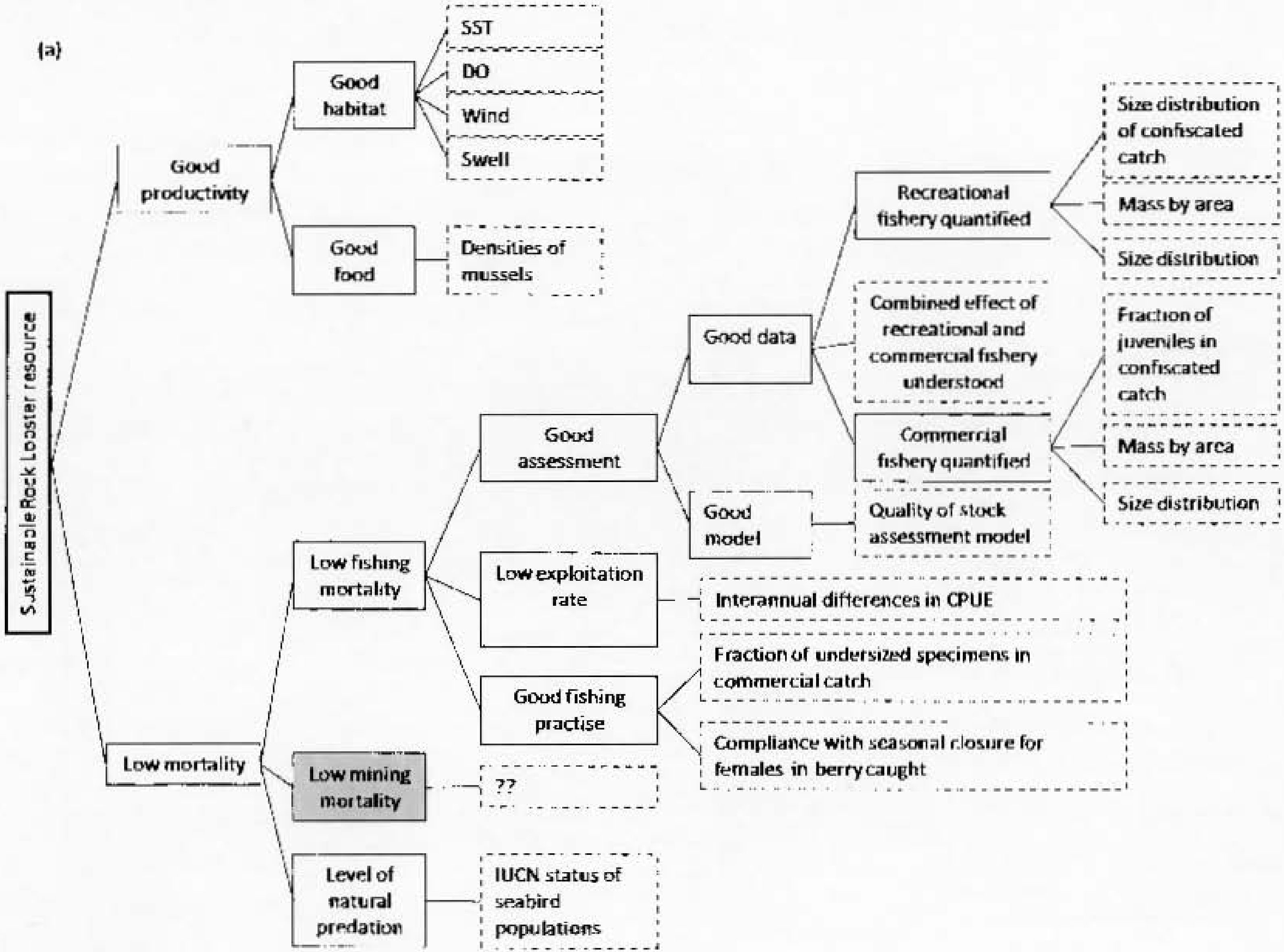
- *Minimise damage to lobster habitat: Low mining impact:*

Specific objective(s): Mining effects on ecosystem known; High percentage recommendations adhered to

Indicator(s): <u>To be identified, defined and tested; possibly % recommendations adhered to</u>

If recommendations put forward by the independent consultants for the mining sectors information are not followed up on, the impacts of mining cannot be mitigated for. The weakness of this suggested category is exacerbated through the severe lack of knowledge needed to propose possible indicators for impacts of mining on the general ecosystem and thus understanding the impacts of mining on the wider ecosystem should be an overarching research objective. The specific indicators for understanding these impacts however will require much more discussion.

(a)


Sustainable Rock Lobster resource
Good productivity
Good habitat
SST
DO
Wind
Swell
Good food
Densities of mussels
Low mortality
Low fishing mortality
Good assessment
Good data
Recreational fishery quantified
Size distribution of confiscated catch
Mass by area
Size distribution
Combined effect of recreational and commercial fishery understood
Commercial fishery quantified
Fraction of juveniles in confiscated catch
Mass by area
Size distribution
Good model
Quality of stock assessment model
Low exploitation rate
Interannual differences in CPUE
Good fishing practise
Fraction of undersized specimens in commercial catch
Compliance with seasonal closure for females in berry caught
Low mining mortality
??
Level of natural predation
IUCN status of seabird populations

(a cont'd)

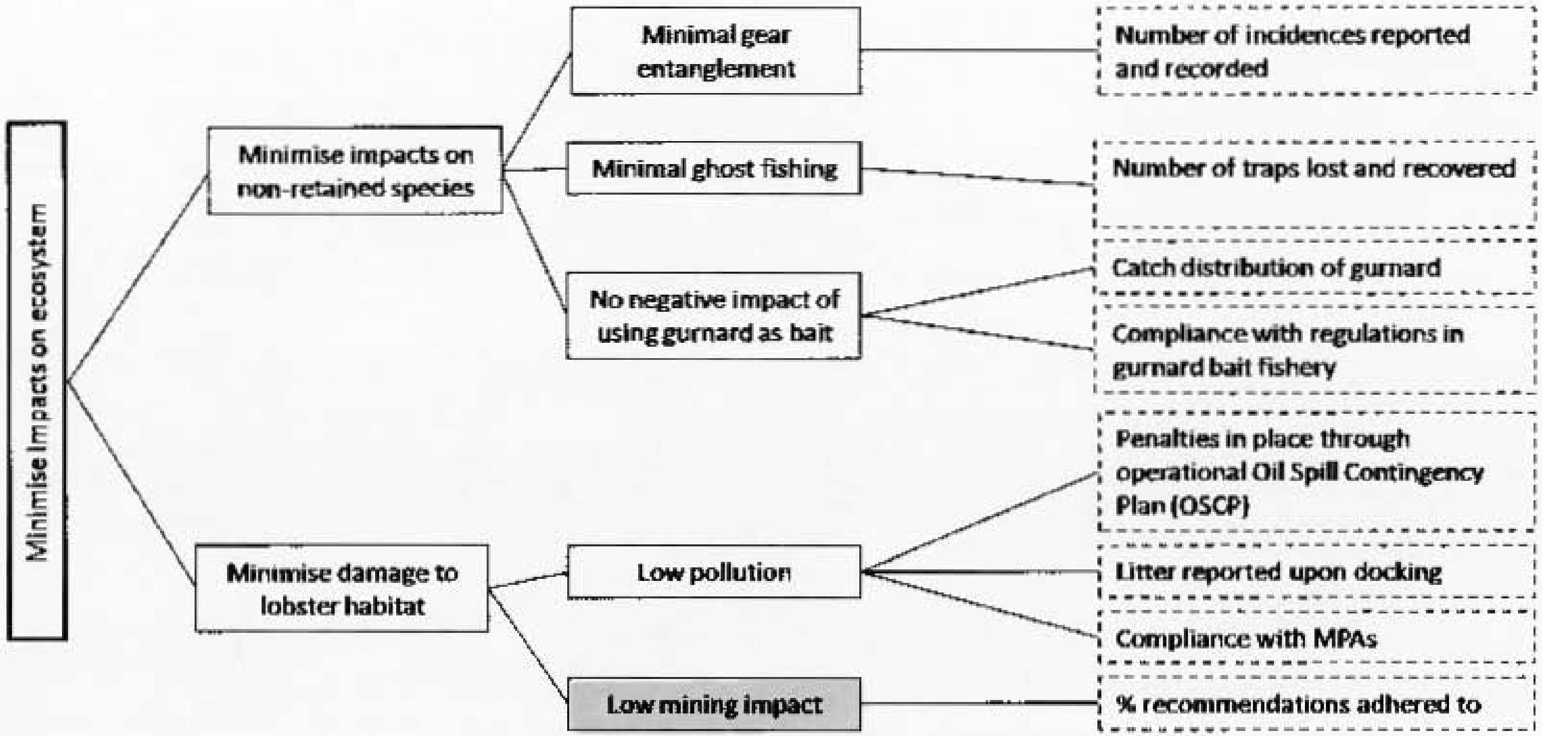


***Figure 10a:** The ecological wellbeing 'branch' of an EAF to the Namibian Rock Lobster fishery, showing specific objectives and selected suggested indicators in dashed boxes. The objectives regarding mining in both instances are shaded to highlight the severe lack of knowledge needed to propose possible indicators for impacts of mining, on both the resource and the general ecosystem. The objectives and accompanying suggested indicators shown in this diagram are described in detail in Appendix 4.*

3.4.2 Human Wellbeing

The objectives and indicators discussed with stakeholders included the following:

MAXIMISE ECONOMIC SUSTAINABILITY (Figure 10b)

- *Fees (observer and port fees) for participation in the Rock Lobster fishery*:

Specific objective(s): Good industry perception of observers; transparent audit of observer fees

Indicator(s): To be identified

Fishers feel the financial burden placed on them through observer and port fees is very great. They feel they are paying for a service that observers are not delivering, and observers feel that the living conditions onboard the vessel are sub-standard. The perception of the observers by the industry is indicative of the level of communication and cooperation that exists between these two stakeholder groups.

- *Individual rights are economically viable*:

Specific objective(s): High percentage of quotas filled; viable rightsholders conditions

Indicator(s): To be identified; possibly interannual differences in TAC filled

Presently, the fishery is dominated by small quota holders, which is seen by stakeholders as a problem due to poor fishing. The TAC has not been reached since 2001 i.e. quotas have not been filled, which may be an indication of individual rights no longer being viable. Viability in this case refers to financial viability; the size of the allocation of the individual rights and the economics of landing that allocation (CPUE, distance steamed and market prices etc.) are all very important and need to be kept in mind (leading to the intricacy of the present situation evident in Figure 7).

- *Long-term company profitability and sustainability*:

Specific objective(s): High employment rates for fishers; Good standard of living onboard the vessels; Good relations between employer and employee; High access to foreign markets

Indicator(s): To be identified

Not much value addition currently takes place in the Namibian Rock Lobster industry. According to rightsholders, Namibia's small TAC makes it difficult to produce certain value added products as it would require significant amounts of lobster to make enough products to penetrate global markets. Furthermore, access to foreign markets is limited due to the remote location of Lüderitz.

MAXIMISE SOCIO-ECONOMIC BENEFITS

- *Employment rates within Lüderitz community*:

Specific objective(s): High number of jobs within the fishery; gender ratio in employment; moderate to high standard of living with the community

Indicator(s): To be identified; possibly interannual differences in employment numbers and gender comprisal of Rock Lobster sector employment

As the CPUE has decreased over the last few years, the proportional contribution of the lobster fishery to the local economy has also decreased. For the fishing sector to provide secure employment of a high quality, there needs to be good understanding of the socio-economic drivers within the Rock Lobster fishery.

- *Forum available for communication between government entities and public*:

Specific objective(s): Good ministerial representation at meetings; number and good attendance of meetings

Indicator(s): To be identified

Communication needs to be facilitated and information transmitted between MFMR and the fishing industry through pre-season briefings and explanations of regulations. Collaboration between line ministries is needed to mitigate for potential socio-economic challenges. The number and attendance of meetings held by the forum will reflect the level of communication.

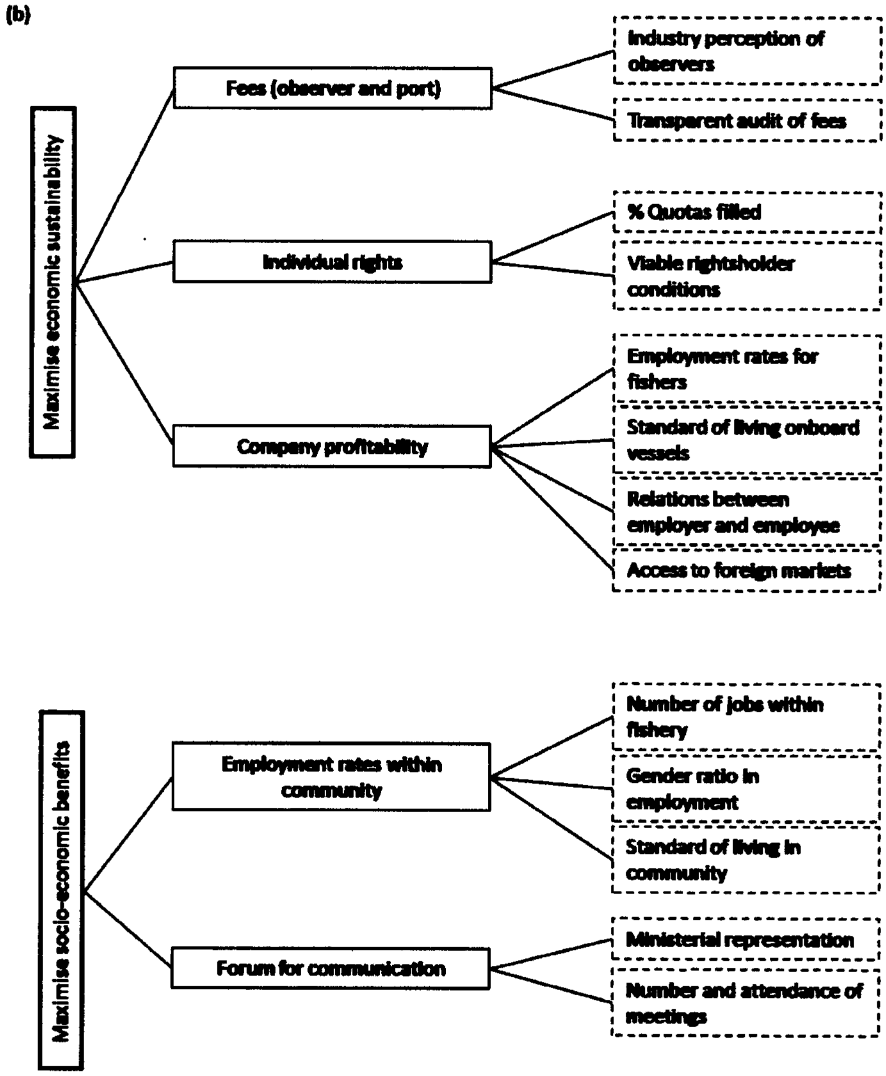


Figure 10b: *The human wellbeing 'branch' of an EAF to the Namibian Rock Lobster fishery, showing specific objectives in dashed boxes*

3.4.3 Ability to Achieve (Governance)

GOOD RESEARCH CAPACITY (Figure 10c)

- *Good staff employed to undertake research*:

Specific objective(s): 100% of the posts are filled; good career advancement opportunities exist; high percentage of time allocated to research; high number of peer reviewed articles

Indicator(s): To be identified; possibly % posts filled, % time allocated to research as evident from job evaluations; interannual differences in the number of peer reviewed articles

Limited scientific capacity, resources and technical skill is seen as a source of major concern. The MFMR experiences very high staff turnover, which results in the loss of expertise and knowledge from the Ministry. The basis for a good management plan is comprehensive and based on thorough research, which should be a top priority for the MFMR in terms of time allocated for research. Career paths need to be enhanced for scientists to retain expertise with the Ministry, for which job evaluation processes need to be in place.

- *Funding*:

Specific objective(s): Fixed annual percentage MFMR budget allocated for research; funding available for travel

Indicator(s): To be identified; possibly interannual differences in % MFMR budget allocated for research and travelling

Often no funding is available through the ministry for work-related travelling, which is essential when undertaking collaborative research. A percentage of the MFMR budget should be set aside for research and research-related travel and expenses.

- *Collaborative research within MFMR, between Namibia and South Africa, and further abroad*:

Specific objective(s): Annual project reports; high number of peer reviewed articles

Indicator(s): To be identified; possibly interannual differences in the number of peer reviewed articles and project reports

Namibia may share Rock Lobster larval pool with South Africa. In light of this (and possible other links in research), collaboration between the two countries (and further abroad) is a necessity for the management of the stock.

GOOD MANAGEMENT BASED ON SCIENTIFIC ADVICE

- *Incentives exist for industry compliance*:

Specific objective(s): Island staff made honorary inspectors; increased Admission of Guilt (AoG) fee; decreased number of convictions

Indicator(s): <u>To be identified; possibly interannual differences in the number of convictions; number of honorary inspectors on islands</u>

The lack of capacity within the inspectorate results in very few convictions. However, even in the event of a trespasser, participants felt the Admission of Guilt (AoG) fee is not high enough to act as a deterrent. Furthermore, the need to instate island-based staff as honorary fisheries inspectors to curb poaching on the sanctuary at Ichaboe Island is necessary.

- *A Functional Fisheries Management Council (FMC)*:

Specific objective(s): Monthly meetings of the FMC; FMC attendance highly representative of affected parties

Indicator(s): <u>To be identified, defined and tested; possibly interannual differences in frequency of meetings; attendance records of meetings</u>

Often members of the FMC (Fisheries Management Council) are not available for meetings regarding matters pertaining to the management of all Namibian fisheries, which are then indefinitely postponed. Crucial decisions are often delayed for months as a result of the FMC not meeting.

- *Good communication channels exist between Lüderitz research staff and the Windhoek management staff*:

Specific objective(s): High efficiency of decision-making process; decreased number of industry complaints regarding delayed management decisions; low discrepancy between TAC and scientific recommendations

Indicator(s): To be identified, defined and tested; possibly interannual record of difference between allocated and scientifically recommended TAC

A need was identified (because of delayed response times from the decision-maker) for the decentralisation of decision-making power from MFMR Head Office (in Windhoek) to Lüderitz staff (LMR). Scientists feel that their advice on TAC recommendations is not taken into account as there is often a large discrepancy between the advised TAC and the allocated TAC.

GOOD CO-MANAGEMENT

- *Functional Working Groups for the dissemination of information between stakeholders groups and other interested and affected parties*:

Specific objective(s): Regular meetings of a Functional Rock Lobster Association, a functional Lüderitz forum, a functional Ecosystems Working Group, and attendance of all these working groups is well represented by all interested and affected parties

Indicator(s): To be identified, defined and tested; possibly interannual differences in frequency of meetings; attendance records of meetings

Overall poor communication (between scientists and the fishing industry; between South African scientists and Namibian scientists; between management and scientists; between the mining industry and the fishing industry; between the FOA and MFMR) was highlighted by participants as the main issue for concern. Participants agreed that different forums are needed consisting of different stakeholder groups depending on the mandate of the forum. These are detailed in Appendix 5.

- *The degree of self-regulation of the Working Groups:*

Specific objectives: Sufficient meetings, good attendance

Indicator(s): To be identified, defined and tested; possibly interannual differences in frequency of meetings; attendance records of meetings

In order for these Working Groups to be effective and the communication to remain transparent, they will need to sustain themselves through regular meetings and high attendance rates. The number of meetings of the different forums and their attendance rates will give a good estimation of the level of communication within the Rock Lobster fishery stakeholders and between interested and affected parties.

- *Good channels of communication exist between and within Working Groups*:

Specific objectives: Good circulation of reports; good perception of transparency by industry

Indicator(s): To be identified, defined and tested

It is as important that communication channels are open between the Working Groups as within the Groups themselves. Reports (progress, monitoring, survey, general) need to be disseminated between Groups promptly and not only on request. Industry members' perception of decision-makers is a good indication of how transparent the decision-making process is. Management of the Rock Lobster fishery needs to be a consultative process.

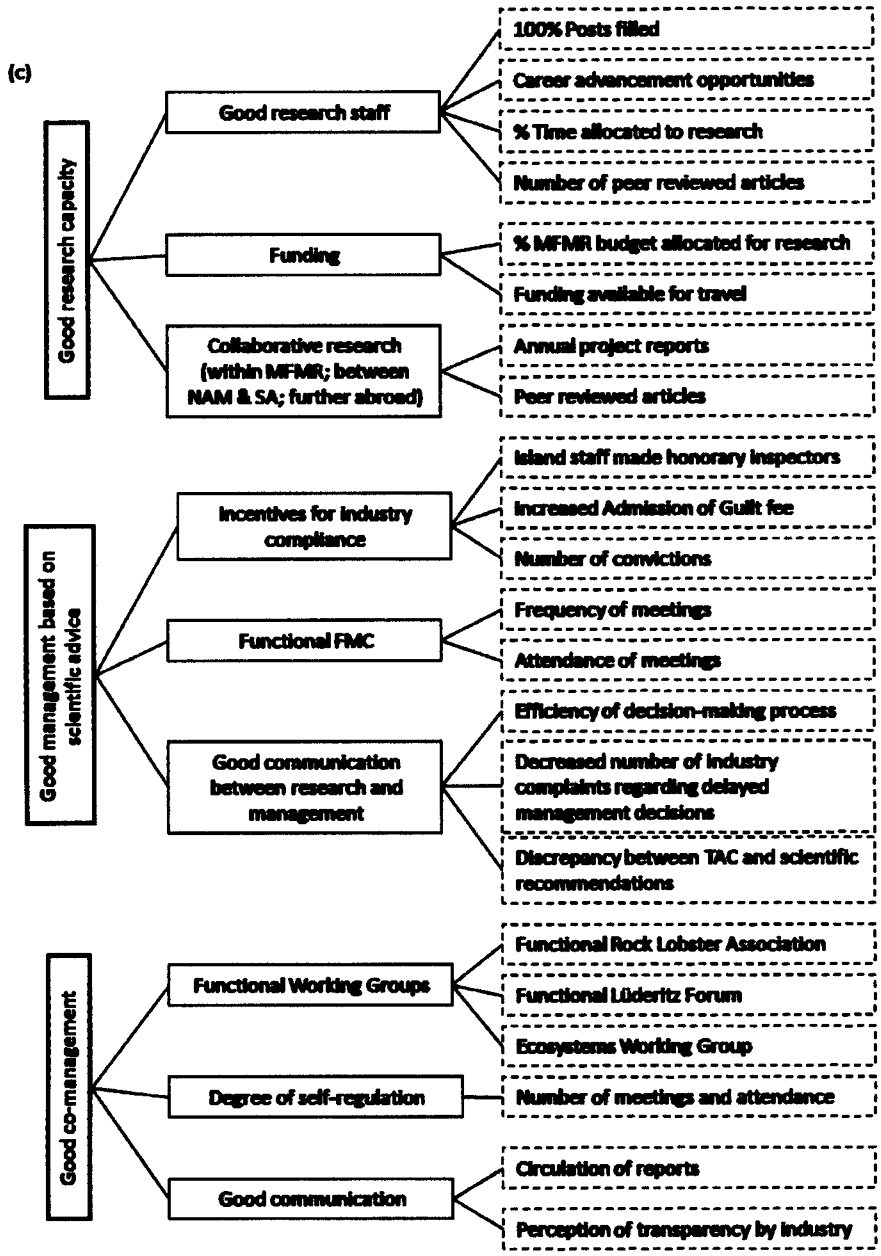


Figure 10c: *The ability to achieve, or governance, 'branch' of an EAF to the Namibian Rock Lobster fisher, showing specific objectives in dashed boxes*

3.5 Time series for selected ecological indicators

Time series for selected suggested ecological indicators are presented here to illustrate the process needed to generate useful indicators. A summary of all the specific objectives and suggested indicators (which are detailed in Appendix 4) is given in Table 2, showing what data are available for each specific indicator. Regular and dedicated monitoring surveys of Namibia's marine ecosystem e.g. environmental variability and the commercial fisheries started shortly after Namibia's independence from South Africa in 1990. Thus, most data series described here are available from this date. Most data regarding the fishery are housed at the Lüderitz Marine Research (LMR) centre on a central database. Data pertaining to the fishery (in terms of catch per unit effort, catch per area, and distribution) as well as environmental data are available since 1990. Other data, such as benthic community structure and data regarding the impacts of mining, are only available more recently, as the research gap was identified and projects put in place to bridge these gaps.

Examples of indicator data series for the ecological wellbeing of the Namibian Rock Lobster fishery are shown in Figures 11 – 14. The data series are taken from the Ministry of Fisheries and Marine Resources' TAC report (Maletzky 2008) and pertain to the 2007/2008 fishing season, which ran from November 2007 and was extended to May 2008 (although the season usually closes in April). This aligning of the indicator data series presented here with the 2007/2008 fishing season is done solely for the purposes of this thesis. Ideally, the time scale for indicators should correspond with the TAC, i.e. on a yearly basis, as this would aid with decision-making regarding the following year's TAC allocation. For example, if the indicator for 'low exploitation rate' is showing a lower CPUE than the previous year, management decisions regarding the following year's TAC can compensate for this, and so on.

