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Ecosystem Based Fisheries Management case study report West Coast Bioregion

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Fish for the future

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Contents

Executive summary

There is an increasing world-wide recognition of the need to shift the management of natural resources towards the concept known in Australia as 'ecologically sustainable development' (ESD). This concept includes the use of 'whole of ecosystem' and 'bioregional approaches' based on ecosystem boundaries rather than sectoral or jurisdictional boundaries.

This report documents the outcomes of the Western Australian Marine Science Institution (WAMSI) funded study to examine the costs and benefits of using a bioregional level, Ecosystem Based Fisheries Management (EBFM) approach. The West Coast Bioregion of Western Australia was selected as a case study and the outputs from the use of the draft national EBFM framework were critically examined to determine whether such an approach would result in more efficient and effective management of fisheries. In addition, this report examined whether this EBFM framework provided better linkages between management bodies, allowing broader marine management covering all activities and relevant agencies – often described as ecosystem based management (EBM).

Using the draft national EBFM framework as a starting point, this study modified this approach to develop a framework that enabled the cost effective implementation of EBFM. The four-step hierarchical, risk-based approach that was developed avoided a common outcome from attempting ecosystem level assessments of merely generating an impossibly large and complex set of issues, uncertainties and expectations.

In applying the EBFM framework to the West Coast Bioregion of Western Australia (WA), the stakeholder workshops initially identified over 600 ecological assets, social and economic outcomes, governance systems and external drivers. This complexity was reduced by consolidating all of these into 60 regional-level risks. A multi-criteria analysis was used to integrate all related ecological, social and economic values and risks into just 24 'Agency level' priorities ranging from urgent to very low priorities.

Conclusions

This study found that taking an 'ecosystem approach' did not require having detailed understanding of the ecosystems or the construction of complex ecosystem models. Instead, it only required the efficient and systematic consideration of each ecological asset in the region and their associated stakeholder outcomes, to identify those assets that most require direct management to deliver the 'best' outcomes for the community. The critical steps in achieving EBFM are therefore being able to clearly identify the ecological assets, linking these to social and economic outcomes that they may generate and objectively assessing their risks and overall priority for management action.

The simple set of steps we developed to implement EBFM in WA has enabled adoption of a fully regional, ecosystem based approach without material increases in funding. It has successfully replaced the previous, disjointed planning systems, with a single, coordinated risk-based system that is already generating efficiencies for the use of Departmental (government) resources. Having a cost effective process means that EBFM can be applied in all circumstances, not just in those regions of the world where a large amount of resources and scientific data are available.

Given the success of this approach to the West Coast (e.g. Fletcher, et al., 2010), this EBFM framework has now been applied to all six bioregions in WA and the resulting priorities are

now used as the basis for annual budget setting by the Department (Fletcher et al., 2011). This has therefore been a highly successful project, the outcomes of which have already seen major changes to the operations and planning processes used by the Department.

The generation of regional level planning strategies as the overarching basis for fisheries management, combined with the wider adoption of the same set of steps at a national level to implement EBM should facilitate more efficient linkages and harmonisation with other government policies and processes. Consequently, we have found that there have been significant positive benefits from the implementation of an EBFM approach, more than merely meeting some long forgotten broad-based political commitment.

1.0 Background

1.1 Purpose

The purpose of undertaking this case study was to assess whether the draft national EBFM framework could really assist in providing a Natural Resource Management planning structure for the optimal management of marine resources at the bioregional level. The draft EBFM framework was initially developed by the National ESD subprogram based on the framework that is currently being successfully used for single fishery assessments and it was proposed that this be trialled as the mechanism to try and collate and utilise the relevant regional, EBFM-related information and management processes for the entire West Coast Bioregion of Western Australia.

The outputs from this case study were to include the generation of a modified set of component trees that identified all of the relevant EBFM level assets (ecological), issues (social and economic) and drivers (governance and external factors) from which a refined list of priority issues, based on a risk assessment process, would be used to evaluate the current status of each issue and identify the need for additional management or research activities.

As this was the first full-scale attempt to apply EBFM at a regional level, it was expected that the outputs from this study would be reviewed in light of the level of whether this generated improvement in the overall management of fisheries resources in a cost effective manner.

1.2 Context

Expectations about the benefits of undertaking more holistic forms of natural resource management have increased greatly over the past two decades. Worldwide this has resulted in a large number of concepts and initiatives, which are often termed "ecosystem-based" (Sissenwine & Murawski, 2004; Sherman, et al., 2005; Rice, 2005; Fletcher, 2006). For instance, in the early 1990s the need to manage marine resources within Large Marine Ecosystems (LME) was recognised and supported by the United Nations Convention for the Law of the Sea (UNCLOS). In Australia, the concept of holistic natural resource management was termed 'ecologically sustainable development' (ESD) and was formally adopted by all levels of government (federal, state and local) nearly twenty years ago (CoA, 1992). Initially, such holistic "ecosystem-based" approaches were found to be difficult to apply in a practical manner (e.g. Garcia, 2000) due to unrealistic expectations, data limitations and complexity of both ecosystems and management systems; few government agencies in Australia were able to implement ESD and generate outcomes that lead to actual management improvements (Productivity Commission, 1999).