Sea surface temperature (SST), wind, dissolved oxygen content (DO), swell and catch by area are shown here as suggested indicators for the ecological wellbeing of the Namibian Rock Lobster fishery. In essence, the biology and ecology of, and fishery for the Rock Lobster is strongly influenced by environmental factors, hence the choice of SST, wind, DO and swell. However, emphasis should again be made that many of these cannot be used as 'stand-alone' indicators and must be used in conjunction with each other to be useful in assessing the wellbeing of the resource. This work represents the first phase of a multi-phase process to establish stakeholder-accepted and useful indicators, and accompanying reference points; the next step would be to identify whether these indicators need to be combined and, if this is the case, to identify a way of merging these into combined indicator(s) affecting the Rock Lobster wellbeing/ecological wellbeing, and essentially moving towards an EAF. This will require much further dedicated research, which is beyond the scope of this current thesis.

Additionally, boundary points/threshold values (detailed for ecological indicators in Appendix 4) are meant merely as a starting point for further discussions and stakeholder deliberations. These suggested boundary points are not to be mistaken for the ultimate result of the process initiated by this thesis, but should rather be regarded as an integral part of the "learning by doing" (e.g. Marawski 2007) process stated earlier.

Table 2: Summary of detailed indicators (described in Appendix 4) of the operational objectives within the Ecological Wellbeing 'branch' of EAF showing the accompanying suggested indicator, whether a data series exists for the indicator and the status of the data which is needed to produce the indicator. Data collection and monitoring started in Namibia in earnest after Independence (1990); hence most monitoring data are available since then.

(a) ECOLOGICAL WELLBEING: Sustainable Rock Lobster resource

Objective	Suggested indicator s or indicator components	Indicator data series exists	Good data exist in a central database	Good data exist but not in a central database	Some data exist	No data exist
Good habitat	Sea surface temperature (SST)	√	X (1990 – present)			
	Bottom dissolved oxygen (DO)	√	X (1990 – present)			
	Wind speed	√	X (1990 – present)			
	Swell conditions	√	X (1990 – present)			
Good food	Densities of different mussel species			X (1993 – present)		
Recreational fishery quantified	Size distribution of confiscated catch					X
	Catch by area					X
	Size distribution					X
Commercial fishery quantified	Fraction of juveniles in confiscated catch by area				X (1990 – present)	
	Catch by area	√	X (1990 – present)			
	Size distribution	√	X (1990 – present)			
Good model	Categorical classification of the quality of the stock assessment model	√	X (1990 – present)			
Low exploitation rate	Interannual differences in CPUE	√	X (1990 – present)			
Good fishing practice	% undersized specimens in commercial catch	√	X (1990 – present)			
	% compliance with seasonal closure for Female Rock Lobsters-in-berry in commercial catch	√	X (1990 – present)			
Low mining mortality	*To be identified and tested*			X (1990 – present)		
Low predation	The IUCN status of the bank cormorant populations	√	X (1990 – present)			

(b) ECOLOGICAL WELLBEING: Minimise impacts on Ecosystem

Objective	Suggested indicator or indicator components	Indicator data series exists	Good data exist in a central database	Good data exist but not in a central database	Some data exist	No data exist
Minimal gear entanglements	Number of incidences of vulnerable species entanglement reported and recorded				X (1990 – present)	
Minimise ghost fishing	Interannual differences in numbers of Rock Lobster traps lost				X (1990 – present)	
No negative impact of using gurnard as bait	Catch size and size distribution of gurnard	√			X (2008)	
Low pollution	Interannual differences in the numbers of pollution-related penalties through the OSCP	√	X (OSCP launched in 2007)			
	Database of litter (per vessel) recorded upon docking					X
	Record of VMS plots of Rock Lobster fishing trips				X (2007/8)	
Low mining impact	% recommendations adhered to				X (1990 – present)	

3.5.1 *Sea surface temperatures (SST) and wind*

Figure 11 summarises daily SST at Lüderitz and the daily average South-North wind speed components at Ichaboe Island during the 2007/2008 commercial Rock Lobster fishing season. A detailed description of this suggested indicator component and associated possible boundary points are given in Appendix 4.

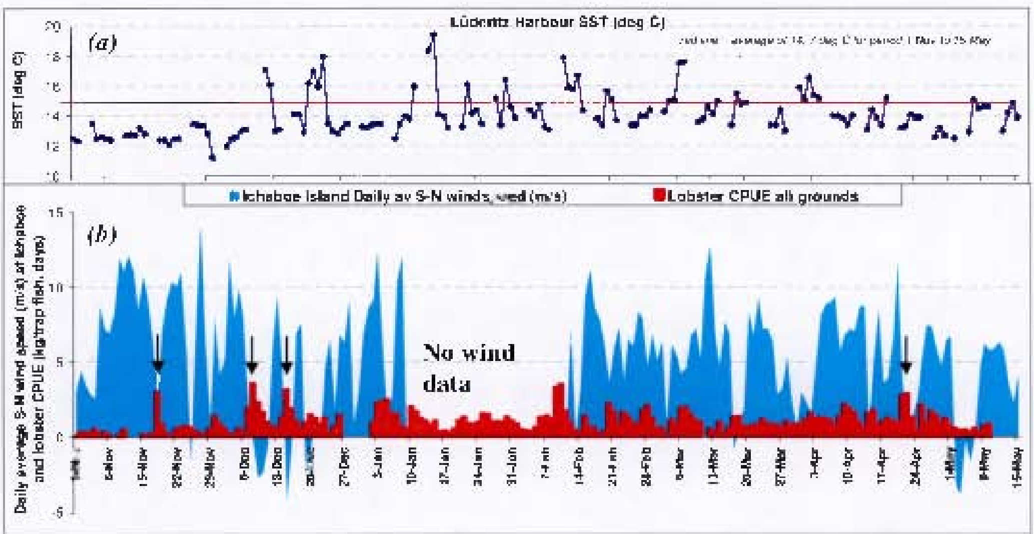


Figure 11: ***(a)*** *Daily SST (°C) for November 2007 to 15 May 2008 measured at Lüderitz harbour. The red line shows the average of 14.7°C for this period.* ***(b)*** *Daily average S-N wind speed (m/s) components at Ichaboe Island, with Southerly winds positive, and Northerly winds negative. Also shown is the daily lobster CPUE (for all grounds combined). Arrows indicate the days when no wind data were available.*

As mentioned before, temperature has been identified as one of the primary factors influencing somatic growth rate in spiny lobster (Hazell *et al.* 2001) and SST is known to influence Rock Lobster distribution and abundance (Grobler and Noli-Peard 1997). SST values were generally below or around 14°C except for short periods of time, mainly during December 2007 to March 2008. Periods of warmer SST values coincided with periods of calm wind conditions. Calmer conditions, i.e. low wind speed, are conducive to primary production (i.e. plankton blooms). On days of Northerly winds inshore advection of warmer offshore surface water occurs, which is then down-welled against the coast, which would cause an increase in bottom dissolved oxygen and hence good conditions for Rock Lobster.

3.5.2 *Dissolved oxygen (DO)*

Bottom concentrations of dissolved oxygen (DO) have been shown to affect Rock Lobster distribution, availability and abundance (Beyers and Wilke 1990). Results of DO sampled at local Rock Lobster reefs showed high DO levels at shallow depths (<6m) but low oxygen levels (<2 ml/L), below which lobsters tend to move out of the area (K. Grobler *pers. comm.*) at depths exceeding 10 m (Figure 12). The CPUE remained comparatively low during this period as a depth of 6m is too shallow for trap fishing. By late February, DO increased at depths of 7-15m (which is more accessible to traps), and CPUE thus also increased. During March and April, DO on the northern lobster reefs were generally below 2 ml/L and CPUE remained low and, as a result, most of the fishing fleet had moved to the southern grounds by April. A detailed description of this suggested indicator component and the suggested boundary points are given in Appendix 4.

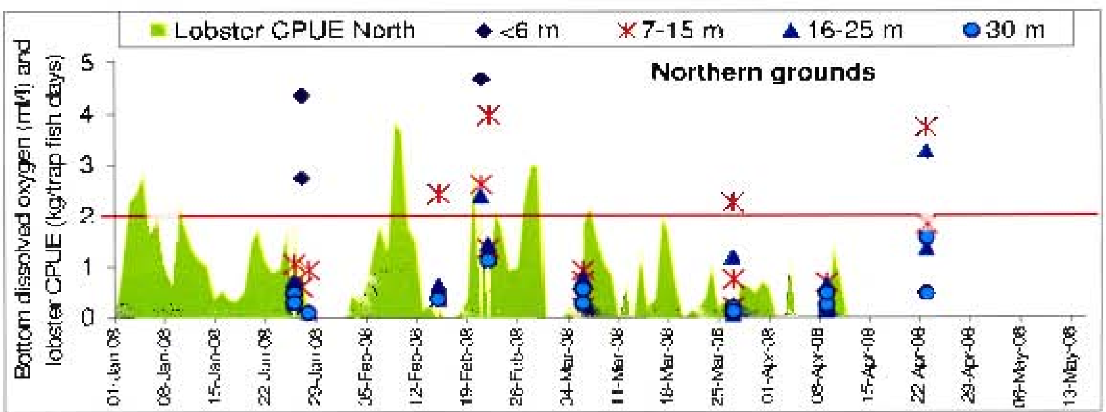


***Figure 12**: Bottom dissolved oxygen levels at the Northern lobster fishing grounds, at four different depths ranges. (The red horizontal line indicates the 2 ml/l critical limit in dissolved oxygen for lobster). Ideally, the DO measurements should be for the whole fishing season. Data for before January 2008 were not available in this case.*

3.5.3 *Swell*

High swell reduces the number of fishing days as setting the traps becomes more difficult and traps cannot be hauled when waves are breaking over lobster reefs where they have been set. The morning swell (08h00) affects fishermen as they haul their traps in the early morning and the evening swell (20h00) affects the nocturnal feeding lobsters. Grobler and Noli-Peard (1997) showed a significant negative correlation between daily catch rates and swell. Rock Lobsters are also known to reduce or even cease feeding during times of strong bottom surges caused by high swell conditions (Grobler 2007).

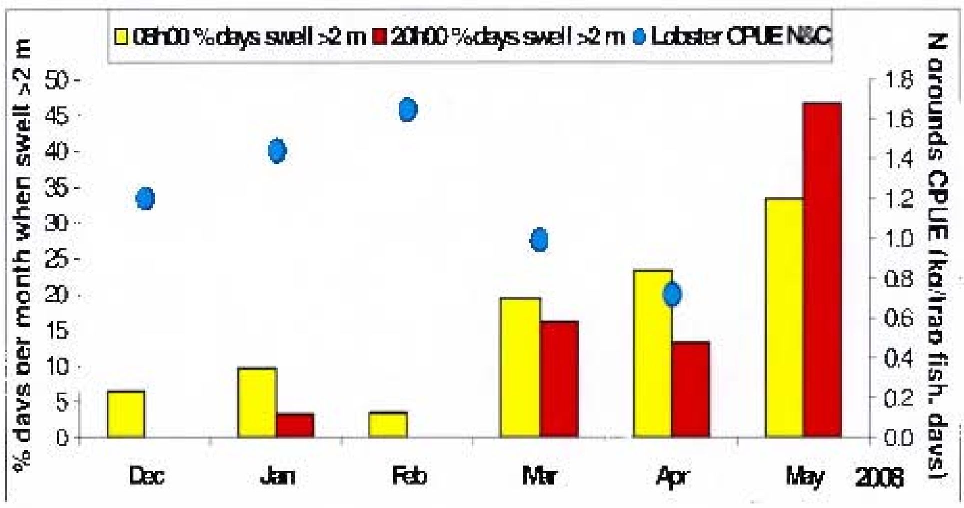


Figure 13: *Swell conditions (calculated as the % of days per month that the swell is >2 m) at the three main islands summarised as monthly swell values for the 2007/2008 season for 08h00 and 20h00. These are compared to monthly lobster CPUE at the Northern and Central fishing grounds (no lobster fishing occurred during May in the North and Central.)*

Visual estimates of swell height are made at Ichaboe, Mercury and Possession Islands three times per day. A comparison of average monthly swell conditions for January 2008 to April 2008 to the monthly lobster CPUE are presented in Figure 13 for grounds north of Lüderitz. These results show increased CPUE during months of relatively low swell conditions (e.g. December 2007), and very low CPUE during months of high swell conditions (e.g. March and April 2008). Swell conditions peaked during May, but by this time no vessels were fishing north of Lüderitz anymore. The visual measurement of swell (which differs depending on island staff's ability to assess swell conditions) makes it difficult to compare measurements between islands. However, this still gives a good estimate of swell conditions. This time series measuring swash on Ichaboe Island on a daily basis shows that, with increased swash conditions (i.e. strong bottom surges), CPUE declines (Maletzky 2008). As an indicator for the wellbeing of the resource (as contrasted to catchability in the fishery), evening swell would be the indicator of choice. A detailed description of this suggested indicator component and the suggested boundary points are given in Appendix 4.

3.5.4 Catch by area

As an indicator for the 'commercial fishery quantified', which is encompassed under the operational objective of 'low mortality', catch by area (in tonnes) could contribute to an understanding of the fishing pressure on the resource. The distribution of catches for each fishing ground gives a good indication of where the most effort has been placed amongst all fishing grounds e.g. the southern fishing grounds of Namibia (Kerbe Huk mainly) carried the bulk (58%) of the 2007/08 season's catch (Maletzky 2008). Catch rates were generally better than that of the preceding season; by the end of the 2007/2008 season, 264 tonnes of the 341 tonne allocation to the commercial sector was landed, as is shown in Figure 14. This accounted for approximately 77% of the overall (350 tonne) TAC, and is an improvement from the 2006/2007 season where only approximately 46% of the TAC was landed.

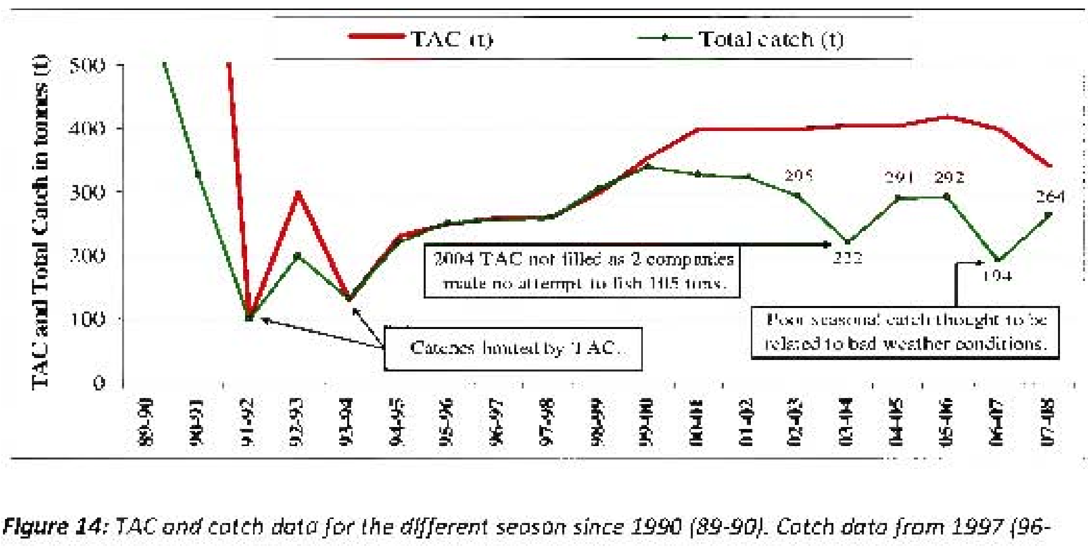


Figure 14: *TAC and catch data for the different season since 1990 (89-90). Catch data from 1997 (96-97) onward are corrected for unreliable data. For the years prior to 1997 (96-97), this correction was not considered necessary since the vessels did not return to shore as frequently as in the years following 1997 (1996-1997).*

The distribution of catches for each fishing ground is an indication of which fishing grounds is potentially being overfished. In combination with other indicators (such as undersized lobsters caught and females in berry) it could be useful in future management decisions regarding possible closed areas and/or MPAs.

3.6 Communication with non-scientific stakeholder groups and managers

As an example of the kind of information that could result from well-defined indicators, the information encompassed in Figure 14 is repackaged for use in communication with non-scientific stakeholders and for managers to inform management decisions (Figure 15) and discussed in section 4.1.4.

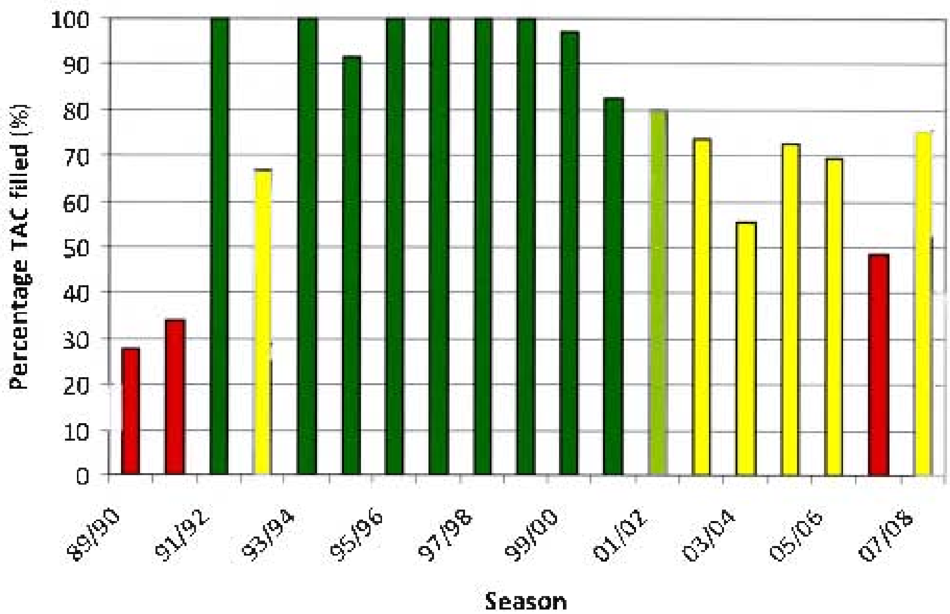


Figure 15: The percentage of allocated TAC filled for each fishing season, showing <50% of the TAC filled as red (dangerous mismatch!), 50-75% as yellow ('caution; large mismatch') and >75% as green (76-80% light green ('acceptable mismatch') and >80% dark green ('good match')). Possible actions necessary for management to address these outcomes could include: green=no immediate action; yellow=investigate reasons for low catches; and red=immediate action is required e.g. lower the TAC for the following season, or possibly implement a limited entry system (accompanied by clear requirements), etc.

4. DISCUSSION

The results of the ERA confirmed that there is a severe lack of transparency and shared understanding amongst stakeholders in the Namibian Rock Lobster Fishery, which is causing high tension and user conflict within the fishery – between fishers and observers; between fishers and the mining sector; between research and the mining sector; and between research and decision-makers. As a result, the management of the fishery has become a battlefield of perceptions and prejudices rather than a movement towards a common goal. However, the results of the ERA also highlighted the small area of common ground that does exist between stakeholders regarding the overall objective for the management of the fishery, which is the rebuilding of the Rock Lobster stock. Thus, as a starting point to addressing the conflicts that exist within this fishery and finding possible further common ground, a wider view of an EAF was adopted to develop the aspects that require monitoring as a basis for suitable management action.

4.1 Towards implementing an EAF in the Namibian Rock Lobster fishery

4.1.1 Ecological Risk Assessments (ERA)

The Rock Lobster fishery, as a much smaller and more localised fishery, has very unique challenges associated with it that were brought to the fore and clarified somewhat through the ERA process. Some weaknesses in the process do exist as more outspoken participants drown out quieter, shyer participants and cultural backgrounds tend to play a strong role in participants speaking up. The time constraints imposed upon the workshop proceedings hindered free-flowing discussions somewhat and, as a consequence, required outputs were rushed. Not all stakeholder groups were represented at the workshop and thus the results obtained and the representation of issues raised could be biased towards those participants that did attend.

Despite this however, the importance and strength of the ERA process lies in the discussion that it facilitates amongst stakeholders. It requires consensus between participants and it allows for comparison across and between different sectors because of its transparency. It provides a structured framework within which to consider divergent issues in a transparent and accountable manner, and is a simple process by which dialogue is facilitated amongst stakeholder groups where there otherwise might not have been any. The process defines the ecosystem in its broadest sense. It serves to bring the ecological, social, economic and governance sectors together in a way that has not previously been achieved. The ERA prioritises the main issues for an EAF implementation and provides suggestions for possible management responses. It provides a valuable framework for the implementation of EAF within this fishery through detailing and prioritising important gaps in current knowledge. It can thus be used as a basis for future research required for progress in the implementation of an EAF.

4.1.2 Causal maps

The relationships founded in the workshop were strengthened through the interview process. Because discussions were allowed to flow freely with no predefined list of questions, participants felt the importance of their opinions within the process and did not feel intimidated by preconceived perceptions and judgements, as might have been the case in the workshop setting. Time constraints were of no importance during the interviews, which, combined with the free-flowing conversation, led to conclusions and statements which would probably not have been expressed had there been a predefined list of questions or a time limit.

Causal maps proved useful in placing perspective on the perceived problems associated with the current management of the Rock Lobster fishery. They concisely display how issues raised in the workshop could possibly interlink with each other. Maps from the different user groups showed the vastly different perceptions held by each group on how their group and other user groups impact upon both the resource and the environment, potentially and otherwise, and often showed agreement between stakeholder groups which was not obvious during workshop proceedings. They highlighted areas of concern for particular stakeholders. The process of one-on-one interviews, although not attended by the fishing industry, was very useful in highlighting possible external drivers and consequences within the fishery, and aided in further teasing out of the issues within the fishery. The difference in perception, as clarified through these causal maps, also point to areas where research efforts towards resolving the discrepancies can best be directed.

4.1.3 Value trees

Together with the results from the ERA, the causal maps were used to formulate a detailed hierarchy of objectives, or a value tree, specifically for the ecological wellbeing of the industry. Value trees, though they do aid in the process of addressing management objectives and attaining management goals, differ from causal maps in that they do not show possible linkages between issues. However, the hierarchical structuring of value trees prove extremely useful in facilitating the transparency of the process; through the process of suggesting useful specific indicators that reflect stakeholders' perspectives to address the issues. Stakeholders are thus aided in understanding how progress towards the overarching objectives, such as the ecological wellbeing, can be measured through the use of indicators.

4.1.4 Indicators

Selection of indicators

As mentioned previously, good management decisions can only be reached when the knowledge they are based on is clearly linked to management objectives. Indicators are a means to an end, a predefined list of characteristics that can provide feedback on progress towards management goals and objectives (Degnbol and Jarre 2004). They should be measurable rather than opinion-based (Burgman 2005) and need to be specific, reflecting both the specific management objectives and the specific management institution they will be informing (Degnbol and Jarre 2004). Some of the properties of good indicators are that they are observable, make sense to both formal research and stakeholders and are relevant to management (Degnbol 2003). They can be of a bio-ecological, techno-economical or socio-cultural nature (Garcia and Cochrane 2005) but need to relate to management objectives as well as constraints. It will thus become clearer how current and future research is contributing, or may contribute, to addressing the types of issues to be faced in developing an Ecosystem Approach to Southern African Fisheries. The boundary or reference points (prescribed by the precautionary approach (FAO 1995) to define strategies) are values of indicators defined on a technical basis (Halliday *et al.* 2001), which can be used as a guide for fisheries management.

Indicator development is a scientific process that needs careful consideration, and candidate indicators need to be tested before routine application. Here, potential indicators are suggested but the weakness is not ignored that many of these 'suggested indicators' e.g. sea surface temperature, dissolved oxygen, swell and wind, are in fact indicators of the state of the environment and *not yet* indicators of the well-being of the ecosystem. It must be emphasised that this work represents the first phase of a multi-phase process to establish accepted and useful indicators and accompanying reference points. A possible next step could be to condense these suggested indicators into one indicator, i.e. status of the physical environment, which could then be used to explain and elucidate indices of rock-lobster production. This will however require much further dedicated research beyond the scope of this current thesis. These kinds of approaches and mechanisms of synthesis (e.g., trading off specificity against the ease of communication) are what need to be discussed and agreed upon by all stakeholders if a suite of useful indices for the well-being of the ecosystem, that both the rock lobster and its fishery depend on, are to be acquired.

In consultation with stakeholders, the primary consideration in the choice of objectives for this fishery was the rebuilding of the depleted Rock Lobster stock. Due to the time constraints of this mini-project however, some specific indicators proved difficult to formulate and may need revision in the future. Nevertheless, this project has produced a potential list of candidate indicators, albeit for only the ecological wellbeing objectives. With respect to the human and institutional ('Ability to Achieve') dimensions, this project constructed value trees as presented in the results section. Details regarding these were beyond the scope of this thesis and, consequently, more work is needed on these dimensions. In agreement with Degnbol and Jarre (2004) however, this is not to say that objectives such as human and socio-economic benefits to society are irrelevant, but that ecological sustainability is considered an ultimate limit condition, which defines the boundaries for fisheries in the long-term. As such, this present work represents the first of many important steps towards attaining a sustainable Rock Lobster fishery.

Reaching consensus on specific objectives for understanding the mining impacts on both the Rock Lobster resource and on the wider ecosystem proved the most difficult of all ecological wellbeing objectives. The antagonism that exists between the mining and the fishing industry was very clear from workshop proceedings, but it would seem that this sparks from a lack of data and is fuelled by a lack of understanding regarding the possible impacts of mining. Much work has been done in the region by the mining industry regarding the cumulative effects of marine diamond mining activities on the BCLME region (Penney *et al.* 2007), one of the conclusions of which was that, compared to the unsustainable fishing effort by the fisheries themselves and the natural environmental processes occurring in the Benguela region, the impact of marine mining activities on fisheries resources has been insignificant. Despite the results of this research, perceptions remain strong that mining activities in Rock Lobster areas is the primary reason for the stock decline. Stakeholders seemed quick to pass the blame on to other user groups without accepting the full responsibility of the possible impacts of their own activities on the current state of the ecosystem.

Data availability to create time series

A list of potential indicators is presented here, but there remains paucity in the data that are needed to inform some of these suggested indicators e.g. good data are available regarding the commercial fishery, but very little data are available for the recreational fishery. The combined effect of the recreational and commercial fishery on the Rock Lobster resource can thus not be quantified. The number of vulnerable species entangled in bait box strapping and fishing gear is equally not quantified. The potential impact of using gurnard as a bait item has not been researched and the implications of this new fishery on the wider ecosystem have not been ascertained or mitigated for. These are gaps in current knowledge that need to be addressed and bridged to move the implementation of an EAF forward in this fishery. However, stakeholder participation and consultation must never be forgotten as this fishery moves towards an EAF. Yes, research gaps identified must be bridged, but the specific objectives (and the resultant indicators) needed to understand the fishery and its potential impacts, and to measure the implementation of EAF, need to be agreed upon and possibly revised through stakeholder consultation, which the transparency of the ERA allows for at any stage. This is what is necessary to take the data series described here for the Namibian Rock Lobster fishery forward to formulate specific indicator data series.

Using indicators to support communication among stakeholders

Although data are collected within sectors, not much data are being disseminated and communicated between sectors. Unfortunately, it is this lack of communication and information dissemination between sectors, representative of the lack of transparency that is so prevalent, which seems to be at the crux of the inefficiency of the current management system. With the commitment made by Namibia to implementing an EAF by 2010, progress of the implementation process itself needs to be measured. Paterson and Petersen (2009) suggest that implementing an EAF in southern Africa may require to first set enabling conditions in place, such as institutional capacity or mechanisms, such as Ecosystem Working Groups or suitable management plans, etc. They also refer to possible stumbling blocks, such as insufficient skills, poor motivation or a lack of incentives, which may need to be addressed before a management mechanism can be implemented effectively.

In order to include such progress into an overall evaluation of the EAF implementation in the Namibian Rock Lobster fishery, it is advisable to review ERAs regularly, ideally on an annual basis as most institutional work-plans run on an annual basis (Paterson and Petersen 2009). Additionally, revising ERAs on an annual basis facilitates the implementation process and movement towards an EAF; often there is a flurry of activity following a workshop, which then phases out over time. Annual reviews take advantage of this activity and ensure the continuation of it (S. Petersen *pers. comm.*).

Additionally, it should be kept in mind that stakeholders may battle with the abstract concept of "the progress towards an EAF". It would therefore be beneficial to present results of ERAs to stakeholders in a visual manner. Various approaches have been suggested to summarise the diverse output of those indicators for communication amongst stakeholders, including the traffic light approach (Halliday *et al.* 2001) and knowledge-based or expert systems (e.g. Jarre *et al.* 2006, Paterson *et al.* 2007). According to the traffic light system, the data can be coloured according to their position relative to a reference point: green if the indicator is in the acceptable domain, yellow if in the warning region, and red if beyond the limit (Halliday *et al.* 2001). As an example, with respect to the percentage of the TAC filled, a way to present the information in Figure 14 to stakeholders would be to repackage *how* the data is presented to stakeholders; in this example, if the percentage of the allocated TAC filled in any given season is less than 50%, the data series shows as red ('dangerous discrepancy!'); if the percentage TAC filled falls between 50 and 75% of the allocated TAC, the data series shows up as yellow ('caution – large discrepancy'); and if the percentage filled of the allocated TAC is beyond 75%, the data series shows up in varying shades of green (to represent varying degrees of 'good' to 'excellent' agreement between TAC and reported catches) (Figure 15). (While a TAC that is not filled for a season may not necessarily be completely disagreeable (possibly devastating for the economy, but could be favourable for the environment!), a large discrepancy between the catch and the allocated TAC for a season could give an indication of the management of this fishery being in dire need of reviewing.) In this way, complicated academic information can easily and quickly be digested by a non-scientific audience and can equally be interpreted with ease to initiate management responses.

Additionally, electronic decision support tools have been shown to help managers in situations characterised by uncertainty (e.g. Mackinson 2000), and several ways of building these exist, including categories (such as the traffic lights) and traditional (crisp) logic, or continuous values and fuzzy logic.

4.2 Expert systems as a means to summarise information

Expert systems are a good tool to synthesize information from a large number of indicators for the decision making process, and to readily incorporate updated information. Expert systems capture information from indicators in a systematized knowledge base, providing a formal means of synthesis, as opposed to analysis, of data (e.g. Jarre *et al.* 2006). In addition to quantitative, measured indicators, it is possible to utilise expert opinion in a structured way in the evaluation process. Paterson *et al.* (2007) demonstrate how to use an expert system to evaluate the implementation of an EAF in the South African sardine fishery, and it is believed that this approach could be useful for the Namibian Rock lobster fishery as well.

As mentioned previously, fuzzy-logic is often thought useful in dealing with uncertainties in our understanding of aquatic systems, and in dealing with low precision in indicators. Fuzzy-logic provides a means for expressing to what degree a statement or, in this case, an objective is 'true' or fulfilled, allowing the use of a sliding scale instead of an absolute value of either 'true' or 'false' (Paterson *et al.* 2007). In a fuzzy-logic expert system, each indicator is transformed into a fuzzy variable representing the degree of trueness of the corresponding specific objective. The value of each fuzzy variable ranges between -1 (false) and +1 (completely true or fulfilled), giving a continuous measure. The various fuzzy variables are evaluated using the structure of the value tree (or objective hierarchy), and fuzzy logic operators such as "AND", "OR", or a "Union" statement corresponding to a weighted average (e.g. Jarre *et al.* 2008).

The particular tool outlined by Paterson *et al.* (2007) produces a numerical output value which can easily be visualised as a bar chart, and thus the progress made by a fishery towards an EAF can by visually understood. Jarre *et al.* (2008) compare two fuzzy-logic expert systems for use in the Benguela against a more conventional, rule-based approach using traditional Boolean ("crisp") logic. In this study, no approach proved superior to the other in terms of results though the advantage of visual outputs for any system was highlighted. Importantly however, it is the definition of the suite of indicators that provides crucial progress in the implementation of an EAF, not the type of logic chosen for their combination (Jarre et al. 2008). The choice of the system should reflect what stakeholders are comfortable with in a particular situation and the sophistication of fuzzy-logic formulations needs to be weighed up consciously against the familiarity of plain language terms in simple categories, as used in the traditional approach, in furthering shared understanding and communication among stakeholders.

Notwithstanding such details in model formulation, expert systems bear an advantage in that they are easy to update and their pre-agreed evaluation mechanisms present a powerful tool in communicating a shared understanding and delivering best practice to those who need to use it e.g. managers (Jarre *et al.* 2008). Complex systems, such as marine fisheries, require an adaptive management plan i.e. one that can be reviewed and revised according to the emerging of new knowledge and understanding.

An expert system does aid in communication but is not an end in itself. However, it can facilitate the movement towards an ecosystems approach to fisheries management in a structured and meaningful, process-oriented as well as goal-oriented, manner. It is my hope that the results of the present thesis will be used in designing such a system, to the benefit of the Namibian Rock Lobster fishery and the ecosystem this fishery depends on.

5. CONCLUSIONS

- As a signatory to the 2002 World Summit on Sustainable Development (WSSD), Namibia has signalled her political will and commitment towards ecosystem-based management by agreeing to develop an ecosystems approach to fisheries (EAF) by 2010. An EAF recognises the interdependence between human wellbeing and ecosystem health and aims to balance these to achieve overall sustainability of all uses and impacts on an ecosystem.
- An Ecological Risk Assessment (ERA) is an approach used to identify and prioritize issues and subsequent action. It works to build consensus amongst diverse groups of stakeholders and it defines the ecosystem in its broadest sense, that is the ecological, socio-economic and governance systems. The Namibian Rock Lobster fishery ERA identified all major issues related to EAF and points out where they are not adequately addressed by current management strategies. It marks the first step in Namibia's evolution toward EAF for its Rock Lobster fishery. The outputs of such a risk assessment should be reviewed to measure progress towards EAF and to develop work plans in association with a broader stakeholder community.
- Causal or cognitive mapping illustrated the degree of agreement between stakeholders and clarified areas of special concern for particular stakeholders.
- The ERA and causal maps together led to a hierarchy of objectives detailed for the ecological wellbeing of the industry.
- Specific objectives in this hierarchy are identified and indicators linked where possible.
- Some time series of selected indicator values are presented. The complete and detailed set of indicators still needs more work, and will need to be carried out in consultation with the stakeholders.
- Time series of agreed indicators must be complied within the Ministry of Fisheries and Marine Resources in Namibia, where the supporting data is already housed. It was beyond the scope of this thesis to do so. Once this is done, there is good potential to build an expert system informing various stakeholders of the state of the fishery from an EAF perspective.

6. ACKNOWLEDGEMENTS

First and foremost, my deepest gratitude goes to my supervisor Astrid Jarre. I can honestly say that without her tireless efforts, this body of work would be nowhere near as comprehensive or comprehensible as it is. This work is based upon research supported by the South African Research Chairs Initiative of the Department of Science and Technology, the National Research Fund and BENEFIT. Thanks also to my two examiners, whose comments and critiques made me rethink and consolidate the concepts behind my thesis. Special thanks to the anonymous examiner for very constructive criticism.

Gratitude is extended to the following people: Anja Kreiner (MFMR) for allowing me to occasionally bounce ideas off her, my colleagues at NatMIRC and the Lüderitz research centre for valuable input and comments, and all participants of the ERA workshop for their active and lively participation.

Thank you to my parents who have always supported and loved me deeply and completely. Your support means more than words could ever convey.

To the friends who always help me to retain my sanity, whether in times of thesis or not: Katherine, Laura, Michael, Dan and Will – even though you are all in far off places, you will never be far from my heart. The good times will not be forgotten, the laughter will be cherished and the friendships will endure.

And to Carl, who inspires and challenges me on a daily basis; thank you for making 2008 the year I will always remember.

7. REFERENCES

Basson J (2008) Ecological Risk Assessment for the Namibian Rock Lobster Fishery. **WWF report of a workshop held on 13-15 October 2008 in Lüderitz, Namibia** 35pp.

Belton V and Stewart T (2002) Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer: Dordrecht 400pp.

Berghöfer A, Wittmer H, Rauschmeyer F (2008) Stakeholder participation in ecosystem-based approached to fisheries management: A synthesis from European research projects *Marine Policy* **32:** 243 – 253

Beyers CJ de B and Wilke CG (1990) The biology, availability and exploitation of rock lobster *Jasus lalandii* off South West Africa/Namibia 1970-1980 **South Africa Sea Fisheries Research Institute Investigational Report No. 133** 56pp.

Beyers CJ de B, Wilke CG and Goosen PC (1994) The effects of oxygen deficiency on growth, intermoult period, mortality and ingestion rates of aquarium-held juvenile rock lobster *Jasus lalandii. South African Journal of Marine Science* **14**: 79 – 87

Brouwer SL, Groenewald JC and Blows B (2006) The effects of appendage loss on growth of South African west coast rock lobster *Jasus lalandii. Fisheries Research* **78:** 236 – 242

Burgman M (2005) Experts, stakeholders and elicitation. *In:* Risks and Decisions for Conservation and Environmental Management. Cambridge University Press, 62 – 124

Cochrane KL, Augustyn CJ, Cockcroft AC, David JHM, Griffiths MH, Groenewald JC, Lipi'nski MR, Smale MJ, Smith CD, Tarr RJQ (2004) An Ecosystem Approach to Fisheries in the Southern Benguela Context *African Journal of Marine Science* **26**: 9 – 35

Cockcroft AC and Mackenzie AJ (1997) The recreational fishery for West Coast Rock Lobster *Jasus lalandii* in South Africa *South African Journal of Marine Science* **18:** 75 – 84

Crawford RJM, Cockcroft AC, Dyer BM and Upfold L (2008) Divergent trends in bank cormorants *Phalacrocorax neglectus* breeding in South Africa's Western Cape consistent with a distributional shift of rock lobsters *Jasus lalandii* African Journal of Marine Science **30(1):** 161 – 166

Crear BJ, Thomas CW, Hart PR and Carter CG (2000) Growth of juvenile southern rock lobsters, *Jasus edwardsii*, is influenced by diet and temperature, whilst diet is influenced by diet and tank environment Aquaculture **190:** 169 – 182

Currie H and Grobler C (2007) *Concept note, background document and management proposal for the declaration of marine protected areas on and around the Namibian offshore islands and adjacent coastal areas.* **Report to the Ministry of Fisheries and Marine Resources (MFMR).** 133 pp.

Daan N, Christensen V and Cury PM (Eds.) (2005) Quantitative ecosystem indicators for fisheries management ICES Journal of Marine Science **62:** 307 – 614

Degnbol P (2003) Science and the user perspective: The gap co-management must address. In: Wilson DC, Nielson JR, Degnbol P (eds) *The Fisheries Co-management Experience: Accomplishments, Challenges and Prospects.* **Fish and Fisheries Series 26**: 31 – 49

Degnbol P and Jarre A (2004) Review of indicators in fisheries management – A development perspective *Ecosystem Approaches to Fisheries in the Southern Benguela* African Journal of Marine Science **26:** 303 – 326

DeLury DB (1947) On the estimation of biological populations **Biometrics Vol. 3** 147 – 167

FAO (1995) Fisheries Management. Code of Conduct for Responsible Fisheries. FAO Technical guidelines for responsible fisheries. 41pp.

FAO (2003) Fisheries Management. The ecosystem approach to fisheries. FAO Technical guidelines **4** (suppl. 2). 112 pp.

Fletcher WJ, Chesson J, Fisher M, Sainsbury KJ, Hundloe T, Smith ADM and Whitworth B (2002) *National ESD Reporting Framework for Autralian Fisheries: The 'How To' Guide for Wild Capture Fisheries.* **FRDC Project 2000/145, Canberra, Australia.** 120pp.

Fletcher WJ (2005) The application of qualitative risk assessment methodology to prioritise issues for fisheries management *ICES Journal of Marine Science* **62:** 1576 – 1587

Garcia SM, Cochrane KL (2005) Ecosystem approach to fisheries: a review of implementation guidelines *ICES Journal of Marine Science* **62:** 311 – 318

Goodwin P and Wright G (2004) Decision Analysis for Management Judgement. Chichester: Wiley, 3rd ed. 493pp.

Gray T, Hatchard J (2008) A complicated relationship: Stakeholder participation and the ecosystem-based approach to fisheries management *Marine Policy* **32:** 158 – 168

Grobler CA and Noli-Peard KR (1997) *Jasus lalandii* in post-independence Namibia: monitoring population trends and stock recovery in relation to a variable environment *Marine Freshwater Research* **48:** 1015 – 1022

Grobler K (2007) State of the Stock Report: Rock Lobster. **Ministry of Fisheries and Marine Resources: Internal report,** 5pp.

Halliday RG, Fanning LP and Mohn RK (2001) *Use of the Traffic Light Method in Fishery Management Planning* **Research document to the Canadian Science Advisory Secretariat – 2001/108**. 41 pp.

Hazel RWA, Cockcroft AC, Mayfield S and Noffke M (2001) Factors affecting growth rate of juvenile rock lobster, *Jasus lalandii* *Marine and Freshwater Research* **52(8):** 1367 – 1373

Hudon C (1994) Large-scale analysis of Atlantic Nova Scotia American lobster (*Homarus americanus*) landings with respect to temperature and wind conditions *Canadian Journal of Fisheries and Aquatic Sciences* **51:** 1308 – 1321

IUCN (2008) 2008 IUCN Red List of Threatened Species. www.iucnredlist.org.

Jarre A, Moloney CL, Shannon LJ, Fréon P, van der Lingen CD, Verheye HM, Hutchings L, Roux J-P and Cury P (2006) Developing a basis for detecting and predicting long-term ecosystem changes. In: Shannon V, Hempel G, Malanotte-Rizzoli P, Moloney C and Woods J (eds) Benguela: Predicting a Large Marine Ecosystem. Elsevier, *Large Marine Ecosystems Series,*. **Volume 14.** Amsterdam, Netherlands.

Jarre A, Paterson B, Moloney CL, Miller DCM and Field J (2008) Knowledge-based systems as decision support tools in an Ecosystem Approach to Fisheries: Comparing a fuzzy-logic and a rule-based approach *In*: Proceedings of the Humboldt Current Symposium, Progress in Oceanography, 79: 390-400

Juanes F and Smith LD (1995) The ecological consequences of limb damage and loss in decapod crustaceans: a review and prospectus. *Journal of Experimental Marine Biology and Ecology* **193:** 197–223

Kemper J, Underhill LG, Crawford RJM, Kirkman SP (2007) Chapter 42 – Revision of the conservation status of seabirds and seals breeding in the Benguela Ecosystem *In:* Final Report of the BCLME project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME. Edited by S.P. Kirkman. Avian Demography Unit, Department of Statistical Science, University of Cape Town. 381 pp.

Link JS (2005) Translating ecosystem indicators into decision criteria. *ICES Journal of Marine Science* **62:** 569 – 576

Louw D (2008) Phytoplankton bloom along the Namibian coast. **Ministry of Fisheries and Marine Resources: Internal Report,** 2pp.

Mackinson, S (2000) An adaptive fuzzy expert system for predicting structure, dynamics and distribution of herring shoals. *Ecological Modelling* **126**: 155–178

Maletzky E (2008) TAC Report: Rock Lobster. **Ministry of Fisheries and Marine Resources: Internal report,** 16pp.

Mayfield S, Branch G.M. & Cockcroft AC (2000) Relationships among diet, growth rate and food availability for the South African rock lobster, *Jasus lalandii*. *Crustaceana* **73(7)**: 815 – 834

McQuaid CD and Dower KM (1990) Enhancement of habitat heterogeneity and species richness on rocky shores inundated by sand *Oecologia (Berlin)*, **84:** 142 – 144

Melville-Smith R and de Lestang S (2007) Changes in egg production of the western rock lobster (Panulirus cygnus) associated with appendage damage. *Fishery Bulletin* **105(3):** 418 – 425

MFMR (2000) Government gazette no. 2458 Marine Resources Act No. 27 of 2000 *Republic of Namibia*

MFMR (2008) Socio-Economic Analysis of the recommended Total Allowable Catch (TAC) for the 2008/2009 season: Rock Lobster. **Ministry of Fisheries and Marine Resources: Internal report.** 21pp.

Morishita J (2008) What is the ecosystem approach for fisheries management? *Marine Policy* **32:** 19 – 26

Murawski S (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 Small Pelagic Fishery. In: Nel DC, Cochrane K, Petersen SL, Shannon LJ, van Zyl B, Honig MB (eds) *Ecological Risk Assessments: a tool for implementing and Ecosystem Approach for Southern African Fisheries.* **WWF Report Series – 2007/Marine/002.** 203 pp.

Newman GG and Pollock DE (1971) Biology and migration of rock lobster *Jasus lalandii* and their effect on availability at Elands Bay, South Africa **South Africa Division of Sea Fisheries Investigational Report No. 94.** 24 pp.

Özesmi U and Özesmi SL (2004) Ecological models based of people's knowledge: a multi-step fuzzy cognitive mapping approach Ecological Modelling **176:** 43 – 64

Paterson B, Jarre A, Moloney CL, Fairweather TP, van der Lingen CD, Shannon LJ and Field JG (2007) A fuzzy-logic tool for multi-criteria decision making in fisheries: the case of the South African pelagic fishery Marine and Freshwater Research **58:** 1056- 1068

Paterson B and Petersen SL (2009) EAF Implementation in Southern Africa: lessons learnt Marine Policy **doi: 10.1016/j.marpol.2009.07.004**

Penney AJ, Pulfrich A, Rogers J, Steffani N and Mabille V (2007) Project: *BEHP/CEA/03/02: Data Gathering and Gap Analysis for Assessment of Cumulative Effects of Marine Diamond Mining Activities on the BCLME Region.* **Final Report to the BCLME mining and petroleum activities task group.** 410pp.

Pollock DE and Shannon LV (1987) Response of rock-lobster populations in the Benguela ecosystem to environmental change – a hyphothesis. In: Payne AIL, Gulland JA and Brink KH (eds) *The Benguela and Comparable Ecosystems.* South African Journal of Marine Science **5:** 887 – 899

Prigent M, Fontenelle G, Rochet M-J and Trenkel VM (2008) Using cognitive maps to investigate fishers' ecosystem objectives and knowledge *Ocean and Coastal Management* **51:** 450 – 462

Pulfrich A (2006) Survey of intertidal and subtidal rocky shore communities at Elizabeth Bay: Intertidal and subtidal monitoring report – 2006. **Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia** 39pp.

Rochet M-J, Trenkel V, Bellail R, Coppin F, Le Pape O, Mahé J-C., Morin J, Poulard JC, Schlaich I, Souplet A, Vérin Y and Bertrand JA (2005) Combining indicator trends to assess ongoing changes in exploited fish communities: diagnostic of communities off the coasts of France. *ICES Journal of marine Science*, **62:** 1647 – 1664

Saiz-Salinas JI and Urdangarin I (1994) Response of sublittoral hard substrate invertebrates to estuarine sedimentation in the outer harbour of Bilbao (N. Spain). *Marine Ecology*, **15:** 105 – 131

Shannon V (1985) The Benguela Ecosystem. 1. Evolution of the Benguela, physical features and processes. *Oceanography and Marine Biology: An Annual Review* **23:** 105 – 182

Shannon LJ, Cochrane KL, Moloney CL and Freon P (2004) Ecosystem approach to fisheries management in the southern Benguela: a workshop overview. *African Journal of Marine Science* **26**: 1 – 8

Shannon LJ, Cury PM, Nel D, van der Lingen CD, Leslie RW, Brouwer SL, Cockcroft AC and Hutchings L (2006) How can science contribute to an ecosystem approach to pelagic, demersal and Rock Lobster fisheries in South Africa? *African Journal of Marine Science* **28**(1): 115 – 157

Shannon LJ, Coll M and Neira S (2009) Exploring the dynamics of ecological indicators using food web models fitted to time series of abundance and catch data. *Ecological Indicators* **doi:10.1016/j.ecolind.2008.12.007**

Stewart TJ, Joubert AR and Janssen (2009) MCDA Framework for Fishing Rights Allocation in South Africa. *Group Decision and Negotiation* **doi: 10.1007/s10726-009-9159-9**

Tomalin BJ (1996) *Specialist study on impacts of diamond mining on rock-lobster populations and the fishery.* In: CSIR, 1996. Environmental Impact Assessment for marine diamond mining in the Namibian Islands concession, CSIR Report EMAS-C96023.

Varjopuro R, Gray T, Hatchard J, Rauschmeyer F, Wittmer H (2008) Introduction: Interaction between environment and fisheries – The role of stakeholder participation *Marine Policy* **32:** 147 – 157

Zadeh LA (1965) Fuzzy sets *Information and Control* **8**: 338 – 353

Appendix 1

Letter of consent from WWF South Africa

WWF for a living planet®

WWF South Africa
World Wide Fund For Nature

Reg. No: 003-226 NPO
VAT NO: 4820122481
Web: www.wwf.org.za

Head Office:
Millennia Park
16 Stellentia Avenue
STELLENBOSCH 7600
Private Bag X2
DIE BOORD 7613
Tel: +27 21 888 2800
Fax: +27 21 888 2888

Gauteng Office:
Pinmill Farm
Ground Floor, Block F
164 Katherine Street
SANDOWN 2031
Postnet Suite 436
Private Bag X9
BENMORE 2010
Tel: +27 11 262 9460
Fax: +27 11 262 9461

To Whom It May Concern:

Re: Ecological Risk Assessment Report for the Namibian Rock Lobster fishery

An ecosystem approach to fisheries (EAF) is globally seen as being necessary for the sustainable use of marine fisheries. A workshop was held in October 2008 in Lüderitz, Namibia, as the basis for the Namibian Rock Lobster Fishery Ecological Risk Assessment (ERA), the goal of which was to identify ecological, social, economic and governance risks facing the management of the fishery. These were then prioritised and correct actions identified for high risk issues.

The workshop was facilitated by WWF-South Africa, in partnership with the Ministry of Fisheries and Marine Resources in Namibia. The results of the workshop form a solid basis on which the Namibian Rock Lobster management plan can be formulated to inform management, thus guiding any management decisions that need to be taken. The workshop results were written up by Ms Janine Basson and will be incorporated into a Master of Science, currently being completed with the University of Cape Town.

This letter serves to inform you that WWF approves the use of the Namibian Rock Lobster ERA report. Ms Basson has our support in this endeavour.

Yours sincerely,

____

Dr Samantha Petersen

Appendix 2

Ecological Risk Assessment Report for the Namibian Rock Lobster Fishery

APPENDIX 2.

Ecological Risk Assessment (ERA) report for the Namibian rock lobster fishery

The ERA workshop for the Namibian Rock Lobster Fishery took place in Lüderitz, Namibia, between the 13th and 15th of October, 2008. The workshop was hosted by the Ministry of Fisheries and Marine Resources (MFMR), and facilitated by Dr. Samantha Petersen of WWF-South Africa. After wide distribution of invitations, the workshop was attended by a total of 19 participants. Most attendees were from MFMR, with good representation from industry and industry bodies. This allowed for very healthy debate despite the lack of representation of social scientists.

Please see Annex 1 for a complete list of attendees.

A brief description of the Rock Lobster Fishery

The West Coast rock lobster *Jasus lalandii* are distributed throughout the inshore areas of Namibia between 24º57'03"S and 28º22'04"S. Commercial exploitation occurs from the south of Lüderitz between the Orange River border in the south to the Easter Cliffs/Sylvia Hill north of Mercury Island. There are two lobster sanctuaries, one off Lüderitz and one at Ichaboe Island.

Exploitation is made of two main sectors: commercial and recreational. A total of four commercial fishing areas are identified, each consisting of one or more lobster grounds. The industry consists of various companies and small quota holders. The fishing fleet in 2008 consisted of 29 vessels. Observers onboard these vessels collect length frequency data throughout the season. Regulations on the fishery include a minimum size limit and not landing females in berry. Commercial fishing occurs throughout the season, which runs from 1 November till 30 April of the following year. Most companies did not manage to fill their 2007/8 quota, with only 77% of the Total Allowable Catch, or TAC, (of 350t) caught. Although the resource is showing signs of recovery, the stock indicator is declining – the fishable biomass is below 1 000 tonnes and the recruitment is below average stock recruitment.

Results of the Workshop

General overview of the ERA process

Identification of issues

A total of 91 issues were identified for this fishery by the workshop participants. These issues are listed and described in full in Annex 2. Most (49%) issues fell within the 'Ecological wellbeing' component, whilst 'Governance' issues (26 %) almost equalled those of 'Human wellbeing' (25 %) (Figure 1).

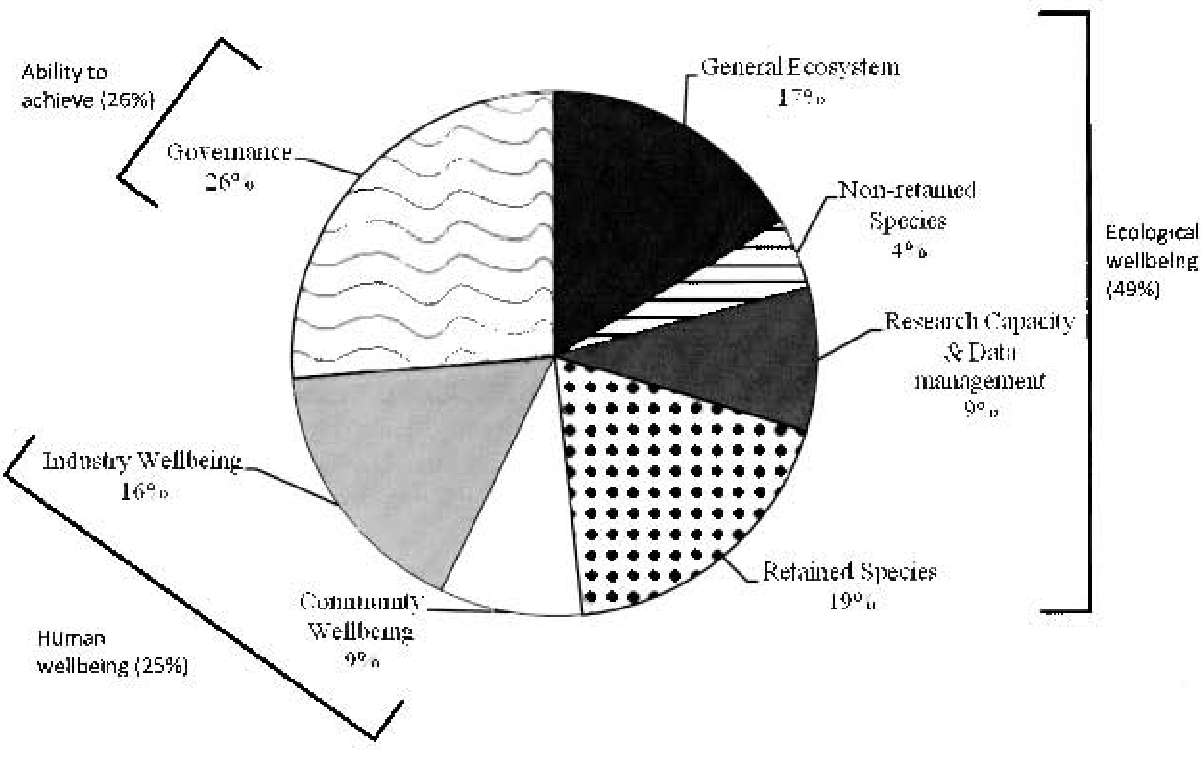


Figure 1. Percentages of issues that were identified within each ERA component and category.

Prioritization of issues

The prioritization process resulted in the majority of the issues falling into the 'Extreme' category (59%) (Figure 2). 'High' and 'Moderate' rated issues accounted for 14% and 16% respectively.

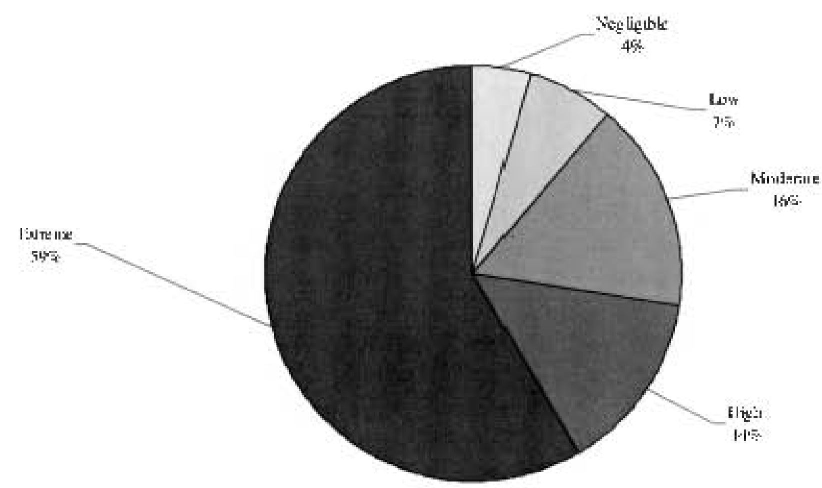


Figure 2. Percentages of Issues per risk category

When considering the spread of risk categories within each of the ERA components (Figure 3), the 'Ecological Wellbeing' component had the highest number of issues in total (44). The highest number of 'Extreme' issues fell into the 'Governance' category (18) within the 'Ability to Achieve' component, with the next highest number of 'Extreme' issues in the Industry Wellbeing (9) and Retained Species (8) categories of the 'Ecological Wellbeing' component. All issues raised within 'Research Capacity and Data Management' category were prioritised as either of 'Moderate', 'High' or 'Extreme' risk.

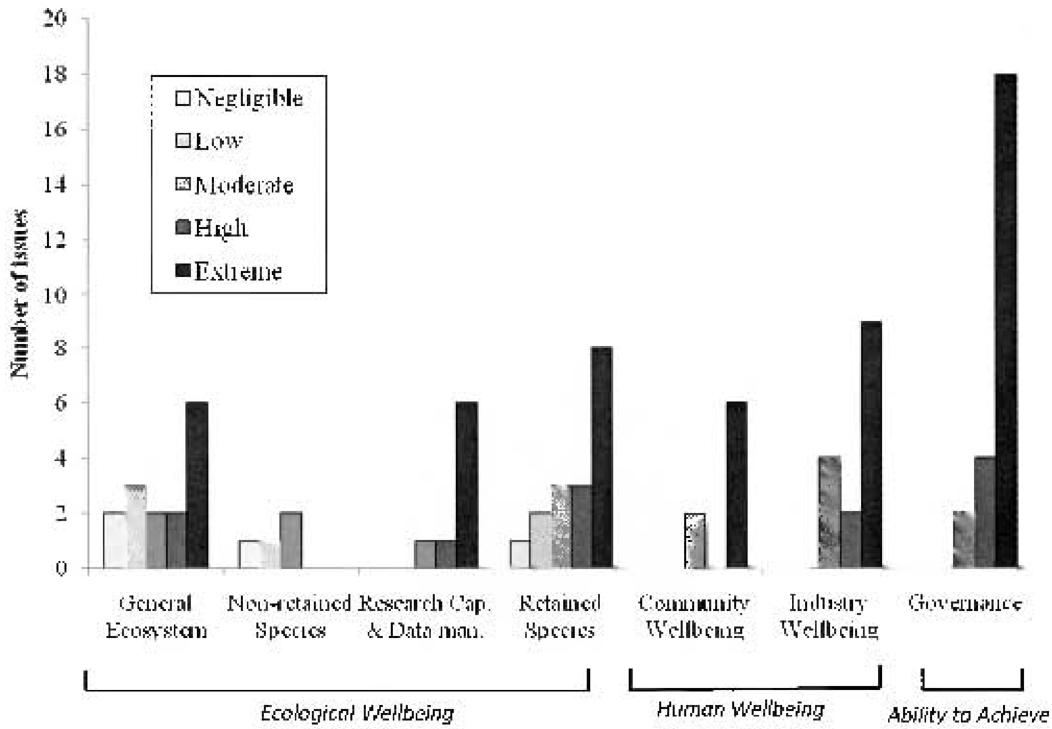


Figure 3. Proportions of issues within given risk categories for each ERA component

Performance reports

Of the 91 issues identified, 81 (89%) were rated as being of 'Moderate' risk or higher. On agreement from the workshop participants, performance reports were developed for all these issues.

The major issues

The issues with a risk rating of 'Moderate' or higher are shown in Table 1. The discussion in this section will highlight some of the main themes under each of the main components.

Ecological Wellbeing

There were many issues that the workshop participants felt were of 'Extreme' importance within the 'Ecological Wellbeing' component. Within the 'Retained

Species' category, participants felt that the declining average size of the lobster and the decreasing CPUE was of concern. The illegal capture of lobster by the commercial fishery was also noted, as were the effects of both extending the fishing season and inappropriate boat-based sorting techniques on females in berry. The lack of understanding of lobster population dynamics was noted by all as cause for concern.

In the 'General Ecosystem' category, the main issue was noted as the interaction between the diamond mining industry and the Rock Lobster industry. Workshop participants felt the diamond mining activities negatively affect the lobster through smothering of lobster prey e.g. mussels, and through habitat destruction. The large quantity of sulphur stored in the harbour was also felt by the participants as being a potential risk to the wellbeing of the lobster population and the ecosystem health in general. The food web implications of removing lobster (as both predator and prey) were also noted.

In the 'Research Capacity and Data management' category, it was felt that the limited scientific capacity, resources and technical skill was a source of major concern. The communication (or lack thereof) between the Ministry of Fisheries and Marine Resources (MFMR) and the Fisheries Observer Agency (FOA), and the inaccurate logging of data by the fisheries observers, was also captured as an issue needing to be addressed.

Human Wellbeing

In the 'Industry Wellbeing' category, the financial burden placed on the Rock Lobster fishery (through observer and port fees) as well as the lack of international market options was noted by the fishing industry as points for concern. The industry noted that the remote location and nature of Lüderitz negatively influences their access to global markets. The relations within the fishing industry itself (in terms of employer-employee relations) were also seen as an 'Extreme' risk as this can influence the productivity of the crew and thus the overall profitability of the industry. The loss of local knowledge through the loss of experienced crew members and the reduction in fishing efficiency through outdated fishing technology was thought to pose a 'High' risk to the fishing industry.

In the 'Community Wellbeing' category, participants noted that as the catch per unit effort (CPUE) has decreased over the last few years, the proportional contribution of the lobster fishery to the local economy has also decreased, which is cause for concern. Also, the socio-economic knock-on effects of unemployment within the Rock Lobster fishery are not fully understood and were identified as issues of extreme importance, as was the potential change experienced by secondary and tertiary businesses due to changes within the fishery. Lack of communication between the different line ministries (e.g. Ministry of Trade and Industry; Ministry of Health and Social Services; Ministry of Education etc.) was also thought to be an issue of extreme importance which needs to be addressed.

Governance

Overall poor communication (between scientists and the fishing industry; between South African scientists and Namibian scientists; between management and scientists; between the mining industry and the fishing industry; between the FOA and MFMR) was highlighted by participants as the main issue for concern within the 'Governance' component. Furthermore, a need was identified (because of delayed response times from the decision-maker) for the decentralisation of decision-making power from MFMR Head Office (in Windhoek) to Lüderitz staff (LMR).

The lack of law enforcement skills necessary to adequately deal with illegal poaching of Rock Lobster was highlighted as an issue of 'Extreme' risk. In addition to this, it was highlighted that penalties for illegal capture of lobster are not high enough to act as a deterrent. Furthermore, the need to instate island-based staff as honorary fisheries inspectors to curb poaching on the sanctuary at Ichaboe Island was highlighted.

Table 1 List of issues that scored a 'Moderate' risk rating or higher.

*Note: Risk score is product of the consequence score (CONS) and the likelihood score (LIKE)

** Categories: E=Extreme, H=High, M=Moderate

ID	ISSUE	CONS	LIKE	RISK	Category
Retained species					
1	Decrease in fishable biomass of lobster resource and consequent increases in fishing effort (traps, days at sea) leads to undersized lobster being repeatedly recaptured. Handling increases risk of mortality and impacts on growth	3	6	18	H
2	Extension of fishing season resulting in an increased capture of females in berry	4	6	24	E
3	Direct take of rock lobster by mining industry (e.g. especially during mass migration)	4	4	16	H
4	Noise pollution (from fishing and mining sectors) may affect lobster behaviour	3	4	12	M
5	Illegal capture of lobster by recreational fishery	3	6	18	H
6	Illegal capture of lobster by commercial fishery	4	6	24	E
7	Localised overfishing and/or population decline	4	6	24	E
8	The effect of boat based inappropriate sorting of undersized juveniles leads to increased chances of mortality and impacts on growth	4	4	16	H
9	The effect of boat based inappropriate sorting of females in berry	4	5	20	E
10	Lack of understanding of population dynamics and distribution	5	6	30	E
ID	ISSUE	CONS	LIKE	RISK	Category
11	The higher proportion of capture of males can impact population structure	2.5	4	10	M
12	Poor understanding of differences in size structures between areas	4	6	24	E
13	Declining average size of lobsters	5	6	30	E

14	Decreasing CPUE (TAC not reached since 2001)	5	6	30	E
Non-retained species					
15	Gear entanglements of vulnerable species (seabirds, cetaceans, turtles)	4	3	12	M
16	Entanglement of seabirds, seals, turtles etc. in bait box strapping	4	3	12	M
General Ecosystem					
17	Loss of fishing gear: ghost fishing	3	6	18	H
18	Direct habitat damage through mining (erosion, plumes, sedimentation, accidental capture)	4	6	24	E
19	Indirect habitat impacts (smothering) on lobster prey e.g. mussels	4	6	24	E
20	Wider impact of recreational fishery	3	5	15	M
21	Food web implications of removing lobster (prey and predators)	5	4	20	E
22	Perceived localised changes in ecosystem which result in change of fishing grounds (for e.g. lice eating bait, high bycatch of whelks)	5	4	20	E
23	Line fishing for bait (fishing for gurnard)	2	6	12	M
24	Direct and indirect damage to habitats (reefs and seabird islands) by wrecks of lobster fishing vessels	4	4	16	H
25	Disturbance to seabirds by illegal recreational landings on islands	4	6	24	E
26	Large quantities of sulphur stored in the harbour	5	5	25	E
Research capacity and Data management					
27	Limited scientific capacity and resources	5	6	30	E
28	Limited data on recreational fishery (size, number, areas) due to limited monitoring	2	6	12	M
29	Inadequate working conditions at sea for observers	3	6	18	H
30	Communication between observers and MFMR regarding standardisation of data collection and required training	4	6	24	E
31	Inaccurate logbook information	4	6	24	E
32	Insufficient observer coverage (limited by resources)	4.5	6	27	E
33	Limited stock assessment skills	4	6	24	E

34	Lack of technical skills (e.g. divers for diving surveys)	5	6	30	E
35	Limited funding for research needs	3	5	15	M
Human Wellbeing					
Industry Wellbeing					
36	Loss of local knowledge through the loss of experienced skippers and crew	3	6	18	H
ID	**ISSUE**	**CONS**	**LIKE**	**RISK**	**Category**
37	Outdated fishing technology and gear reduces fishing efficiency	3	6	18	H
38	Southward shift in catch increases cost of production	2	4	8	M
39	NamPort rates and fees undermine the profitability of the fishery	5	6	30	E
40	Observer fees pose a financial burden	5	6	30	E
41	Access to global markets is limited by remote location of Lüderitz	5	6	30	E
42	Limited market options (partly because of suboptimal stock or low catches)	5	6	30	E
43	Decreasing CPUE results in higher fishing costs for smaller catches	5	6	30	E
44	Limited transport technology from fishing grounds to factory reduces product quality	2	6	12	M
45	Individual rights are not viable (especially new entrants/small quota holders)	5	6	30	E
46	Employer - employee relations leads to strikes and decreases productivity	5	6	30	E
47	Need for a 'fisheries bank' to aid the fishery	5	6	30	E
48	Labour law doesn't accommodate the sea faring employer	5	6	30	E
49	Changing consumer preferences and lack of eco-label	3	4	12	M
Community Wellbeing					
50	Proportional contribution of the lobster fishery to the local economy is reduced	4	6	24	E
51	Loss of jobs due to decreases in profitability	4	6	24	E

52	Socio-economic knock on effects of unemployment e.g. increase in crime, access to health care, access to education etc.	4	6	24	E
53	Secondary & tertiary businesses are affected by changes in the fishery	4	6	24	E
54	Seasonal nature of fishery affects the quality of employment	4	6	24	E
55	Lack of communication between line ministries (e.g. MTI, MoHSS, MoE, MLGH) and local government to mitigate socio economic challenges	5	6	30	E
56	Industry issues are not effectively conveyed to the general public nationally	2	5	10	M
57	A collapse in the recreational fishery could impact on local tourism and community recreation	3	4	12	M
Governance					
58	User conflict between fishing and mining sectors	4	6	24	E
59	Need for communication and joint research between SA and Namibia about the shared stock with SA (shared larval pool)	3	4	12	M
ID	**ISSUE**	**CONS**	**LIKE**	**RISK**	**Category**
60	Limited communication between MFMR and the industry	4.5	6	27	E
61	There is poor communication between management and scientists	5	5	25	E
62	Lack of management of recreational sector	2	6	12	M
63	Lack of communication between different ministries	3	6	18	H
64	Limited skilled manpower in fisheries management	3	5	15	H
65	High turnover of staff	5	6	30	E
66	Delayed response times from decision maker	5	6	30	E
67	Poor communication between FOA and MFMR	4	5	20	E
68	Need for decentralisation of power within MFMR from Windhoek to Lüderitz	4	6	24	E

69	Need for understanding of role of FOA and to facilitate communication	5	6	30	E
70	Lack of policy on subsidies	3	5	15	H
71	The need to review the qualification requirements	5	6	30	E
72	Penalties do not act as a deterrent	5	6	30	E
73	Lack of law enforcement skills leads to reduced convictions	4	6	24	E
74	Lack of specialised courts	4	6	24	E
75	Need to reinstate Lüderitz stakeholder forum with broad representation	5	6	30	E
76	Lack of a scientific working group with stakeholder representation	3	6	18	H
77	Lack of a Rock Lobster management plan	5	6	30	E
78	Lack of incentives to comply	4	6	24	E
79	No verification of fishing in misreported areas (VMS)	5	6	30	E
80	Need for improvement of enforcement of fishing regulations	5	4	20	E
81	The need for island based staff to receive honorary fishery inspector status: the risk of not having them there	4	5	20	E

Performance Reports

The complete performance report table can be found in Annex 3. The following section will distil some of the key data requirements and management responses to the issues outlined above within the three main ERA components. Please refer to the complete performance reports for a more overall understanding of these needs.

Ecological Wellbeing

Further collaboration between the fishing industry and the MFMR Lüderitz Marine Research centre (LMR) is necessary to tackle the issue of at-sea handling effects on juveniles and females in berry. Suggestions were made of investigating other mesh designs and possibly increasing the mesh size to 80mm. Further improvements on the stock assessment model currently used (De Lury model) are necessary, and additional, more reliable data needs to be included into the model in future (e.g. observer data; environmental parameters; recruitment, growth and distribution data etc.). The need to assess stocks by fishing areas was identified and suggestions were made to extend the surveys to include historical and new fishing grounds.

The interaction between the mining industry and the fishing industry needs to be better understood and appropriate management actions must be identified. Central to this is the need to draft and complete a Rock Lobster Management Plan for the recreational and commercial fisheries. The mining industry (i.e. Namdeb) put forward an invitation to the rock lobster industry for a site visit to better understand mining operations and facilitate communication between these two industries. A monitoring program must be established to quantify the illegal capture of rock lobster. The uncertainty of the illegal capture should also be incorporated into the stock assessment model.

The interactions between non-retained species (e.g. cetaceans, turtles, birds) and the rock lobster industry need to be better understood, especially the entanglement of animals in the gear and the bait box strapping. It was suggested that the observer data be expanded to include incidental capture and awareness raised around the consequences of slack gear. The overall fishing impact on the marine habitats and other ecologically important areas needs to be better understood and mitigated for through the development and implementation of the Rock Lobster Management Plan and the establishment of an Emergency Action Plan (or oil contingency plan). Gear loss needs to be quantified and minimised, and a central database established where information of recovered fishing gear can be stored. A regular monitoring program of intertidal and reef ecology should be initiated to better understand the role of the rock lobster within the food web, as a predator and as prey. Current data needs to be analysed to identify indicator species, as well as future research opportunities to understand reef ecology.

Human Wellbeing

The conditions of rights given to the fishing industry need to be reviewed as individual rights are not seen as being viable currently. The financial pressure placed on the fishing industry through fees (to the FOA and the NamPort) also needs to be reviewed and the process made transparent and available to the public. With the long-term sustainability of the fishery in question, the idea of a potential "fisheries bank" was put forward for further investigation. Extensive research needs to be undertaken in identifying international market opportunities to ensure future profitability of the fishery.

No specific law is currently in place for regulation and stipulation of rights of sea-going staff. Thus, the need for a marine labour law was identified, which should be incorporated into the current Labour Act of Namibia to ensure good employer-employee relations.

Communication needs to be facilitated and information transmitted between MFMR and the fishing industry through pre-season briefings and explanations of regulations. A multi-ministerial forum should be established to facilitate communication between line ministries, local government and non-governmental organisations (NGOs) to mitigate for socio-economic challenges that may arise in the future. An integrated strategic plan for Lüderitz has been undertaken by the Lüderitz Town Council, but a socio-economic plan for the rock lobster fishery should be incorporated to ensure secure, high quality employment. More strategic use of the media is needed to ensure the issues of the fishing industry and their potential effect on community wellbeing are being conveyed to the general public.

Governance

The lack of a Rock Lobster Management Plan lay at the heart of many of the issues raised within the Governance category (as in the other categories), and all participants agreed that this needs to be addressed as soon as possible. The Annual Research meetings should be reinstated, as well as the Lüderitz stakeholder forum, in order to ensure communication between MFMR, Lüderitz community members, the fishing industry and other interested and affected parties. The internal Rock Lobster Working Group must be reinstated to meet bi-annually to ensure communication between industry, managers, observers, the inspectorate, and also the mining industry when appropriate.

Improved communication is also needed within MFMR between the Windhoek Head Office and the Lüderitz office. MFMR Head office must delegate some decisions to the Lüderitz MFMR (LMR) as some decisions can be made locally and implemented as deemed appropriate.

Lastly, career paths need to be enhanced for scientists to retain expertise with the Ministry. International collaborations are seen as key to building human capacity with the Ministry and to adequately understand EAF in this sector.

Table 2. Summary of Performance Reports developed for issues scoring a risk rating of 'Moderate' or higher

ID	Operational objective	Issues	Management response	Target	Indicators	Responsibility	Notes
Ecological Wellbeing (EW)							
Retained species							
EW1	At sea handling techniques – minimise risk of increased natural mortality on juveniles and females in berry.	1,2,8, 9,17	*Current:* mesh size limit for commercial traps = 65 mm, some vessels are using an increased mesh size of 70mm. There is a closed season; regular checking on grounds for proportion of lobster in berry; continue egg surveys and ensure sufficient capacity and skills to undertake them effectively and in a timely manner *Future:* increase mesh size; further testing of 80mm mesh size and other methods (such as escape grids) in collaboration with industry; investigate mesh design: square versus diamond mesh; testing identifies appropriate measure, acceptance by stakeholders, action by	Less than 20-30 % of catch undersized; season closes or opens when <20% mature females are in berry	Proportion of undersized lobsters in catch or females in berry	Research (LMR)	A sorting grid experiment was conducted and found to be successful but there was concern that it lead to lobster damage. It was therefore not implemented. Further grid and mesh experiments on traps were conducted and results showed that an increase in mesh

			decision makers, implementation				size was recommended.
EW2	The life history parameters of target species are adequately understood and incorporated in stock assessment.	11,12, 14, 15, 16, 17	Current: assessment (De Lury model) based on commercial data more than survey data; commercial catch and effort data and commercial size frequency; recruitment index from larval settlement, average size distribution (observer data) Future: need to improve model, need to incorporate observer data, more time series, more analysis on observer data need to incorporate into stock assessment, start conducting FIMS; standardisation of data through incorporation of environmental variables using General Linear Models (GLMs)	Reliable information to be incorporated into an improved stock assessment model (recruitment, growth, distribution) Size structure and sex ratios of fishing areas mimics that of non fished areas e.g. lobster sanctuaries	Recruitment index validated, growth index, CPUE if below certain level, age of female maturity, average size, (Note: indicators of stock status not comprehensive enough); presence and comprehensive analysis of reliable data pertaining to above. Sex ratio and size structure of rock lobster population	LMR	

					understood. *TBD (to be discussed further)		

ID	Operational objective	Issues	Management response	Target	Indicators	Responsibility	Notes
EW3	The spatial distribution and genetic variability of target species are understood and incorporated into stock assessment procedures or other appropriate management action	7,11, 13,17	Current: observer data, survey and logbook data spatially explicit; South Africa investigating genetic variability; QMAs: quota allocated per region (north and south); surveys insufficient to cover entire distribution; Future: need to assess stocks by fishing ground (area); need to extend surveys to include historical and new fishing grounds	Knowledge of shared stock (confirmation); manage in spatially explicit manner;	Biomass estimate and size structure for each fishing area	LMR	
EW4	Impacts of the mining sector	3, 4, 24, 25,	*Current:* NAMDEB is undertaking the following through the use of independent	Platform to facilitate	TBD	Mining sector, LRM, rock	Samicor and De Beers marine

	on the Rock Lobster fishery are quantified, understood and appropriate management actions are identified.	17	consultants: rocky shore monitoring, sandy beach monitoring, shallow subtidal monitoring, studies on fine tailings' positions, monitoring of nearshore communities, plume modelling and water quality measurements of dredging activities, offshore benthic surveys, numerous beach accretion studies,. MFMR completing desktop studies and the process of developing an MPA management plan *Future:* Invitation to rock lobster industry for site visits to mining operations; closer collaboration to be revived (limited MFMR capacity) continue monitoring, evaluate results so far, improve capacity within MFMR to verify NAMDEB and other mining companies' data; summarise reports into easily understandable format for general public	communication between various sectors; fishing industry, MFMR and mining sector are not in conflict, agreed mitigation measures exist where there is consensus; TBD		lobster industry	Namibia were not represented at the workshop and thus their activities are not recorded here. Dredging for other minerals is also not captured here.
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**

	(through bait box strapping) of vulnerable species is minimised		sea *Future:* Need for baseline information, spatially referenced. Improved enforcement. Plastic on ships will be phased out in next 7 months	phased out	incidences reported	and LMR	with ghost fishing and lost gear, marine litter. Need enforcement
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**
FW8	Entanglement (with gear) of vulnerable species is minimised	19	*Current:* Report from skippers *Future:* Review observer data. Incidental capture recorded in logbooks. Reduction in slack of fishing gear; need to raise awareness around the consequences of slack gear. Liaison of entanglement occurrence and frequency between observers, skippers and MFMR, research.	Baseline data is collected. Every incidence reported.	Number of incidences	LMR, observers, the inspectorate and the industry	
General Ecosystem							
FW9	Fishing impact on marine habitats and	27,34,35,26	*Current:* MPA, TAC *Future:* MPA regulations need to be	Have an effective oil Emergency Response	TBD biological indicators of habitat health; oil	DMA (Department of Maritime Affairs	

EW5	Illegal capture of Rock Lobster is minimised and uncertainty is built into the stock assessment	5,6,17, 35, 92	*Current:* inspectors, observer program, patrols *Future:* island staff appointed as honorary fisheries inspectors; more efficient enforcement, increase observer coverage and inspections, improve follow up between observers and compliance; appropriate penalties; improve accessibility of regulations e.g. newspapers and attached to permit	Reduction in proportion of convictions, increase in inspections, 100 % observer coverage, appropriate penalties	Number of inspections, convictions	Inspectorate, observer agency	
EW6	Combined effects of the commercial and recreational fishery are understood and incorporated into management actions	17,17, 26,38	*Current:* limited quantification of recreational fishery *Future:* monitoring program implemented	Reliable landing information. Length frequency, size and sex ratio	Baseline data	Inspectorate and LMR	
Non-Retained species							
EW7	Entanglement	18	*Current:* Illegal to leave or dump gear at	Bait box straps	Number of	The industry	Could be grouped

	ecologically important areas have been assessed, quantified and appropriate management actions have been implemented		enforced; Emergency Action Plan (oil contingency plan) in case of wreckages occurring; the science behind the TAC recommendation needs to be improved (e.g. closed areas) ; ecological important areas need to be identified, a Rock Lobster Management Plan needs to be developed and implemented	Developed	contingency drills are conducted on a regular basis; ecologically sensitive areas identified	in Ministry of Works, Transport and Communication MWTC), Namport, mining and fishery industries, LMR	
EW10	Gear loss and ghost fishing are minimised	22	*Current:* Ghost fishing experiments have been conducted in the past; industry traps are marked *Future:* quantify all gear loss and bring it together in a database per area; information from fishing gear recovered by fishing industry should be included in the database; each vessel should have a tracking system (records) of their gear that could be inspected; assessment of ghost fishing under swell conditions; improve patrol inspections and beach	Reduce the number of fishing gear losses	Number of traps lost and recovered	Industry; (Namdeb re co-ordination of collecting traps in closed areas) Inspectorate.	

ID	Operational objective	Issues	Management response	Target	Indicators	Responsibility	Notes
			clean-up; penalties or fines for loss gear; incentives for gear recovered				
EW11	Risk posed by general marine pollution is minimised (including littering)	23,26	*Current:* regulations are in place but not enforced *Future:* regulations need to be improved; waste management plans for the vessels; improve report of littering by observers; beach clean ups to quantify	Have a decreasing rate of litter	kg of litter /km (CPUE)	Inspectorate, NAMPORT responsible for checking off-loading of rubbish from vessels	
EW12	There is good understanding of the role of Rock Lobster as a predator and prey in the trophic web. The biomass needed to ensure stability	28,30	*Current:* good information exists elsewhere, limited information locally *Future:* regular monitoring of intertidal and reef ecology; analysis of current data; research program to have a background understanding of reef ecology (benthos vs. crustaceans); identify indicator species	Consolidation of existing knowledge; come up with recommendations; to have reliable results from comparative studies; key species identified;	Density of mussel, urchins and whelks	LMR	

	in the ecosystem has been quantified and formally included in management procedures.			long term target: incorporate above into management advice			
EW13	The impact of fishing for gurnard for bait is adequately understood and incorporated into management advice	31	*Current:* No baseline data regarding stocks, biology of the spp., etc.; 150 Kg limit per boat per day (max. 1050Kg. per week), experimental for this season, to be re-evaluated after the season *Future:* baseline information on gurnard biology, biomass; monitoring of the catches; review regulation based on improved understanding and make recommendation	Good understanding of gurnard stock; frequency distribution; catch regulations based on scientific data;	TBD	LMR	
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**
Data management and research capacity							

EW14	Good research capacity, skills and funding is available to adequately understand EAF in this sector.	37, 43, **44**	*Current:* high turnover of good research capacity *Future:* separate bureaucracy/admin from research; enhance career paths for scientists; facilitate international collaboration; identifying Key Performance Indicators/Areas (KPI/As); attract skilled personnel; science should be of a higher priority to the Directorate, skills development mechanisms (e.g. training courses); the Ministry needs to have proper collaboration with other academic institutions of repute; fill vacant posts and address frozen posts	Scientifically peer review (external) advanced to management; Marine Centre of Excellence recognised internationally	Number of scientific publications per year, percentage of MFMR budget spent on scientific research and percentage spent on EAF; proportion of time allocated to research as opposed to administration	MFMR, Public Service Commission (PSC)	
EW15	An observer programme is operational and provides accurate information to inform the	39, 40, **42**	*Current:* Observer Programme in place, some useful data is collected for stock assessment *Future:* Data collected from observers should be reviewed/improved to include EAF issues; EAF training; review observers	100% observer coverage i.e. every vessel has an observer on every trip; everybody (industry	% observer coverage	Inspectorate and LMR	

	management of the sector.		qualifications and induction training required; improved analysis of observer data	included) understands the observers' role			
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**
FW16	Appropriate data systems are in place to adequately understand recreational sector dynamics	38	*Current:* there are some inspections on recreational fishery but data is not collected *Future:* gather sex, size and landing information from recreational fishery and incorporate into management decisions regarding permits; dive surveys in recreational areas	Reliable information exists on recreational fisheries landings, which can be incorporated into TAC recommendation s	Numbers, sizes, sexes	Inspectorate and LMR	
FW17	Logbooks provide accurate information to base management decisions	41	*Current:* logbooks are filled in by skippers, penalties are not enforced; checked by observers *Future:* increase awareness in industry of EAF and importance of accurate data gathering in logbooks; develop a cross-checking system; consider amending	Timely reliable information. Completed forms	Consistency between landings and logbooks.	Inspectorate, skippers, LMR, observers	

ID	Operational objective	Issues	Management response	Target	Indicators	Responsibility	Notes
			logbooks to Include EAF factors				
Human Wellbeing							
Industry Wellbeing							
HW1	Individual rights are economically viable.	55	*Current:* Time period for Levy/observer fees to be paid have been extended, vessel sharing exemptions may have been granted *Future:* Review conditions of rights e.g. sharing of vessels btw rights holders (especially in critical periods when catches are low); Investigate "fisheries bank"	All rights are economically viable: Quotas are filled i.e. TAC is reached	Proportion of quotas filled		50% of quota is allocated to small rights holders; issue at present because of poor fishing
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**
HW2	Long-term profitability of the fishery is ensured.	47,48, 49,50	*Current:* Meeting held between Fisheries Minister, NAMPORT and fishing industry, but nothing resolved. A working group was established, but never met. FOA has requested Future funding from the government.	Differential fee structure per sector e.g. cargo, fishing vessels, passenger liners and mining; Transparent	% of fees in relation to production cost		

			Future: MFMR to put pressure on NAMPORT to review fees, external review observer fees and audits to ensure transparency and publically available	external audit of observer fees, X % of fees in relation to production cost			
HW3	Management of the fishery is aimed at long-term stability and financial security.	53,58, 81	*Current:* *Future:* Investigate "fisheries bank"	Profitable and stable fishery	Profit margin		all measures addressing stock status will contribute to this objective
HW4	Good employer - employee relations ensure optimal productivity.	56,59	*Current:* No specific labour law for sea-going staff, brought to the attention of the Minister of Labour *Future:* Develop a marine labour law which incorporate the Merchant Shipping Act	Marine Labour Law or precedent that clarifies, Fishing commences at the beginning of the season.	Numbers of days lost to striking		
HW5	Relevant members of the industry have the necessary knowledge to	46	*Current:* *Future:* Needs analysis; sharing of information between MFMR and the industry, pre-season briefing which	Fishing takes representatively	Proportion of fishing in hotspots		

	implement responsible and sustainable fishing practices.		includes explanation of regulations, consider spatial planning and management .e.g. management grid/SA case				
ID	Operational objective	Issues	Management response	Target	Indicators	Responsibility	Notes
HW6	The industry has good access to international markets.	51,52, 54,60	*Current:??* Dave Russel report *Future:* Lobster association will be undertaking extensive research investigating market opportunities	Increased market options	No of markets		
HW7	Living conditions on board Rock Lobster vessels are adequate.	39,57	*Current:* Legal standards exist *Future:* Review legal standards and their implementation, enforcement of legal standards	Adequate legal standards are implemented across the fleet	Proportion of vessels implementing legal standards		
Community Wellbeing							
HW8	A healthy and profitable Rock Lobster fishery contributes proportionally	61,62, 63,64	*Current:* Some activities to diversify local economy underway e.g. promotion of tourism *Future:* Socio-economic section of Rock	The proportional contribution of the RL fishery to the local economy is	% contribution of the RL fishery to the local economy	MFMR, town council	

	to the local economy		Lobster plan completed, integrated strategic plan for Lüderitz	maintained or increased			
HW9	The sector provides high quality and secure employment.	62	*Current:* *Future:* Integrated strategic plan for Lüderitz which considers the seasonal nature of the fishery, consider incentives for labour intensive practices e.g. use of dinghies (Note: barrier is that many crew can't swim)	The number of jobs provided by the RL fishery is maintained or increased	Number of jobs in the RL industry	MFMR, town council	Some migrant workers from the North
HW10	There is a good understanding of socio-economic drivers and management policies are implemented to provide incentives to maximise	63,64	*Current:* *Future:* Need to understand the socio-economic context and drivers (including the quantification of the extent to which secondary businesses are dependent on the RL industry, provide recommendations to management	Socio-economic drivers identified and incentives to maximise community benefits	Gender ratio/no of females employed, number of migrant workers ...	Town council, MFMR	

	community benefits.						
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**
HW11	Collaborations between line ministries (e.g. MTI, MoH, MBE, MLGH), local government and NGOs to mitigate socio-economic challenges	66	*Current:* National development plan under development??? *Future:* Multi-ministerial forum to facilitate communication	Multi-ministerial forum exist and meets regularly; multi-lateral decisions are taken and implemented	No of meetings, no of participants, no of decisions implemented	MFMR, MTI, MoHSS, MoE, MLGH	The fishing industry of often neglected from integrated development plans because it contributes a relatively small component of the GDP, but locally it is very important
HW12	Industry issues and their effect on community wellbeing are effectively conveyed to the general public	67	*Current:* ad hoc media, Rock Lobster festival, Lüderitz Crayfish derby *Future:* More strategic use of the media		No of media hits	RL Association, LMR	
HW13	An effectively managed	68, 73	*Current:*	Management Plan which	No of recreational		

	recreational fishery provides tourism opportunities and community recreation		*Future:* Refer GOV4 Revise after MPA is proclaimed, once Sperrgebiet is opened	incorporates recreational fishery, tourism plan	fishers		
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**
Governance							
GOV1	Effective participatory management fora (e.g. Working Groups) are functioning.	71,72, 74, 69, 78, 80, 86, 87	*Current:* Reports are available from mining sector; scientific reports from the Ministry; Advisory council meeting once a year for TAC recommendations ; Fisheries Management Council (FMC) in existence; Quarterly reports to the Minister from the scientists; Scientific reports based on observer data disseminated to the observers *Future:* Annual research meeting should be reinstated; Lüderitz forum needs to be reinstated; Need for an internal working group (Rock Lobster Working Group to be	Lüderitz forum meets twice a year, and attended by mining, fishing, MFMR, MME, MET, town council - to start 2009; Rock Lobster Working Groups to start 2008 - meeting before season (October) and	Number of meetings; number of participants	MFMR (Lobster section)	Rock lobster working group to may incorporate Lüderitz Forum functions and aspects

			reinstated, incl. industry, managers, researchers, inspectorate, observers - mining invited when appropriate) to meet bi-annually, just before the season starts to involve the skippers and just after the season ends; improved informal communication between scientists and observers during the season; WWF-Responsible Fisheries training	after the season, and is attended by fishing industry, managers, researchers, inspectorate, observers;			
GOV2	Decentralisation facilitates efficient and timely decision making	77,79	*Current:* Recommendations and internal memos; informal communication (phones, faxes, emails); current decision-making is in Head Office *Future:* Decide which decisions could be made locally and implement as appropriate; general improved communication channels from Head Office to coastal offices	Regular communication; appropriate decision-making (e.g. transferral of quota from one area to another decided by LMR and Inspectorate, not Head Office); timely decision making that ensures optimal utilisation of the	Industry related decisions made by LMR and Inspectorate; response time	LMR	

resource

ID	Operational objective	Issues	Management response	Target	Indicators	Responsibility	Notes
GOV3	MFMR (e.g. PPI, Resource management) has adequate capacity to implement fisheries management advice and decisions	75, 76	*Current:* Some skills-development opportunities exist *Future:* Improved career path for staff; improved salaries for staff; performance-based incentives; job satisfaction surveys; review capacity needs; fill vacant posts; improve management skills; review decision-making process by management	All posts filled; average staff retained for 5-10 years; appropriate level of expertise	Proportion of posts filled; average length of employment term	Office of the Prime Minister (OPM), MFMR	Drivers - salaries; career advancement opportunities; frustrated by inefficiencies within the Ministry
GOV4	Rock lobster management plans which incorporate EAF considerations for all three dimensions of EAF are in place and peer reviewed.	73, 88	*Current:* Elements of a Rock Lobster Management Plan exist *Future:* Fill vacant positions; Draft Rock Lobster Management Plan; Stakeholder consultation; Amended and adopted Rock Lobster Management Plan; step before draft management plan is to identify individuals responsible for other components, (socio-economic, &	Rock Lobster Management Plan (commercial and recreational sectors) adopted and supported by relevant stakeholders; implemented	Report status; process milestones	LMR, head office, PPE, operations	

			governance), then co-ordination into a draft				
GOV5	Appropriate regulatory mechanisms exist and adequate follow-through provides effective disincentive for non compliance.	83, 84, 85, 91, 92	*Current:* Unsatisfactory penalties do exist (N$300 Admission of Guilt (AoG)) *Future:* Island-based staff given honorary fishery inspector status; AoG should be raised to a more appropriate amount (does not always have to be utilised but power exists); training on procedures, regulations, report-writing and evidence-led investigations; more inspectors with the responsibility to deal with cases reported; improved feedback between observers and inspectors on reported cases	Appropriate increase in AoG; increased follow-up leading to increased convictions; increase in successful prosecutions, decrease in non-compliance	Number of convictions; number of convictions relative to reported cases	Inspectorate	
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**
GOV6	Adequate voluntary incentives are in	89	*Current:* Long-term rights allow for a long-term view on sustainable utilisation of the resource	Existence of incentives	Number of incentives	LMR, PPE; Inspectorate	

	place to reward good compliance by industry (e.g. performance review procedures, eco-labelling, etc).		*Future:* Performance review criteria should include convictions i.e. those complying to regulations have a higher chance of retaining their rights than those that have not; ministry should investigate the pros and cons of eco-labelling; multi-stakeholder forums communicate benefits of compliance				
GOV7	All aspects of MCS are functioning well and are leading to good compliance.	90, 92	*Current:* No VMS requirements; occasional patrol vessel inspections; observers onboard lobster vessels; island staff not honorary inspectors but report on suspected illegal activities *Future:* Investigate pros and cons of implementing VMS on lobster vessels; island staff given honorary inspector status; implement MPA management plan	Honorary inspectors; VMS investigated; MPA management plan implemented	Proportion of convictions from island reported cases; reported convictions on closed-area violations	Inspectorate; PPE; LMR	VMS data provides valuable information to inform the understanding and management of the fishery and ecosystem in general in addition to the MCS application.
ID	**Operational objective**	**Issues**	**Management response**	**Target**	**Indicators**	**Responsibility**	**Notes**

GOV8	Regional co-operation is operational and has been institutionalized (e.g. BCC).	70	*Current:* BCC ratified and office in process of being set up *Future:* Functional BCC office; functional ecosystem working group; sharing of information and collaborative research between South Africa and Namibia; harmonization of management advice	Collaborative research and harmonisation of management btw South Africa and Namibia; Ecosystem Working Group meet regularly and is well-attended by relevant stakeholders	Number of research projects; number of peer-reviewed papers; number of working group meetings and participants attending meetings	MCM; DRM, BCC	

Annex 1: List of participants

Name	Affiliation
Cynthia Gomez	Namdeb
J. P. Roux	Ministry of Fisheries and Marine Resources
Jessica Kemper	Ministry of Fisheries and Marine Resources
Isak Aluvilu	Fisheries Observer Agency
Elwin Kruger	Fisheries Observer Agency
Pineas Andreas Ekandjo	Fisheries Observer Agency
Petrus Siloka	Fisheries Observer Agency
R. D. Shanjengange	Namibian Rock Lobster Industry
Astrid Jarre	University of Cape Town (UCT)
Michael Mackenzie	Namibian Rock Lobster Industry
Ursula Witbooi	Namdeb
H. Ndeutopo	Fisheries Observer Agency
Samantha Petersen	WWF-South Africa
Nicola Okes	WWF-South Africa
Janine Basson	Ministry of Fisheries and Marine Resources
Heidi Currie	WWF-South Africa
Erich Maletzy	Ministry of Fisheries and Marine Resources
I. Davids	Namibian Rock Lobster Industry
Kolette Grobler	Ministry of Fisheries and Marine Resources

Annex 2: Complete list of all issues raised and their consequence, likelihood and risk ratings

Note: Risk score is product of the consequence score (CONS) and the likelihood score (LIKE)

ID	ISSUE	CONS	LIKE	RISK	Category	NOTES
Ecological Wellbeing						
Retained species						
1	Decrease in fishable biomass of lobster resource and consequent increases in fishing effort (traps, days at sea) leads to undersized lobster being repeatedly recaptured. Handling increases risk of mortality and impacts on growth	3	6	18	H	Increase from 100 to 150 traps per vessel; handling of recaptured undersized lobster can have negative impacts - increased chance of mortality
2	Extension of fishing season resulting in an increased capture of females in berry	4	6	24	E	Seem to be coming into season earlier in recent years. Fishing extension prior to females coming into berry is not as problematic.
3	Direct take of rock lobster by mining industry (e.g. especially during mass migration)	4	4	16	H	Mining technology changes therefore need to review annually
4	Noise pollution (from fishing and mining sectors) may affect lobster behaviour	3	4	12	M	Unknown effect on rock lobster
5	Illegal capture of lobster by recreational fishery	3	6	18	H	including undersized lobster
6	Illegal capture of lobster by commercial fishery	4	6	24	E	This was more of an issue historically (including undersized and unreported landings and misreported catches between

						areas)
7	Localised overfishing and/or population decline	4	6	24	E	
8	The effect of boat based inappropriate sorting of undersized juveniles leads to increased chances of mortality and impacts on growth	4	4	16	H	
9	The effect of boat based inappropriate sorting of females in berry	4	5	20	E	
10	Retained bycatch of kob, kingklip, gurnard and octopus impacts on these stocks	0	5	0	Negligible	Stock status unknown for the south. Two or three kingklip caught in a day (not even a tonne for the year)
11	Lack of understanding of population dynamics and distribution	5	6	30	E	Including understanding of recruitment and growth
12	Targeting of large lobster by recreational fishery may impact on recruitment and thus have negative effect on commercial fishery	1.5	2	3	L	Recreational targeting largest size, commercial targeting smaller sizes (market dependent). Limited recreational area but unknown effort/catch in restricted areas
13	Possible southward shift of lobster population	1	3	3	L	Shift southwards would be towards the mining sections
14	The higher proportion of capture of males may impact population structure	2.5	4	10	M	Larger males mate with females; larger females have more eggs - losing out. Approx 80mm plus are returned
15	Poor understanding of differences in size structures between areas	4	6	24	E	

16	Declining average size of lobsters	5	6	30	E	
17	Decreasing CPUE (TAC not reached since 2001)	5	6	30	E	
Non-retained species						
18	Gear entanglements of vulnerable species (seabirds, cetaceans, turtles)	4	3	12	M	Known to occur but rarely
19	Entanglement of seabirds, seals, turtles etc. in bait box strapping	4	3	12	M	
20	Bycatch of crabs, klipfish, small demersal sharks, jacopever	0	6	0	Negligible	No assessment of the impact on bycatch species
21	Bycatch of whelks	0	6	0	L	
General Ecosystem						
22	Loss of fishing gear: ghost fishing	3	6	18	H	Change in fishing practices have lead to fishers no longer tending their traps , leaving them vulnerable to storm conditions etc and being lost (fishing vessels transporting catch ashore instead of transport vessel); during storms the traps roll and lobsters can't escape
23	General (land based and sea based; all except oil) pollution can impact rock lobster	1	2	2	L	Includes littering
24	Direct habitat damage through mining (erosion, plumes, sedimentation, accidental capture)	4	6	24	E	For industry to review, need collaboration on this issue
25	Indirect habitat impacts (smothering) on lobster prey eg mussels	4	6	24	E	no significant impact on rock lobster so monitoring every 2 years

26	Wider impact of recreational fishery	3	5	15	M	E.g.. more pollution, driving on beaches etc.
27	Direct damage to benthic habitats by fishing gear (setting of traps)	2	4	8	L	
28	Food web implications of removing lobster (prey and predators)	5	4	20	E	
29	Oil pollution (not limited to lobster vessels)	3	2	6	L	
30	Perceived localised changes in ecosystem which result in change of fishing grounds (for e.g. lice eating bait, high bycatch of whelks)	5	4	20	E	32 and 30 are linked
31	Line fishing for bait (fishing for gurnard)	2	6	12	M	No assessment of the impact on baitfish species; approx a tonne of gurnard per vessel.
32	Linefishing for snoek	0	6	0	Negligible	
33	Impact on horse mackerel (for bait)	0	6	0	Negligible	
34	Direct and indirect damage to habitats (reefs and seabird islands) by wrecks of lobster fishing vessels	4	4	16	H	impact of oil, no contingency plan, will impact inshore MPA areas and islands, can only be really solved at governance level
35	Disturbance to seabirds by illegal recreational landings on islands	4	6	24	E	
36	Large quantities of sulphur stored in the harbour	5	5	25	E	Potential of a fire exists which would result in the release of Sulphuric Acid

Research capacity and Data management						
37	Limited scientific capacity and resources	5	6	30	E	Analysis
38	Limited data on recreational fishery (size, number, areas) due to limited monitoring	2	6	12	M	
39	Inadequate working conditions at sea for observers	3	6	18	H	Intimidation by crew; safety, impact on data quality collected
40	Communication between observers and MFMR regarding standardisation of data collection and required training	4	6	24	E	
41	Inaccurate logbook information	4	6	24	E	E.g. spatial quota (landing mismatched with logbook) E.g. Poor recording of lost gear
42	Insufficient observer coverage (limited by resources)	4.5	6	27	E	Seasonal fluctuations due to other vessels from other fisheries needing observers. Insufficient funding for observers
43	Limited stock assessment skills	4	6	24	E	
44	Lack of technical skills (e.g. divers for diving surveys)	5	6	30	E	
45	Limited funding for research needs	3	5	15	M	
Community Wellbeing						
Industry Wellbeing						
46	Loss of local knowledge through the loss of experienced skippers and crew	3	6	18	H	Can lead to localised overfishing of well known grounds
47	Outdated fishing technology and gear reduces fishing efficiency	3	6	18	H	Ageing vessels
48	Southward shift in catch increases cost of production	2	4	8	M	Higher cost of longer trips. Driven by market because smaller catches (in terms of

						tonnage) are in the south. Stronger lobsters are now found in the south.
49	Namport rates and fees undermine the profitability of the fishery	5	6	30	E	
50	Observer fees pose a financial burden	5	6	30	E	
51	Access to global markets is limited by remote location of Lüderitz	5	6	30	E	Transport infrastructure limits the export of live product
52	Limited market options (partly because of suboptimal stock or low catches)	5	6	30	E	There is a need to diversify markets; at present very dependent on the Japanese market
53	Decreasing CPUE results in higher fishing costs for smaller catches	5	6	30	E	
54	Limited transport technology from fishing grounds to factory reduces product quality	2	6	12	M	Possible barrier to potential higher value product
55	Individual rights are not viable (especially new entrants/small quota holders)	5	6	30	E	Conditions of rights could be more flexible e.g. sharing of vessels (100t fishery); small quota holders dependent on larger quota holders for markets, technology etc
56	Employer - employee relations leads to striking and decreases productivity	5	6	30	E	
57	Sub-optimal living conditions on board some vessels	2/5	1/6	2/30	*L/E	*Divergent views in group therefore two scores recorded
58	Need for a 'fisheries bank' to aid the fishery	5	6	30	E	"Fisheries bank" = access to loans
59	Labour law doesn't accommodate the sea	5	6	30	E	

	faring employer					
60	Changing consumer preferences and lack of eco-label	3	4	12	M	Industry plans on investigation eco-labelling; current market is Japan
Community Wellbeing						
61	Proportional contribution of the lobster fishery to the local economy is reduced	4	6	24	E	Mining has proportionally become more important which won't last in the long-term; the need for diversification of economy
62	Loss of jobs due to decreases in profitability	4	6	24	E	
63	Socio-economic knock on effects of unemployment e.g. increase in crime, access to health care, access to education etc.	4	6	24	E	
64	Secondary & tertiary businesses are affected by changes in the fishery	4	6	24	E	Boat building, supermarkets (less money to spend)
65	Seasonal nature of fishery affects the quality of employment	4	6	24	E	Temporary jobs which don't qualify for benefits etc.
66	Lack of communication between line ministries (e.g. MTI, MoHSS, MoE, MLGH) and local government to mitigate socio-economic challenges	5	6	30	E	
67	Industry issues are not effectively conveyed to the general public nationally	2	5	10	M	
68	A colapse in the recreational fishery could impact on local tourism and community recreation	3	4	12	M	Discussion focussed on reviewing recreational areas and consider artisanal fishery
Governance						

69	User conflict between fishing and mining sectors	4	6	24	E	
70	Need for communication and joint research between SA and Namibia about the shared stock with SA (as Namibia shares a larval pool with SA)	3	4	12	M	Current theory is that there is the possibility of a shared stock but there is potential for joint research beyond that. Possibly link with Benguela Current Commission (BCC) to address this.
71	Limited communication between MFMR and the industry	4.5	6	27	E	TAC often communicated late i.e. just before season starts which limits planning
72	There is poor communication between management and scientists	5	5	25	E	
73	Lack of management of recreational sector	2	6	12	M	Bag limits and permit conditions not reviewed. Monitoring should enable management to make informed decisions.
74	Lack of communication between different ministries	3	6	18	H	E.g. would be useful to know impact of the rock lobster recreational fishery on tourism
75	Limited skilled manpower in fisheries management	3	5	15	H	
76	High turnover of staff	5	6	30	E	Loses institutional memory; effort of retraining.
77	Delayed response times from decision maker	5	6	30	E	
78	Poor communication between FOA and MFMR	4	5	20	E	E.g. feedback to observers during the season
79	Need for decentralisation of power within MFMR	4	6	24	E	To facilitate speedy/independent

	from Windhoek to Lüderitz					decision making; empowerment of the region
80	Need for understanding of role of FOA and to facilitate communication	5	6	30	E	i.e., need for forum to bring together observers and industry
81	Lack of policy on subsidies	3	5	15	H	Equality between sectors regarding access to hidden subsidies
82	The need to review the qualification requirements	5	6	30	E	Qualification requirements too rigid; not acknowledging experience for sea going fishermen. Ministry of transport's MWTC legislation
83	Penalties do not act as a deterrent	5	6	30	E	N$300 not sufficient (AOG); needs to be relevant to the socio economic context of the fishery (and the person being fined); relevant also to the fishery i.e. recreational vs. commercial
84	Lack of law enforcement skills leads to reduced convictions	4	6	24	E	Inspectorate has high staff turnover
85	Lack of specialised courts	4	6	24	E	
86	Need to reinstate Lüderitz stakeholder forum with broad representation	5	6	30	E	
87	Lack of a scientific working group with stakeholder representation	3	6	18	H	
88	Lack of a Rock Lobster management plan	5	6	30	E	
89	Lack of incentives to comply	4	6	24	E	E.g. in rights review; improved awareness

						and training for crew regarding legislation
90	No verification of fishing in misreported areas (VMS)	5	6	30	E	May need to install VMS
91	Need for improvement of enforcement of fishing regulations	5	4	20	E	Need to enforce full set of issues and legislation and address inconsistencies, need to have the ability (the means) to do it
92	The need for island based staff to receive honorary fishery inspector status: the risk of not having them there	4	5	20	E	

Appendix 3

Ontological tree of grouped issues within the Namibian Rock Lobster Fishery

APPENDIX 3.

Ontological tree of grouped issues

1. **ROCK LOBSTER RESOURCE**
    1.1. STATE OF RESOURCE
        1.1.1. Reduction in mortality
        1.1.2. Reduction in number of juveniles caught
        1.1.3. Reduction in number of females-in-berry caught
        1.1.4. Reduction in poaching
    1.2. POPULATION BIOLOGY
        1.2.1. Distribution of rock lobster
        1.2.2. Size structure
        1.2.3. Confirmation of shared larval stock with South Africa

2. **GENERAL ECOSYSTEM**
    2.1. STATE OF GENERAL ECOSYSTEM
        2.1.1. Entanglement of vulnerable species (Seabirds, cetaceans, turtles)
        2.1.2. Food web implications of removing rock lobster
        2.1.3. Understand attributes of gurnard population
    2.2. POLLUTION
        2.2.1. Dumping at sea (bait box strapping etc.)
        2.2.2. Ghost fishing
        2.2.3. Improved Oil Spill Contingency Plan (OSCP)
        2.2.4. Sulphur stored in harbour – potential for pollution

3. **MINING**
    3.1. EFFECT OF MINING ON ROCK LOBSTER HABITAT
        3.1.1. Direct take of rock lobster
        3.1.2. Effect of noise pollution on rock lobsters
    3.2. EFFECT OF MINING ON GENERAL ECOSYSTEM
        3.2.1. Direct habitat damage through mining (erosion, plumes, sedimentation, accidental capture of other species)
        3.2.2. Indirect habitat impacts (smothering) on lobster prey e.g. mussels

4. **COMMERCIAL FISHING**

4.1. FISHING EFFORT

4.1.1. Number of viable individual fishing rights

4.1.2. Number of quotas

4.1.3. Number of fishing licenses

4.1.4. Fishing zones

4.1.5. Catch distribution

4.1.6. Number of vessels

4.1.7. Combined effect of commercial and recreational fishery

4.2. BAD FISHING PRACTICE

4.2.1. Undersized rock lobster caught

4.2.2. Females-in-berry caught

4.2.3. Inappropriate boat-based handling techniques

4.2.4. Localised overfishing

4.2.5. Illegal capture of rock lobster

4.3. SOCIAL ENVIRONMENT OF FISHING

4.3.1. Good living conditions aboard vessels

4.3.2. Good employer-employee relations

4.3.3. Passing on of fishing experience and knowledge

4.4. INTERACTION BETWEEN OBSERVERS AND FISHERS/SKIPPERS

4.4.1. Good understanding between fishers/skippers and observers

4.4.2. Industry perception of observers

5. RECREATIONAL FISHING

5.1. FISHING EFFORT

5.1.1. Number of fishing licenses

5.1.2. Catch distribution

5.1.3. Combined effect of recreational and commercial fishery

5.2. BAD FISHING PRACTICE

5.2.1. Illegal capture of rock lobster

5.2.2. Catching of undersized rock lobster

6. ECONOMIC FACTORS

6.1. FACTORS INFLUENCING SALES

6.1.1. Number of markets (local and foreign)

6.1.2. Access to foreign markets

6.1.3. Demand

6.1.4. MSC approval/eco-labels

6.1.5. Proportional contribution to the Lüderitz community

6.1.6. Number of jobs

6.2. EXPENSES

6.2.1. Observer fees

6.2.2. NamPort fees

6.2.3. Fuel price

6.3. INCOME

6.3.1. Income

7. MARINE ENVIRONMENTAL POLICY

7.1. RESOURCE MANAGEMENT

7.1.1. Improved stock assessment

7.1.2. Understand combined effect of commercial and recreational fishery

7.1.3. Research

7.1.4. Improved logbook data

7.1.5. Regulation of fishing activity (through policies, observers etc.)

7.1.6. Incentives for industry compliance

7.1.7. Adequate penalties

7.1.8. Honorary island staff inspectors

7.1.9. Enforcement

7.2. FUNDING

7.2.1. Funding

7.3. STAFF RETENTION

7.3.1. Job evaluations e.g. number of peer reviewed articles

7.3.2. Maximise experience of employees

7.3.3. 100% posts are filled

7.4. GOOD COMMUNICATION

7.4.1. Decentralisation of decision-making power

7.4.2. Forums for dissemination of information

7.5. POLLUTION MANAGEMENT

7.5.1. Update OSCP

Appendix 4

Detailed description of specific objectives and suggested indicators of the Ecological Wellbeing of the Namibian Rock Lobster Fishery

APPENDIX 4.

Detailed description of specific objectives and suggested indicators of the Ecological Wellbeing of the Namibian Rock Lobster Fishery

(Refers to section 3.4.1 in the main text and Figure 10a)

Overarching objectives from the ERA workshop that were decided on by all stakeholders were disaggregated into more specific objectives through simply asking 'How?' e.g. 'a sustainable Rock Lobster resource' (a general objective) is attained *how;* through 'good productivity' and 'low mortality' of the resource (more specific objectives); 'Good productivity' of the resource is attained *how*; through a 'good habitat' (most specific objective). To suggest possible indicators, questions were asked regarding how the most specific objectives could be measured e.g. how can a 'good habitat' be measured? These were answered in terms of what influences the resource in terms of abundance, productivity and distribution i.e. 'sea surface temperature (SST)', 'dissolved oxygen (DO)', 'swell' and 'wind' (speed and direction), all of which influence the abundance and productivity of the resource, albeit indirectly. Following this example, the following specific objectives were decided on through consultation with stakeholders, and corresponding potential indicators suggested, after which value trees were circulated again to stakeholders for comments and/or critiques.

It must be emphasised here that this work represents the first phase of a multi-phase process to establish accepted and useful indicators and accompanying reference points; the next step would be to identify a way of merging these into combined indicator(s) affecting Rock Lobster wellbeing/ecological wellbeing. This will require much further dedicated research, which is beyond the scope of this current thesis. What is presented here is a first attempt at identifying potential indicators and this is done with a firm understanding that this work needs much further refinement and discussion before being acceptable as indicators for the ecological wellbeing of the Namibian Rock Lobster fishery.

ECOLOGICAL WELLBEING: Sustainable Rock Lobster resource

- *Good productivity: Good habitat*

Specific objective(s): Tracking favourable environmental conditions

Indicator(s): Composite indicator (still to be defined and tested), including sea surface temperature (SST), bottom dissolved oxygen (DO), wind and swell

Suggested indicator component: Sea surface temperature (SST)

Characteristic: SST gives an indirect indication of the abundance and productivity of Rock Lobster.

Description: Temperature has been identified as one of the primary factors influencing somatic growth rate in spiny lobster (Hazell *et al.* 2001) and SST is known to influence Rock Lobster distribution and abundance (Grobler and Noli-Peard 1997). This in turn affects the distribution of commercial catches, so that care must be taken to disentangle favourable conditions for rock lobster (growth, production) from favourable conditions for rock lobster fishing (catchability). In the same way, SST influences recreational fishing; SST is one of the environmental factors influencing the duration and frequency of lobster dives. SST is closely related to wind speed; during periods of calm conditions, SST has been shown to increase by as much as 6ºC due to solar warming, thus conducive to primary productivity i.e. plankton blooms as increased food available to the lobsters (Grobler 2007). Hazell *et al.* found that temperature, along with diet, affected grow-out of lobsters significantly and optimal growth was at 15ºC. Depending on wind strength (which would affect the mixed layer depth), SST gives an indication of Rock Lobster productivity and distribution, especially in shallower waters. SST is measured every working day at the Lüderitz harbour, the fisheries jetty and near one of the local mariculture sites, using a bucket and mercury thermometer (Grobler *pers. comm.*). The data is stored on a central Excel database. For the purposes of this thesis, the indicator time series is shown on the timescale of the fishing season i.e. 1st of November till 30th of April of the following year (Figure 11 in the main text). This applies for all indicators, where data is currently available. Ideally, the indicator should reflect the influence of SST on Rock Lobster for a full year.

Boundary point(s): Newman and Pollack (1971) found that *J. lalandii* tended to avoid water with SST of 10-13°C. Hazell *et al.* found that juvenile Rock Lobster tended to have the highest growth rate at 15ºC. Crear *et al.* (2000), working on a similar cold water species of Rock Lobster, *Jasus edwardsii*, found that, given adequate food quality and quantity, lobsters thrived at temperatures of 18ºC.

<u>Good</u> ~13 ºC – 18ºC

<u>Bad</u> < 13 ºC and > 18ºC

Properties: Although Pollack and Shannon (1987) found consistent trends of SST and lobster catches in the southern and northern Benguela, these authors suggested that *J. lalandii* is not likely to be adversely affected by slight changes in SST *per se*. Because lobsters are benthic organisms, SST does not give a direct indication of their environment. Thus, SST alone is not a sufficient indicator of the wellbeing of the resource with respect to the abiotic environment; only when combined with other environmental parameters, such as wind, swell and dissolved oxygen, does it give a good indication of the influence of the environment on the wellbeing of the resource.

Suggested indicator component: <u>Bottom Dissolved Oxygen</u> (DO)

Characteristic: Bottom concentrations of DO give a direct indication of the environment and a direct indication of the abundance and distribution of the resource.

Description: Bottom concentrations of DO have been shown to affect Rock Lobster distribution, availability and abundance (Beyers and Wilke 1990). Grobler and Noli-Peard (1997) showed that lobster depth distribution coincided with changes in bottom concentrations of DO during dive surveys conducted off the coast of Lüderitz. Experiments performed by Beyers *et al.* (1994) showed a reduction in growth and ingestion rates in juvenile Rock Lobster exposed for prolonged periods of time to reduced concentrations of DO. If exposed to levels of DO less than 2ml/L seawater for extended periods of time, Rock Lobsters tend to move out of the area (Grobler 2007). Bottom DO concentrations is a good indicator of the distribution of the resource, as lobster will migrate to avoid low oxygen water. It is this behaviour that eventually results in mass walk-outs when lobsters get trapped in shallow water by upwelling or shorewards-moving oxygen depleted water. There have been a number of lobster walk-outs in Namibia in the south (Luderitz) and the central region (Walvis Bay to Swakopmund), most recently in 2008 (Louw 2008). A large phytoplankton bloom was observed in Walvis Bay harbour during the weekly monitoring sampling, which, with an increased demand for oxygen, led to anoxic conditions within the water column. The low oxygen conditions forced the lobsters into the surf zone and intertidal pools where they were easy prey targets.

In extended-fisheries independent monitoring survey (FIMS) conducted along the southern Namibian coast from Chameis Bay to Mittag (including the commercially important Kerbe Huk southern Namibian lobster grounds) between January 2005 and September 2006, Pulfrich *et al.* (2006) noted a strong inverse relationship between seabed dissolved oxygen levels, and lobster trap-fishing catch rates.

Boundary point(s): Newman and Pollack (1971) found that *J. lalandii* tended to avoid water with dissolved oxygen below 2 ml/L. Grobler and Noli-Peard (1997) showed that lobsters were abundant at bottom DO concentrations of above 3ml/L. Pulfrich *et al.* (2006) showed that catch rates essentially showed a step function, with catches being unaffected by dissolved oxygen levels above 2.3 ml/L, but dropping rapidly to near-zero below 2.3 ml/L.

<u>Good</u> >3ml/L

(<u>OK</u> >2.3ml/L, ≤3ml/L)

<u>Bad</u> ≤2.3ml/L

Properties: Weekly DO measurements are taken on various lobster reefs off the coast of Lüderitz. Bottom DO concentrations gives a good indication of the distribution of the resource. When utilised in conjunction with measurements of SST and wind direction and speed however, it has been shown to be a very good indicator of the stock (Grobler and Noli-Peard 1997).

Suggested indicator component: Wind speed (m/s)

Characteristic: Wind direction (and strength) gives a direct indication of the environment and an indirect indication of the abundance, productivity and availability of the resource.

Description: Lüderitz lies near one of the principle upwelling cell of the Benguela Current (Shannon 1985). This upwelling cell is driven by south-westerly winds at Lüderitz that prevail throughout the year, with lowest speeds in autumn-winter. The duration of upwelling varies from a few days of strong south-westerly winds, particularly in summer (January – April), to two-week periods of uninterrupted winds at a daily average of more than $5m/s^2$ in spring (September – December) (Grobler and Noli-Peard 1997). High wind speeds inevitably mean rougher conditions at sea and more difficulty in setting and hauling traps (Grobler 2007). In areas exposed to predominantly longshore south-westerly winds, Hudon (1994) observed low catches and high annual variability in catch rates.

Boundary point(s): Calmer conditions, i.e. low wind speed, mean increased SST, which is conducive to primary production (i.e. plankton blooms). On days of Northerly winds inshore advection of warmer offshore surface water occurs, which is then down-welled against the coast, which would cause an increase in bottom dissolved oxygen and hence good conditions for Rock Lobster.

Good daily average ≤5m/s

Bad daily average ≥13 m/s

Properties: Wind speeds are measured every day on an hourly basis on Ichaboe Island. Grobler and Noli-Peard (1997) found indication of an inverse relationship between daily catch rates and the strength of prevailing south-westerly winds. Wind speeds are closely linked with both DO and SST; there exists a complementary relationship between these parameters. Thus, when combined with SST and DO, it gives a good indication of the conditions for Rock Lobster.

Suggested indicator component: Swell conditions [height of waves] (m)

Characteristic: Swell gives a direct indication of the environment and an indirect indication of the abundance of the resource in a preferred habitat.

Description: High swell reduces the number of fishing days as setting the traps becomes more difficult and traps cannot be hauled when waves are breaking over lobster reefs where they have been set. The morning swell (08h00) affects fishermen as they haul their traps in the early morning and the evening swell (20h00) affects the nocturnal feeding lobsters. Grobler and Noli-Peard (1997) showed a significant negative correlation between daily catch rates and swell. Rock Lobsters are also known to reduce or even cease feeding during times of strong bottom surges caused by high swell conditions (Grobler 2007).

Boundary point(s): Visual estimations of swell height are made and recorded as the percentage of days of the month where wave height is >2m.

<u>Good</u> wave height ≤2m

<u>Bad</u> wave height >2m

Properties: Currently, visual estimates of swell are made 3 times a day at Ichaboe, Mercury and Possession Islands. The visual measurement of swell (which differs depending on island staff's ability to assess swell conditions) makes it difficult to compare measurements between islands. However, this still gives a good estimate of swell conditions. Studies done in the past show an increased CPUE during months of relatively low swell conditions (e.g. Dec 2007, Jan-Feb 2008), and very low CPUE during months of high swell conditions (e.g. Mar-Apr 2008) (Maletzky 2008). A time series measuring swash on Ichaboe Island on a daily basis shows that, with increased swash conditions (i.e. strong bottom surges), CPUE declines (Maletzky 2008). As an indicator for the wellbeing of the resource (as contrasted to catchability in the fishery), evening swell would be the indicator of choice.

- *Good productivity: Good food*

Specific objective(s): Favourable benthic community structure

Indicator(s): <u>Still to be defined and tested; possibly densities of mussels</u>

Suggested indicator: <u>Densities of different mussel species</u>

Characteristic: Benthic community in itself is however not an indicator, but a *group* of potential indicators. Indicators of benthic community structure could be ratios of different feeding guilds or species in terms of biomass or the relative contribution of different prey species for Rock Lobster, as examples. Mussels (*Aulacomya ater* and *Choromytilus meridionalis*) (and urchins) constitute the main food source for *Jasus lalandii*. Thus, the fraction of mussels (and urchins) within the benthic community structure i.e. the available prey items, is an indirect indicator of the abundance and distribution of Rock Lobster.

Description: The discharge of tailings is an inevitable consequence of marine diamond-mining activities. The significance of such discharge depends on the nature and volume of the sediments being discharged and also the nature of the environment receiving such discharges. Mayfield *et al.* (2000) established that the growth rate of lobsters, which show strong dietary preferences, is related to the availability of preferred prey on the seabed (the food of choice for *Jasus lalandii* being ribbed (*Aulacomya ater*) and black (*Choromytilus meridionalis*) mussels). Reduction in availability of those preferred prey due to smothering by mud would therefore be expected to result in reduced growth. Whereas adults of many species can tolerate extended periods of sediment burial, it is more likely to detrimentally affect larval settlement and/or juvenile survival (Penney *et al.* 2007). Smothering of the substrate reduces both the sediment stimuli and the food supply for juveniles, which affects recruitment success of the disturbed macrobenthos and ultimately impacts upon the community structure. Nearshore reefs, islands and kelp beds play an important role as habitats for rock lobster, as well as being significant for post-puerulus settlement and juvenile recruitment (Tomalin 1996). The potential reduction or loss of suitable rock lobster habitat through large-scale smothering by mining-derived sediments is thus of particular concern in Namibia.

Shore-based diver units targeting rocky coasts can also damage or destroy intertidal and subtidal fauna through movement of mining equipment, removal of boulders from subtidal gullies into the intertidal zone or into rock piles, discard of tailings and other general activities of the contractors around the mining unit (Pufrich *et al.* 1998a). This diver-assisted mining is practiced in localised areas between Doring Bay in South Africa (~31°49"S) and Hottentots Bay in Namibia (~26°08"S) and thus the overall impact on intertidal communities is considered to be of medium significance (Pulfrich 2006).

Boundary point(s): There is a paucity of information on the specific physiological tolerance levels of southern African intertidal and subtidal species to increased and prolonged sedimentation. Saiz-Salinas & Isasi Urdangarin (1994), in a study along an estuarine siltation gradient in Spain, showed that increased sedimentation was correlated with a progressive decrease of algal and epifaunal species, and their progressive replacement by an assemblage of sediment-tolerant and opportunistic suspension feeders e.g. the Cape reef worm *Gunnarea capensis*, and algae, such as *Cladophora* sp., *Enteromorpha* sp. and *Ulva* sp (Pulfrich 2006). Because of this scarcity of data, the exact thresholds would still need to be discussed, clarified and decided on.

Properties: From the literature, it has been shown that, in sediment-influenced areas, species richness appears to be controlled by the frequency, nature and scale of disturbance of the system through sedimentation (McQuaid & Dower 1990). Thus, understanding the benthic community structure (including prey items such as mussels) is a good basis for understanding the wellbeing of the resource. (NOTE: Benthic community in itself is however not an indicator, but a group of potential indicators. Indicators of benthic community structure could be ratios of different feeding guilds or species in terms of biomass or the relative contribution of different prey species for Rock Lobster, as examples.)

- *Low mortality: Low fishing mortality: Good assessment: Good data: Combined effect of recreational and commercial fishery understood*

Specific objective(s): Combined catch of recreational and commercial fisheries is sustainable

Indicator(s): Still to be defined and tested, but suggested to be based on the following data categories:

Suggested data category 1: Recreational pressure (or recreational data information)

(a) Number of recreational permits sold

(b) An estimate of number and weight of lobster caught per area per year

(c) An indication of recreational catch size composition

Suggested data category 2: Commercial data information (or potential contribution to the fishery; to be collected on an annual basis)

(a) Catch, effort and CPUE (all areas combined and per area)

(b) Size composition and sex ratios of unsorted catch (all areas combined and per area)

(c) Percentage of unsorted catch < minimum size limit (all areas combined and per area)

(d) Percentage of unsorted catch > 60 mm CL but < 65 mm CL (all areas combined and per area)

Suggested data category 3: Illegally harvested (poached) lobsters (to be collected on an annual basis)

(a) Fishery component responsible for poached (confiscated) lobsters (commercial, recreational or other)

(b) Specific area from which poached

(c) Number, size composition and sex (including berries females) of poached lobster per year

(d) Estimate of total amount poached (kg/tonnes)

(e) Number of poaching-related arrests made and/or fines issues per year

(f) Annual register of transgressions of permit conditions by commercial industry – record number and type of transgressions together with boat or rightsholder number

These suggested data categories should be further discussed and formalised through intensive stakeholder consultation beyond the scope of this thesis. It should be kept in mind though that the rating of these suggested indicator categories and subsequent indicators should relate to how accurately these data were collected and the trends in the results of each sub-component over time.

Potential indicators and boundary points for the recreational and commercial fisheries specifically are suggested below.

- *Low mortality: Low fishing mortality: Good assessment: Good data: Recreational fishery quantified:*

Specific objective(s): Size distribution in catch reflects size distribution of rock lobsters in nature (which can be caught legally)

Indicator(s): Size distribution of confiscated catch (i.e. poached); Catch by area and size distribution: Median & suitable percentile to represent central tendency and spread

Suggested indicator: Size distribution of confiscated catch i.e. poached (mm)

Characteristic: The size distribution of confiscated illegally caught Rock Lobster is an indirect indicator of the productivity and abundance of the resource, as well as an indication of the fishing mortality (in combination with other indicators).

Description: Rock Lobsters are a high-value resource and the financial incentive to operate illegally is great. Thus, illegal capture of Rock Lobster (poaching) is rife within both commercial and recreational fisheries. Illegal activities comprise the occasional disregard of bag limits and selling of catch to either individuals or restaurants. Recreational permits are also issued for the diamond mining areas but monitoring is done in these "no-go" areas. Shannon *et al.* (2006) suggest using the size frequency of confiscated illegal catch as indicators in addressing the illegal catch of Rock Lobster in South Africa, which can also be done for Namibia. Cockcroft and Mackenzie (1997), using a multistage telephone interview of permit holders over the 1991/92 to 1994/94 fishing seasons to ascertain permit sales and estimates of total recreational catch (based on these sales and the average number of lobsters caught per permit holder over these seasons), included questions asking the interviewees whether they had permits for the lobsters they caught over these seasons. This information would be relevant in understanding the extent of poaching in the recreational fishery.

Boundary point(s): The legal size limit for Rock Lobster catches in Namibia is 65mm CL. Because of this, the boundary points are exact with no graduation between what would be considered 'good' and possibly 'OK'. Further discussion with stakeholders would be necessary to decide upon a possible graduation scale e.g. 'Good' ≥85mm CL and 'OK' ≥65mm CL. This explanation holds for any and all further references to CL in this text.

<u>Good</u> CL≥65mm (legal size limit)

<u>Bad</u> CL<65mm

Properties: Not much is known about the extent or the possible effects of poaching in Namibian waters, but the illegal capture of Rock Lobster needs to be quantified and included into the stock assessment. Much research is required to address and respond to the poaching issue more effectively.

Suggested indicator: <u>Catch by area</u> (per metre of coastline)

Characteristic: The mass of Rock Lobster caught per area gives an indirect indicator of the productivity and abundance of the resource, as well as a direct indication of fishing pressure (showing areas of localised overfishing).

Description: Cockcroft and Mackenzie (1997), using a multistage telephone interview of permit holders over the 1991/92 to 1994/94 fishing seasons to ascertain permit sales and estimates of total recreational catch (based on these sales and the average number of lobsters caught per permit holder over these seasons), included questions asking the interviewees what method of Rock Lobster fishing they employ, at or near which resort they have done their lobster catching and in total how many lobster they have caught. This information could also be collected in Namibia and would be relevant in understanding the distribution of catch within the recreational fishery.

Boundary point(s): <u>Good</u> ≤7 Rock Lobster per diver/recreational fisher; CL≥65mm (legal size limit)

<u>Bad</u> >7 Rock Lobster per diver/recreational fisher

CL<65mm

Properties: The catch per area would most likely be more of a direct indicator of the environmental conditions than of the resource. Because lobsters are highly mobile, they are capable of moving into deeper water away from the less experienced divers incapable of holding their breath for too long a time. However, when combined with other indicators, such as size distribution and the level of poaching, it can be a good indicator of the pressure applied to the resource by recreational users.

Suggested indicator: Size distribution: Median & suitable percentile to represent central tendency and spread (mm)

Characteristic: The size distribution of recreationally-caught Rock Lobster gives an indirect indicator of the productivity and abundance of the resource, as well as an indication of the fishing mortality (in combination with other indicators).

Description: Participation in the recreational fishery is by permit only (with a daily bag limit of seven lobsters), a minimum size limit of 65mm carapace length (CL) and lobsters must be caught by free diving. Lobsters caught for own use cannot be sold or offered for sale. Presently, there is no data collected on recreationally caught Rock Lobster. Thus, the effect of the recreational fisheries on the resource is not known. It is however possible to gain baseline information on the Namibian Rock Lobster fishery if necessary. Cockcroft and Mackenzie (1997) used a multistage telephone interview of permit holders over the 1991/92 to 1994/94 fishing seasons to ascertain permit sales and estimates of total recreational catch (based on these sales and the average number of lobsters caught per permit holder over these seasons). This can then be added to with current catch and size frequency data on recreational catch.

Boundary point(s):

Good CL≥65mm (legal size limit)

Bad CL<65mm

Properties: The size distribution of recreationally caught Rock Lobster gives a good indication of the abundance and distribution of the resource over the coastal area around Lüderitz. It gives a good indication of the areas in which juveniles/undersized lobsters may be more prevalent and could be useful in future management decisions regarding possible closed areas and/or MPAs.

- *Low mortality: Low fishing mortality: Good assessment: Good data: Commercial fishery quantified:*

Specific objective(s): Reduction in fraction of juveniles in confiscated catch i.e. poached lobsters; Size distribution in catch reflects size distribution of rock lobsters in nature (which can be caught legally);

Suggested indicator(s): Fraction of juveniles in confiscated catch by area

Characteristic: The size distribution of confiscated illegally caught Rock Lobster is an indirect indicator of the productivity and abundance of the resource, as well as an indication of the fishing mortality (in combination with other indicators).

Description: The incentive for poaching of Rock Lobster as a high value resource is very high in both recreational and commercial fisheries. In the commercial fishery, because there is not 100% observer coverage, the prevalence of poaching is very difficult to quantify. Vessels are also allowed to dock at night (J-P Roux *pers. comm.*), making it difficult for inspectors to monitor and record all lobster landed. Shannon *et al.* (2006) suggest using the size frequency of confiscated illegal catch as indicators in addressing the illegal catch of Rock Lobster in South Africa, which can also be done for Namibia. Socio-economic studies would also aid in understanding the incentives for poaching and to assess the economic forces possibly driving the larger-scale commercial illegal catching.

Boundary points:

Good	100% of confiscated catch ≥65mm CL
Neutral	80% of confiscated catch ≥ 65mm CL
Bad	50% of confiscated catch <65mm CL

Properties: The size distribution of confiscated catch in the commercial fishery combined with size distribution of unsorted catch gives a good indicator of the abundance, distribution and productivity of the resource. It also speaks of the fishing practice employed within the industry and gives a slight indication of the possible socio-economic pressure on the industry.

Suggested indicator: Catch by area (tonnes)

Characteristic: The mass of Rock Lobster caught per area gives an indirect indicator of the productivity and abundance of the resource, as well as a direct indication of fishing pressure (showing areas of localised overfishing).

Description: The distribution of catches for each fishing ground gives a good indication of where the most effort has been placed amongst all fishing grounds e.g. the southern fishing grounds of Namibia (Kerbe Huk mainly) carried the bulk (58%) of the 2007/08 season's catch. This was followed by the northern fishing grounds which accounted for 35% of the seasonal catch, and the central fishing grounds that yielded the lowest catch (2%) of the season (Maletzky 2008).

Boundary point(s): There are seven main fishing grounds in Namibian waters, in the Southern (Kerbe Huk), Central (SW Blinder and Marshall Reef) and Northern regions (Gallovidea, Hottentot Point, Black Rock and Saddle Hill). Catches and catch effort should be equally spread out between these fishing grounds i.e. TAC should be evenly distributed across all fishing grounds and no localised overfishing should be occurring.

Good ~14% of TAC caught at any one fishing area

Bad >50% of TAC caught in one fishing area

Properties: The distribution of catches for each fishing ground is an indication of which fishing grounds is potentially being overfished. In combination with other indicators (such as undersized lobsters caught and females in berry) it could be useful in future management decisions regarding possible closed areas and/or MPAs.

Suggested indicator: Size distribution: Median & suitable percentile to represent central tendency and spread (mm)

Characteristic: The size distribution of commercially-caught Rock Lobster gives an indirect indicator of the productivity and abundance of the resource, as well as an indication of the fishing mortality (in combination with other indicators).

Description: Current regulations include a minimum size limit of 65mm CL (based on the length of sexual maturity) and a mesh size limit for commercial traps of

65mm, with some vessels using 70mm mesh size. Observer coverage, currently close to 100%, is in place to enforce this minimum size limit.

Boundary point(s): Good CL≥65mm

Bad CL<65mm

Properties: The size distribution of commercially caught Rock Lobster gives a good indication of the abundance and distribution of the resource over the fishing grounds. The average length of unsorted Rock Lobster i.e. including undersized lobster, gives a good indication of the status of the stock; a declining average length would be cause for concern that the lobster stock is experiencing a change in population size structure and the adult stock is not recruiting fast enough to keep ahead of the fishing pressure. It gives a good indication of the areas in which juveniles/undersized lobsters may be more prevalent and could be useful in future management decisions regarding possible closed areas and/or MPAs.

- *Low mortality: Low fishing mortality: Good assessment: Good data: Good model:*

Specific objective (s): High quality stock assessment model

Suggested Indicator(s): Categorical classification of the quality of the stock assessment model

Characteristic: Incorporating environmental factors into the stock assessment would give a better indication of the abundance and productivity of Rock Lobsters, giving a better estimate for the TAC.

Description: Input data for the current model (DeLury) are commercial catch and effort since 1971, estimates of natural mortality, catch selectivity, and number of new recruits (65-69mm CL) and fully grown recruits (>69mm CL). The current model is felt to be very biased towards the fishing sector as it uses only commercial fishing data. Fisheries Independent Monitoring Surveys (FIMS) used to be undertaken but these only monitored the commercial fishing grounds and should incorporate data regarding the whole coastline). Because of a lack of research capacity and funding, it was discontinued (C. Grobler *pers. comm.*). Current stock assessment can be improved by incorporating additional, more reliable data and assessing stocks by fishing areas. It should incorporate environmental factors e.g. wind, sea surface temperature (SST), dissolved oxygen and swell as well as recruitment, growth and distribution data etc. The stock assessment should use data from fisheries research, observer logbooks as well as industry logbooks. The research surveys should include not only the commercial grounds, but should cover the whole coastline. Suggested covariates for the model are suggested here but these would still need to be reworked to be combined appropriately.

Boundary point(s): Good Model incorporating environmental factors, in addition to spatial distribution of resource, population dynamics, seasonality of resource, age at maturity, and the age/sex structure.

OK DeLury model

Bad No stock assessment model

Properties: Rock Lobster distribution is known to be affected by environmental factors such as temperature and bottom dissolved oxygen (Beyers and Wilke 1990, Grobler and Noli-Peard 1997, Hazell *et al.* 2001). Hudon (1994) observed low catches and high annual variability in catch rates in areas exposed to predominantly longshore south-westerly winds. Thus, incorporating environmental factors into the stock assessment would be a better indicator of resource abundance and productivity than the current model.

- *Low mortality: Low fishing mortality: Low exploitation rate:*

Specific objective(s): Low interannual variability in commercial catch per unit effort (CPUE)

Suggested indicator(s): Interannual differences in CPUE

Characteristic: Comparisons of CPUE gives a direct indication of the fishing mortality (and catch distribution) and abundance of the resource.

Description: A declining CPUE is cause for concern regarding the state of the resource and industry wellbeing. The 2006/2007 fishing season is testament to how poorly the fishing fleet has performed since 2000 (the CPUE of most vessels operating was below 1.5 kg/trap fishing days) (Grobler 2007). Historically, there have been reports of unreported landings and localised overfishing – additional pressure upon the resource which is not monitored or accounted for. In other Namibian fisheries, Vessel Monitoring Systems (VMS) were required to be installed on all licensed vessels by the 21st of March 2007 (C. Bartholomae *pers. com.*). This should apply for all licensed vessels operating in the Rock Lobster fishery and would ensure compliance to quotas and lobster sanctuaries, and would contribute to a better understanding of lobster distribution and abundance.

Boundary point(s): Good CPUE > 4 kg/trap fishing days (based on the CPUE in 2000)

Bad CPUE ≤ 4 kg/trap fishing days

Properties: The natural predation on a healthy resource i.e. one with a favourable environment for growth and good productivity and enough good prey items, combined with the fishing pressure should not have a negative impact on the stock. A declining CPUE is a definite sign of a stock in trouble. A stable (and increasing) CPUE is a good indicator of the productivity and abundance of the resource. If both effort and catches are taken into account, it is a direct, and good, indicator of the health of the stock.

- *Low mortality: Low fishing mortality: Good fishing practice:*

Specific objective(s): Reduction in the fraction of undersized specimens in commercial catch; Good compliance with seasonal closure for Female Rock Lobsters-in-berry in the catch

Suggested indicator: % undersized specimens in commercial catch

Characteristic: The number of undersized/juvenile Rock Lobster caught is an indirect indicator of the impact of the fishery on future recruitment.

Description: The capture of sub-legal sized lobsters in commercial trap-fisheries can lead to physical damage due to the loss of appendages. Surviving lobsters can and typically do regenerate these lost limbs, but at a long-term functional cost, such as reduced foraging efficiency, mating success, and increased vulnerability to predation (Juanes and Smith 1995). The prevalence of appendage loss is quite high for decapods in general, but particularly so for heavily exploited populations as contact with gear and handling by fishers increases appendage loss (Brouwer *et al.* 2006). Current regulations include a minimum size limit of 65mm CL (based on the length at sexual maturity) and a mesh size limit for commercial traps of 65mm, with some vessels using 70mm mesh size. At all the fishing grounds sampled, the legal sized male lobsters generally made up <25%, and the females <10%, of the overall number of lobsters handled by the fishermen. This means that, on average, 88.6% of the lobsters hauled on-deck and sorted by fishermen for the 2007/2008 season were thrown back into the ocean (approximately 2 051 tonnes) (Maletzky 2008).

Poor boat-based sorting techniques exercised by the crew result in damaged lobster returned to the sea with a lower chance of survival to reach maturity. Brouwer *et al.* (2006) showed that growth of lobsters with ≥3 missing limbs was significantly less than those with no missing appendages. Their studies suggest that increased injuries may cause lobsters to moult earlier, thus prolonging the overall moulting season for *J. lalandii.* They postulate that the net effect of prolonged, unsynchronised moulting may include natural mortality through higher rates of cannibalism (Brouwer *et al.* 2006). Melville-Smith and de Lestang (2007) showed that appendage damage is associated with the reduced probability of a female rock lobster (*Panulirus cygnus*) developing ovigerous setae and, if setae were produced, with the reduced probability that females would produce more than one batch of eggs within a season. These effects were more pronounced as the number of damaged appendages increased (Melville-Smith and de Lestang 2007). Future research is directed at possibly increasing the mesh size to 80mm and further collaboration is needed with the industry to investigate possible advantages of square versus diamond mesh design.

Boundary point(s): From workshop discussions, all stakeholders realise that the Namibian Rock Lobster stock is under severe pressure and the number of undersized lobster caught in the 2007/2008 fishing season is testament to this. Much emphasis should be placed on this indicator in the overall evaluation and for management follow-up, considering the magnitude of the number of lobster that are currently thrown back.

Good <25% of catch is undersized (i.e. <65mm CL)

Bad ≥25% of catch is undersized

Properties: The total number of juveniles caught by commercial fishing vessels is a good indicator of the fishing practice of the vessel. Under constant effort and practise, it also gives an indication of the productivity of the resource via indicating good or poor recruitment.

Suggested indicator: % compliance with seasonal closure for Female Rock Lobsters-in-berry in commercial catch

Characteristic: The number of Female Rock Lobsters-in-berry caught is an indirect indicator of the production of the resource.

Description: Poor boat-based sorting techniques are thought to negatively impact on the resource, in particular females-in-berry. Lobster caught in traps are more prone to loss of appendages which Melville-Smith and de Lestang (2007) showed can be associated with the reduced probability of a females (*Panulirus cygnus*) developing ovigerous setae. If setae are consequently produced, there will most likely be a reduced probability that these females would produce more than one batch of eggs within a season. These effects were more pronounced as the number of damaged appendages increased (Melville-Smith and de Lestang 2007). Current regulations include a closed season, when grounds are regularly checked for the proportion of lobsters-in-berry and regular egg surveys. Observer forms and/or skippers logbooks need to include the fraction of females-in-berry. Poor handling of females-in-berry could affect the recruitment index (through possibly dislodging of berry or maiming of lobsters), and can also bias the stock assessment. The recruitment index (R-index) is calculated as an anomaly of the long-term average pueruli settlement per crate in the Lüderitz lagoon (Maletzky 2008). Good recruitment was recorded during 2000/2001 and 2002/2003, while all the other years (including 2007/2008) generally had poor recruitment (Maletzky 2008), which may possibly be an indirect indication of damage to females-in-berry returned to the sea. Future research is directed at possibly increasing the mesh size to 80mm but further collaboration is needed with the industry to investigate mesh design (square vs. diamond mesh), which may exclude more females-in-berry or at least possibly damage them less.

Boundary point(s): From workshop discussions, participants felt strongly that the percentage of females-in-berry caught forms a good foundation for the decision to close the fishery i.e. a threshold level of females-in-berry caught can be allowed after which the season will be closed if a greater percentage than this is in the catch. Thus, the boundary points are based on compliance of the industry to this decision.

Good	100% compliance
Ok	90% compliance with closing the fishery if ≥25% mature females-in-berry are caught
Bad	<25% compliance with closing the fishery if ≥25% mature females-in-berry are caught

Properties: The fraction of female Rock Lobster in the catch, when combined with other indicators such as the number of undersized lobster caught gives a good indication of the fishing practices of the crew operating within the industry. The fishing practices are important in understanding the pressure placed upon the resource by the industry and in balancing the fishing pressure with the overall health of the resource. This suggested indicator, although maybe not be a direct indicator of ecological wellbeing, has been included here as it would be indicative of good fishing practise, which is integral to 'low fishing mortality'. If so decided through stakeholder consultation, this indicator could be more suited to the 'ability to achieve' branch and ultimately moved under that branch.

- *Low mortality: Low mining mortality:*

Specific objective(s): Low direct and indirect mortality of Rock Lobsters through mining-related activities i.e. mining effects on Rock Lobster quantified

Indicator(s): To be identified, defined and tested

Characteristic: Quantifying the effects of mining on the Rock Lobster resource gives an indirect indication of the abundance of the resource and the environment (because of sedimentation caused by mining activities).

Description: Declining Rock Lobster catches after 1980 and the associated development of coastal and marine diamond mining resulted in a rise of concern about the sustainability of the stocks and allegations that marine mining must at least be partially responsible for these declines. The impacts of diamond mining operations on Rock Lobster include (taken from Pulfrich *et al.* 2006):

- Direct damage to and mortality of adult, breeding and juvenile lobsters if they are sucked up during mining operations
- Illegal fishing for lobster during shore- and vessel-based mining operations
- Blanketing of nearshore reefs and bedrock outcrops and their associated communities by remobilising sediments discharged from treatment plants
- Emigration and/or reduced growth rate and fecundity of Rock Lobster in the mining areas due to loss of suitable habitat and reduction of availability, or direct disturbance by mining operations
- Inundation and loss of kelp bed habitats, potentially reducing suitable Rock Lobster recruitment habitats.

Scientific studies are undertaken regarding possible impacts of mining Rock Lobster but these studies are seen as biased as the consultants are paid by companies operating within the mining sector. Additionally, the reports produced by these consultancies are not circulated amongst stakeholders for comments and/or questions. Thus data and information regarding the effect of diamond mining on the resource are still limited, a severe weakness in this suggested category.

Boundary point(s): Understanding the impacts of mining on Rock Lobster, directly and indirectly, should be an overarching research objective. Specific indicators, and accompanying boundary points, would still need to be discussed further with relevant stakeholder groups. The user conflict that exists between the sectors makes any collaboration very difficult. It will however be imperative to reach consensus between stakeholder groups in order for this objective to be realised.

Good Independent monitoring of mining activities for *ALL* companies mining in the Rock Lobster area e.g. studies on beach accretion; impacts on macrofauna; changes in grain size of sand etc. and information is disseminated amongst stakeholders and impacts are understood and mitigated for.

OK Monitoring of mining activities for all *MAJOR* companies through independent studies, the information and data of which should be made available on specific request by other stakeholders and/or published in peer reviewed journals.

Bad Relative contribution of different mining companies/stakeholders not well understood. Monitoring of mining activities is considered inadequate (according to standard scientific practice in lieu of international mining standards).

Properties: Besides the impact made on the resource by fishing (commercial and recreational), additional pressure is placed on the resource through diamond mining activities. Mining in Rock Lobster areas is not going to cease within the near future and thus, for the effective management of the resource, these impacts need to be quantified and potential mitigation measures suggested. Currently, despite there being information and data on the impact of mining on Rock Lobsters, it is not being adequately disseminated amongst stakeholders and the antagonism which exists between the sectors perpetuates. Quantifying the effects of marine diamond mining on the resource, combined with data on the commercial and recreation fishing sectors, would give a very good indication of relative mortality induced in Rock Lobster through human activities.

- *Low mortality: Low predation (i.e. direct predation of Rock Lobster):*

Specific objective(s): Healthy predator populations e.g. bank cormorant

Suggested indicator(s): The IUCN status of the bank cormorant (*Phalacrocorax neglectus*) populations

Characteristic: The IUCN conservation status gives a good indication of the abundance and productivity of the species and whether urgent management measures are required.

Description: The bank cormorant is classified as endangered (IUCN 2008) and is endemic to both Namibia and South Africa, with between 80 – 90% of the species breeding on Mercury and Ichaboe Islands in Namibia (BCLME 2007). They feed inshore, sometimes amongst kelp beds, where their main prey items include pelagic Goby and *Jasus lalandii* (BCLME 2007). According to the final report of the BCLME project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME, the main threats to the bank cormorant population includes a lack of prey items, such as *J. lalandii* (other threats include predation of eggs and chicks by Kelp Gulls and Great White Pelicans, predation of adults and fledglings by Cape Fur Seals, oil pollution, human disturbance, drowning in lobster traps and diseases such as avian cholera). Crawford *et al.* (2008) considered the relationship between the trends in bank cormorants and recent changes in the distribution of Rock Lobster in the Western Cape. They found that the reduction of bank cormorants in the north of the Western Cape and increases in the south are consistent with recent changes in the production and distribution in the province of Rock Lobster (Crawford *et al.* 2008). With the decline in the Namibian Rock Lobster population, the diet of the bank cormorant has shifted to consist almost entirely of gobies (J-P Roux *pers. comm.*).

Boundary point(s): The specific boundary points for this indicator should still be discussed amongst researchers in some depth and consensus reached. The IUCN gives a summary of expert understanding of global bank cormorant populations, which are dependent on Rock Lobster stock as a primary food source. If there are good data available on trends in the Namibian bank cormorant population, this would ultimately be the best supplementation for this indicator.

<u>Good</u> IUCN conservation status of 'Least concern'

<u>Bad</u> IUCN conservation status of 'Endangered'

Properties: In an ecosystems approach to fisheries management, there needs to be a balance reached between the human induced impact on the resource and the wellbeing of natural predators of the resource. This is recognised in international conventions that Namibia is signatory to.

ECOLOGICAL WELLBEING: Minimise Impacts of Ecosystem

- *Minimise impacts on non-retained species: Minimal gear entanglement:*

Specific objective(s): Reduction in the number of incidences of vulnerable species entanglement reported and recorded

Suggested indicator(s): Number of incidences of vulnerable species entanglement reported and recorded

Characteristic: The number of incidences reported gives a direct indicator of the environment and ecosystem.

Description: The Rock Lobster fishery does incur detrimental effects upon the general ecosystem, which includes damage to benthic community structure and entanglement of vulnerable species (such as seabirds, sea turtles, cetaceans and seals) in gear and bait box strapping. There are incidences of bycatch (of small demersal sharks, crabs and klipfish) although the consequences of these incidences are considered to be negligible. However, according to the Namibian Marine Resources Act of 2000 (MFMR 2000), it is illegal to leave or dump any gear at sea. Despite this, the entanglement of vulnerable species in bait box strapping and gear is still quite prevalent within the fishery and, as yet, not quantified. There is a need for spatially referenced baseline information. Observer forms can and should be expanded upon to include information about entanglements.

The identification of vulnerable species such as seabirds, sea turtles and cetaceans can be difficult and require training to do so accurately. Currently, training workshops are run by the MFMR for the FOA in identification and sampling methodology of targeted species. In the event of an entanglement, neither the observers, skippers or crew are educated in identifying the species or trained in releasing the species (if possible) in such a manner as to incur as little damage as possible. As such, there is no baseline information regarding the effect of the fishery on the wider ecosystem. Entanglement of birds in lobster trap ropes is rare but does happen on occasion. The birds in question (Bank Cormorants and Crown Cormorants) are listed as endangered and near-threatened on the IUCN Red List of Threatened Species (IUCN 2008); thus any additional pressure on the existing population can have possibly devastating effects. There have also been reports of cetaceans entangled in lobster trap ropes, which can be avoided through raising awareness about the consequences of slack rope. Fines could possibly be imposed and act as a possible incentive for decreasing entanglements.

Boundary point(s): The FAO has established guidelines for responsible fishing, which gives thresholds of entangled species (specifically seabirds) allowed per unit of effort. This would however still need to be refined within the context of the Namibian Rock Lobster fishery through extensive discussions with stakeholders and further research. Granted, the Rock Lobster fishery is much smaller than many other fisheries operating within Namibian waters. International standards should still however apply.

Properties: Reporting and recording incidences of entanglement of vulnerable species in Rock Lobster gear and/or bait box strapping is a good indicator of the wider effect of the fishery on the general ecosystem. In combination with indicators such as the number of traps lost and recovered, the overall impacts of the fishery on the wider ecosystem can be quantified and mitigated for.

- *Minimise impacts on non-retained species: Minimal ghost fishing:*

Specific objective(s): Reduction in the number of Rock Lobster traps lost; Decreased discrepancy between numbers of traps lost and those recovered

Suggested indicator(s): <u>Interannual differences in numbers of Rock Lobster traps lost</u>

Characteristic: The number of traps lost and recovered gives a direct indication of pollution introduced by individual vessels.

Description: In recent times, there have been some changes in fishing practices that have resulted in fishermen no longer tending their lobster traps, leaving them vulnerable to storm conditions. Concern was raised in the workshop about the potential for ghost fishing with these discarded traps when swell increases and traps roll around on the benthos, sometimes fatally trapping animals. Although industry traps are marked, gear losses need to be quantified per fishing area and contained within a central database. Each vessel should have a tracking system for their own gear and there should be penalties and/or fines for gear loss, to be enforced by the Inspectorate. Field studies undertaken in the past by the MFMR show that traps on the seabed do not continue to fish indefinitely as virtually all test lobsters (marked for the experiment) escaped from the traps with two days (K. Grobler *pers. comm.*). However, these tests were undertaken during calmer conditions. Future research could thus be directed at assessing ghost fishing under swell (storm) conditions and also look at possible damage to reefs and benthos by heavy rolling traps. Observer forms could also be expanded to include possible gear losses.

Boundary point(s): The boundary points for this indicator will need to be discussed with stakeholders. Due to time constraints, this falls outside the scope of this thesis.

Properties: Recording the loss and regain of lobster traps per vessel in combination with recordings of entanglements of vulnerable species in Rock Lobster gear gives a good indication of the impacts of the fishery on the wider ecosystem.

- *Minimise impacts on non-retained species: No negative impact of using gurnard as bait:*

Specific objective(s): Decreased catch of gurnard; Good compliance with regulations in gurnard bait fishery

Suggested indicator(s): <u>Catch size and size distribution of gurnard (Median & suitable percentile to represent central tendency and spread)</u>

Characteristic: The mass of gurnard *Chelidonichthys capensis* caught per area gives an indirect indicator of the productivity and abundance of the resource, as well as a direct indication of fishing pressure (showing areas of localised overfishing).

Description: Currently, there is no baseline data regarding gurnard stocks and nothing is known about the biology of the species in Namibia. Fishing for gurnard as bait for the Rock Lobster fishery is experimental for this season and will be re-evaluated after the season.

Boundary point(s): Good ≤60 kg of gurnard fished per week

Bad >60kg of gurnard fished per week

Properties: The magnitude of catches of gurnard gives a good indication of the impact of a fishery for Rock Lobster bait.

- *Minimise damage to lobster habitat: Low pollution:*

Specific objective(s): Effective penalties in place for vessels leaking oil through operational Oil Spill Contingency Plan (OSCP); Decrease in the amount of litter reported upon docking; Good compliance with marine protected area (MPA)

Suggested indicator(s): Interannual differences in the numbers of pollution-related penalties through the OSCP

Characteristic: Interannual differences in the number of penalties should give an indication of the effectiveness of the OSCP. An operational OSCP, with prescribed and effective penalties, is a good indicator of the level of efficacy in reacting to environmental hazards.

Description: Oil leaked from Rock Lobster fishing vessels during fishing operations can have far reaching consequences on the wider ecosystem e.g. damaging reef habitats, immobilising vulnerable species such as seabirds and seals, suffocating filter-feeders etc. An oil spill contingency plan (OSCP) already exists but is outdated and, because of staff turnover within the various institutions, responsible parties are unaware of their duties in the case of an event. The OSCP must be updated and any waste incurred through fishing operations (besides offal) should be brought back to harbour in order to be cleared for the next trip out.

Boundary point(s): Good Operational OSCP i.e. responsible entities know their role in the event of an oil spill; regular oil spill drills are run; water quality checks are in place at relevant institutions e.g. MFMR NatMIRC sub-division Aquaculture.

Bad OSCP is outdated and/or relevant entities are not identified for mitigating oil spills; no chain of command in place in the event of an oil spill.

Properties: An operational OSCP gives a good indication of the governance and mitigation measures that are in place to deal with an emergency. In the case of any fishery, there is always the possibility of unforeseen leaking and oil spillages. An operational OSCP is necessary and needs to be continually updated to deal with new possible threats to the wellbeing of the ecosystem.

Suggested indicator: Database of litter (per vessel) recorded upon docking

Characteristic: Matching the record of what is taken onboard the vessel before a trip with what is brought back to port gives a direct indication of pollution introduced by individual vessels into the environment i.e. the state of the environment.

Description: According to the Namibian Marine Resources Act of 2000 (MFMR 2000), it is illegal to leave or dump any gear at sea. Despite this, vessels do still pollute; unintentionally through gear loss and intentionally through discarding plastics and other waste items overboard instead of returning it to port. Incentives are needed for industry compliance. Skippers report of bait box strapping tossed overboard during fishing operations, which could lead to the entanglement of vulnerable species such as turtles, seabirds or seals. An incentive is necessary for industry to bring their waste and discards back to port. Keeping a record of what vessels take onboard for trips and what they bring back will give a good indication of the pollution contribution of each vessel. It should be mandatory for vessels to be cleared for their next trips; a record of waste brought back to port would be a good prerequisite for clearance and thus a good incentive for industry compliance. Rubbish removal from vessels in ports is currently organised by the Namibian Ports Authority, NamPort. The vessel owner can pay for the removal of waste from the vessel as part of the landing fee to NamPort. Permit conditions

	stipulate no discarding. Thus, this needs to be actively enforced through appropriate penalties against transgressors. This will require closer collaboration than what is currently the case between NamPort, the MFMR, the Inspectorate and the industry.
Boundary point(s):	<u>Good</u> >80% waste/plastics/discards brought back to port <u>Bad</u> ≤80% waste/plastics/discards brought back to port
Properties:	Litter reported upon docking is a good indicator of the contribution of pollution of each individual vessel to the environment.

Suggested indicator:	<u>Record of VMS plots of Rock Lobster fishing trips</u>
Characteristic:	Marine Protected Areas (MPAs), if carefully designed to protect rock lobster, are a direct indicator of conditions conducive to ecosystem wellbeing and an indirect indicator of habitat conducive to good productivity of the resource. A record of the VMA plots for each vessel would show compliance with the declared MPA.
Description:	Namibia's coastline provides important retention areas and nursery grounds for juvenile and larval stages of Rock Lobster. MPAs have been shown to have spillover effects to adjacent fishing areas and provide an important role in sustaining lobster populations (Currie and Grobler 2007). Because lobsters are slow-growing and have low natural mortality, they are very susceptible to overfishing and need to be managed carefully. Namibia's first MPA was declared at the end of 2008 (H. Currie, WWF *pers. comm.*) and covers many important lobster areas e.g. north of Chamais Bay, an important lobster recruitment area for the commercial fishing grounds south of Chamais Bay (Currie and Grobler 2007).
Boundary point(s):	<u>Good</u> Specific MPA declared and enforcement of MPA regulations <u>Bad</u> No MPA declared
Properties:	Declaration of MPAs is a good indicator of the efforts of individual countries to manage their fisheries responsibly and in a sustainable manner. Possible effects of displacement of fishing activities, however, have to be managed very carefully. Possible additional indicators may therefore have to be devised.

➢ *Minimise damage to lobster habitat: Low mining impact:*

Specific objective(s): Mining effects on ecosystem known

Suggested indicator(s): To be identified, defined and tested; possibly % recommendations adhered to

Characteristic: The percentage recommendations adhered to by the mining companies e.g. NamDeb is a direct indication of how mining impacts are mitigated for. It also gives a direct indicator of the environment.

Description: Namdeb currently undertakes extensive studies through the use of independent consultants: rocky shore monitoring, sandy beach monitoring, shallow subtidal monitoring, studies on fine tailings' positions, monitoring of nearshore communities, plume modelling and water quality measurements of dredging activities, offshore benthic surveys, numerous beach accretion studies. These reports contain recommendations for NamDeb's information and follow-up. Understanding the impacts of mining on the wider ecosystem should be an overarching research objective. For management purposes, specific indicators, and accompanying boundary points, would still need to be discussed further with relevant scientific stakeholder groups. The user conflict that exists between the sectors makes any collaboration very difficult. Studies are currently being undertaken to understand and quantify mining impacts on both the Rock Lobster resource and the wider ecosystem. However, if recommendations put forward by the independent consultants are not followed up on, the impacts of mining are not being mitigated and the effects of mining on the ecosystem are not lessened.

Boundary point(s): Good >90% recommendations adhered to or followed up

Bad <70% recommendations adhered to or followed up

Properties: The percentage recommendations adhered to is a good indication of whether or not mining impacts are being mitigated in order to minimise the overall impact of mining.

Appendix 5

Outline of specific objectives for the 'Human Wellbeing' and 'Ability to Achieve' EAF pillars of the Namibian Rock Lobster Fishery

APPENDIX 5.

Outline of indicators for other EAF pillars ('Human Wellbeing' and 'Ability to Achieve') of the Namibian Rock Lobster Fishery

(Refers to section 3.4.2 in the main text and Figures 10b and 10c)

Indicators for the 'Human Wellbeing' and 'Ability to Achieve' (or governance) pillars of an EAF for the Rock Lobster fishery were discussed in the workshop with stakeholders. There were not many specific indicators agreed upon due to time constraints. Many 'indicators' shown in Figures 10b and 10c are, in fact, management objectives and most of these indicators, at present, cannot be measured. Formulation of these into indicators will rely specifically on expert scientific opinion; they will need to be refined through further discussion and collaboration with scientific stakeholders.

As was done for the ecological wellbeing pillar (Appendix 4), overarching objectives from the ERA workshop decided on by all stakeholders were disaggregated into more specific objectives through simply asking 'How?' To attain indicators, questions were asked regarding how the most specific objectives could be measured. Following this example, the following specific objectives and corresponding indicators were decided on through consultation with stakeholders, after which value trees were circulated again to stakeholders for comments.

It must be emphasised that this work represents the first phase of a multi-phase process to establish accepted and useful indicators and accompanying reference points. To refine these indicators and establish useful reference points will require much further dedicated research, which is beyond the scope of this current thesis. What is presented here is a first attempt at identifying potential indicators and this is done with a firm understanding that this work needs much further refinement and discussion before being acceptable as indicators for the human wellbeing and governance of the Namibian Rock Lobster fishery.

HUMAN WELLBEING: Maximise economic sustainability

- *Fees (observer and port fees) for participation in the Rock Lobster fishery:*

Specific objective(s): Good industry perception of observers; transparent audit of observer fees

Indicator(s): <u>To be identified</u>

Description: Fishers feel the financial burden placed on them through observer and port fees is very great. The high tensions between the fishers and observers are very evident; fishers feel they are paying for a service that observers are not delivering, and observers feel that the living conditions onboard the vessel are sub-standard. The perception of the observers by the industry is indicative of the level of communication and cooperation that exists between these two stakeholder groups. Presently, fishers do not understand what the fees they are required to pay is used for. A transparent audit of fees would facilitate trust, as well as entrench communication channels, between observers and industry.

- *Individual rights are economically viable:*

Specific objective(s): High percentage of quotas filled; viable rightsholders conditions

Indicator(s): <u>To be identified; possibly interannual differences in TAC filled</u>

Description: Presently, the fishery is dominated by small quota holders, which is seen by stakeholders as a problem due to poor fishing; 16 out of the 19 rightsholders were allocated a quota of 10.5 tonnes or less during the 2007/2008 season. Of the 777 130.05 NAD quota fees that were payable in 2007/08, only 748 131.65 NAD has been paid to date (MFMR 2008), mostly due to one rightsholder that was financially unable to gain access to a vessel and thus could not fill his quota. The TAC has not been reached since 2001 i.e. quotas have not been filled, which could be an indication of individual rights no longer being viable. The conditions of rights given to the fishing industry need to be reviewed and possibly amended as currently individual rights are not seen as being viable. The percentage of quotas that are filled would give a good estimate as to whether individual rights are viable. Viability in this case refers to financial viability; the size of the allocation of the individual rights and the economics of landing that allocation (CPUE, distance steamed and market prices etc.) are all very important and need to be kept in mind (leading to the intricacy of the present situation evident in Figure 7).

- *Long-term company profitability and sustainability*:

Specific objective(s): High employment rates for fishers; Good standard of living onboard the vessels; Good relations between employer and employee; High access to foreign markets

Indicator(s): To be identified

Description: Not much value addition currently takes place in the Namibian Rock Lobster industry. According to rightsholders, Namibia's small TAC makes it difficult to produce certain value added products as it would require significant amounts of lobster to make enough products to penetrate global markets. The Namibian rock lobster industry is also disadvantaged by the geographical positioning of Lüderitz and lack of appropriate infrastructure in and around the town. The lack of a large airport in Lüderitz means that the industry is disadvantaged in terms of export logistics. Consequently, access to foreign markets is limited. Furthermore, the poor relations that exist within the fishing industry itself (in terms of employer-employee relations) can influence the productivity of the crew and thus the overall profitability of the industry. However, no specific law is currently in place for regulation and stipulation of rights of sea-going staff. Extensive research needs to be undertaken in identifying international market opportunities to ensure future profitability of the fishery, which would result in a high employment rate for fishers. Specific marine labour laws need to be established regulation and stipulation of rights of sea-going staff, which incorporates the Merchant Shipping Act and which would address employee-employer relations as well as living conditions onboard vessels for fishers and observers alike.

HUMAN WELLBEING: Maximise socio-economic benefits

- *Employment rates within Lüderitz community*:

Specific objective(s): High number of jobs within the fishery; gender ratio in employment; moderate to high standard of living with the community

Indicator(s): To be identified; possibly interannual differences in employment numbers and gender comprisal of Rock Lobster sector employment

Description: As the CPUE has decreased over the last few years, the proportional contribution of the lobster fishery to the local economy has also decreased. Furthermore, the socio-economic knock-on effects of unemployment within the Rock Lobster fishery are not fully understood. For the fishing sector to provide secure employment of a high quality, there needs to be good understanding of the socio-economic drivers within the Rock Lobster fishery. Thus the standard of living within the community should be high. The number of job and the gender ratio of employment would reflect the knock-on effect of the Rock Lobster fishery.

- *Forum available for communication between government entities and public:*

Specific objective(s): Good ministerial representation at meetings; number and good attendance of meetings

Indicator(s): To be identified

Description: Communication needs to be facilitated and information transmitted between MFMR and the fishing industry through pre-season briefings and explanations of regulations. The potential changes experienced by secondary and tertiary businesses due to changes within the fishery are not well conveyed to the public at present. Collaboration between line ministries is needed to mitigate for potential socio-economic challenges. A multi-ministerial forum should be established to facilitate communication between line ministries, local government and non-governmental organisations (NGOs) to mitigate for socio-economic challenges that may arise in the future. More strategic use of the media is needed to ensure the issues of the fishing industry and their potential effect on community wellbeing are being conveyed to the general public. The number and attendance of meetings held by the forum will reflect the level of communication.

ABILITY TO ACHIEVE (Governance): Good research capacity

➤ *Good staff employed to undertake research*:

Specific objective(s):	100% of the posts are filled; good career advancement opportunities exist; high percentage of time allocated to research; high number of peer reviewed articles
Indicator(s):	<u>To be identified; possibly % posts filled, % time allocated to research as evident from job evaluations; interannual differences in the number of peer reviewed articles</u>
Description:	Limited scientific capacity, resources and technical skill is seen as a source of major concern. The MFMR experiences very high staff turnover, which results in the loss of expertise and knowledge from the Ministry. The high staff turnover is a result of a number of different factors, but primarily because of uncompetitive salaries, few career advancements opportunities (those that exist tend to lead away from research) and lack of job evaluation processes. Many of the research positions within the Ministry are currently unfilled, and this needs to be addressed. The basis for a good management plan is comprehensive and thorough research, which should be a top priority for the MFMR in terms of time allocated for research. Career paths need to be enhanced for scientists to retain expertise with the Ministry, for which job evaluation processes need to be in place (e.g. number of peer reviewed articles).

➤ *Funding*:

Specific objective(s):	Fixed annual percentage MFMR budget allocated for research; funding available for travel
Indicator(s):	<u>To be identified; possibly interannual differences in % MFMR budget allocated for research and travelling</u>
Description:	Often no funding is available through the ministry for work-related travelling, which is essential when undertaking collaborative research. A percentage of the MFMR budget should be set aside for research and research-related travel and expenses.

➤ *Collaborative research within MFMR, between Namibia and South Africa, and further abroad*:

Specific objective(s): Annual project reports; high number of peer reviewed articles

Indicator(s): <u>To be identified; possibly interannual differences in the number of peer reviewed articles and project reports</u>

Description: Namibia may share Rock Lobster larval pool with South Africa. In light of this (and possible other links in research), collaboration between the two countries (and further abroad) is a necessity for the management of the stock. International collaborations and projects are seen as key to building human capacity with the Ministry and to adequately understand EAF in this sector. Peer reviewed articles and annual project reports would highlight the research undertaken.

ABILITY TO ACHIEVE (Governance): Good management based on scientific advice

➤ *Incentives exist for industry compliance*:

Specific objective(s): Island staff made honorary inspectors; increased Admission of Guilt (AoG) fee; decreased number of convictions

Indicator(s): <u>To be identified; possibly interannual differences in the number of convictions; number of honorary inspectors on islands</u>

Description: The lack of law enforcement skills necessary to adequately deal with the illegal take of Rock Lobster by both the commercial and recreational fisheries was highlighted as an issue of 'Extreme' risk. The lack of capacity within the inspectorate results in very few convictions. However, even in the event of a trespasser, participants felt the Admission of Guilt (AoG) fee is not high enough to act as a deterrent. Penalties for the illegal capture of lobster are not high enough to act as a deterrent and needs to be increased. Furthermore, the need to instate island-based staff as honorary fisheries inspectors to curb poaching on the sanctuary at Ichaboe Island is necessary. Capacity at the Inspectorate needs to be strengthened to apprehend possible trespassers. Theoretically, if industry is complying, the number of convictions should decrease.

➤ *A Functional Fisheries Management Council (FMC)*:

Specific objective(s): Monthly meetings of the FMC; FMC attendance highly representative of affected parties

Indicator(s): To be identified, defined and tested; possibly interannual differences in frequency of meetings; attendance records of meetings

Description: The Fisheries Management Council is an MFMR intra-ministerial body that should meet on a monthly basis to discuss matters pertaining to the management of all Namibian fisheries e.g. TAC allocations, fishing regulations etc. Often members of the FMC are not available for these meetings, which are then indefinitely postponed. Crucial decisions are often delayed for months as a result of the FMC not meeting. The FMC needs to meet on a monthly basis, and be attended by all members needed for the decision-making process, in order for management of fisheries to be carried out in a transparent and accountable manner.

- *Good communication channels exist between Lüderitz research staff and the Windhoek management staff:*

Specific objective(s): High efficiency of decision-making process; decreased number of industry complaints regarding delayed management decisions; low discrepancy between TAC and scientific recommendations

Indicator(s): To be identified, defined and tested; possibly interannual record of difference between allocated and scientifically recommended TAC

Description: Improved communication is needed within the MFMR between the Head Office in Windhoek and the Lüderitz office. A need was identified (because of delayed response times from the decision-maker) for the decentralisation of decision-making power from MFMR Head Office (in Windhoek) to Lüderitz staff (LMR). Scientists feel that their advice on TAC recommendations is not taken into account as there is often a large discrepancy between the advised TAC and the allocated TAC. MFMR Head office must delegate decisions to the LMR as some decisions can be made locally and implemented as deemed appropriate. This would increase the efficiency of the decision-making process and decrease the number of industry complaints regarding delayed management decisions. The discrepancy between the advised TAC and allocated TAC should be less, especially with a resource that is clearly in trouble.

ABILITY TO ACHIEVE (Governance): Good co-management

- *Functional Working Groups for the dissemination of information between stakeholders groups and other interested and affected parties*:

Specific objective(s): Regular meetings of a Functional Rock Lobster Association, a functional Lüderitz forum, a functional Ecosystems Working Group, and attendance of all these working groups is well represented by all interested and affected parties

Indicator(s): To be identified, defined and tested; possibly interannual differences in frequency of meetings; attendance records of meetings

Description: Overall poor communication (between scientists and the fishing industry; between South African scientists and Namibian scientists; between management and scientists; between the mining industry and the fishing industry; between the FOA and MFMR) was highlighted by participants as the main issue for concern. Currently, reports are available from mining sector and scientific reports are available from the Ministry. These are only received upon request. The ministerial advisory council meets once a year for TAC recommendations and the FMC is in existence. Quarterly reports are sent to the Minister from the scientists and scientific reports based on observer data are disseminated to the observers. Despite these efforts, more communication is necessary for transparency and accountability of the decision-making process. Participants agreed that different forums are needed consisting of different stakeholder groups depending on the mandate of the forum.

- **Rock Lobster Association:** Consists of only industry members, their mandate being industry wellbeing. A needs analysis of the Rock Lobster fishery is necessary, as well as research into market options and possibly a 'fisheries bank'.
- **Lüderitz forum:** Consists of scientists, industry, mining and Lüderitz community, their mandate being the dissemination of information regarding the Rock Lobster fishery to interested members of the public.

- **Ecosystems/Rock Lobster Working Group:** Consists of scientists, inspectorate, observers and industry, with contributions when necessary from mining and other ministerial bodies (e.g. Ministry of Environment and Tourism), their mandate being research on Rock Lobster and the general ecosystem. They should meet bi-annually, just before the season starts, to involve the skippers, and just after the season ends.

➢ *The degree of self-regulation of the Working Groups*:

Specific objectives: Sufficient meetings, good attendance

Indicator(s): To be identified, defined and tested; possibly interannual differences in frequency of meetings; attendance records of meetings

Description: In order for these Working Groups to be effective and the communication to remain transparent, they will need to sustain themselves through regular meetings and high attendance rates. In the past, forums have fallen by the wayside e.g. the Lüderitz forum had their last meeting in 2005 after which time the responsibility for its momentum was handed over to the Lüderitz town council. No meetings have been planned since. The number of meetings of the different forums and their attendance rates will give a good estimation of the level of communication within the Rock Lobster fishery stakeholders and between interested and affected parties.

➢ *Good channels of communication exist between and within Working Groups*:

Specific objectives: Good circulation of reports; good perception of transparency by industry

Indicator(s): To be identified, defined and tested

Description: It is as important that communication channels are open between the Working Groups as within the Groups themselves. Reports (progress, monitoring, survey, general) need to be disseminated between Groups promptly and not only on request. All stakeholders should be informed at all times of all issues and all possible mitigation or management measures. Industry members' perception of decision-makers is a good indication of how transparent the decision-making process is. They should feel consulted on decisions. Management of the Rock Lobster fishery needs to be a consultative process. The circulation of reports would aid the perception between stakeholder groups.