During the last decade there has been significant progress in the management of natural resources towards implementing ESD (Fletcher, 2008). Therefore management of individual fisheries in Western Australia is already based on ESD principles that require that the impacts on target and bycatch species, habitats, and indirect impacts on the broader ecosystem are all managed using a risk based framework (Fletcher, 2002; 2005) for each individual fishery. In implementing this policy and to meet the requirements of the Commonwealth government's EPBC requirements (CoA, 2001, 2007), separate ESD-based assessments have been completed for each major WA fishery (e.g. Kangas et al., 2006). Although this ESD based process is comprehensive at an individual-fishery level, these assessments do not address the combined effects of all fisheries within the same area nor do they cover the cross-fishery allocation issues.

The Department, through its Integrated Fisheries Management (IFM) initiative is not only seeking to limit the overall harvest of target species to sustainable levels but to establish specific levels of access by each of the various catching sectors (see DoF, 2000). These allocation processes cover the sharing issues amongst commercial fisheries, recreational, and indigenous sectors (Fletcher & Curnow, 2002). A number of other sectors utilise, impact or have an interest within the marine environment but are not covered by fisheries legislation (e.g. shipping, coastal development, marine parks, tourism). Therefore, conflicts associated with access arrangements are not solely confined to conflicts between fishing sectors but, increasingly, between the entire wild capture fishing sector and other stakeholders and industries (Fletcher and Curnow, 2002). Such issues are usually regionally based rather than being associated with a particular resource and require different processes and frameworks to achieve effective outcomes. This all suggests that the management of individual fisheries sectors may be best if nested within a regional level framework.

1.3 What does EBFM mean for fisheries and marine management?

Ecosystem Based Fisheries Management (EBFM) has been defined in Australia as the assessment and management of all impacts and outcomes related to any commercial, recreational, charter, customary, or 'no-take' sector operating within an ecosystem or bioregion (Fletcher, 2006). EBFM therefore deals with the cumulative impacts on the environment (including fish stocks, habitats and ecosystems) from all the fisheries-related activities operating in a region, and includes explicit consideration of the overall social and economic outcomes generated by these activities. It also identifies any impacts that might be influenced by 'external' sources. External sources could include climate shifts or, importantly, non-fishing activities and processes, such as catchment management and industrial activities, which are managed by non-fishery agencies.

Many of the negative impacts on fisheries outcomes are generated by external sources operating at a regional or ecosystem level. Consequently, management plans (or systems) are required that can influence or even mitigate such regional or ecosystem impacts. This is also the scale at which most other relevant agencies operate, so taking a regional focus would better align fisheries management with other regional marine planning processes that may be operating in the area. Thus, applying the EBFM risk assessment framework could form a starting point for a hierarchy of the management of individual activities up to the holistic management of all the activities operating within a region (often defined as Ecosystem Based Management - EBM, see Figure 1).

EBFM assessments should, therefore, cover the cumulative impacts on the environment that arise from the current suite of fisheries-related activities. These assessments should also document the overall social and economic outcomes that are generated by these activities given the current allocations of access within a region. Managing fisheries on an ecosystem basis also requires the assessment of external drivers (e.g. climate change, environmental variability, pollution, introduced pests and diseases) on fish stocks and fisheries (Fletcher et al., 2010).

The management of fisheries and marine resources must be ecosystem-based because, whilst the maintenance of the target stocks has long been the primary management goal for fisheries agencies, there is now the recognition that non-target stocks and the broader ecosystem must also be maintained at acceptable levels in order to achieve stock sustainability. Recent legislative changes and policy initiatives at both the State and Commonwealth level, reflecting

the community's concerns on these issues, now require a comprehensive assessment that incorporates ecosystem-level responses to extraction for each commercial fishery. This is important for some fisheries in order to enable them to maintain access to lucrative export markets.

Given the overlaps in the capture of some suites of species by different fisheries within the one region, the assessment of ecosystem-level impacts has proven difficult to achieve on an individual fishery basis (Fletcher, 2008). It was recognised that an overall assessment of each of the key ecosystems would be more appropriate for the assessment of the cumulative impacts of fisheries. The move to undertake a regional level assessment is therefore a logical extension of the individual fishery level ESD assessments that have been completed by the Department over the past 8 years and should provide a sound basis for the overall management of marine resources. Because EBFM explicitly considers all elements (or values) within an exploited system, the development and reporting of an EBFM plan will also facilitate the development of regional marine plans.

EBFM should be seen as a key strategy towards the full implementation of ESD, which is the overall goal for government (Fletcher, 2006). All the various 'ecosystem based' strategies that are currently being pursued are, in reality, variations on a theme with the main differences between them being the scope of issues managed (see Fletcher 2006 for details). It is recognised that in addition to the management of fishing activities, broader ecosystem based management is also required in the marine environment. The various management systems should preferably form a hierarchy within an overall ESD context, with each level providing the building blocks for the next (Figure 1). Specifically, the difference between Ecosystem Based Management (EBM) and Ecosystem Based Fisheries Management (EBFM) is that in EBFM the scope of issues covered is restricted to those that can be managed or directly influenced by a fisheries management agency. EBM would be used to implement broader levels of management and types of impacts in a region. For example, EBM would include all activities operating in the region, of which fishing is only one component.

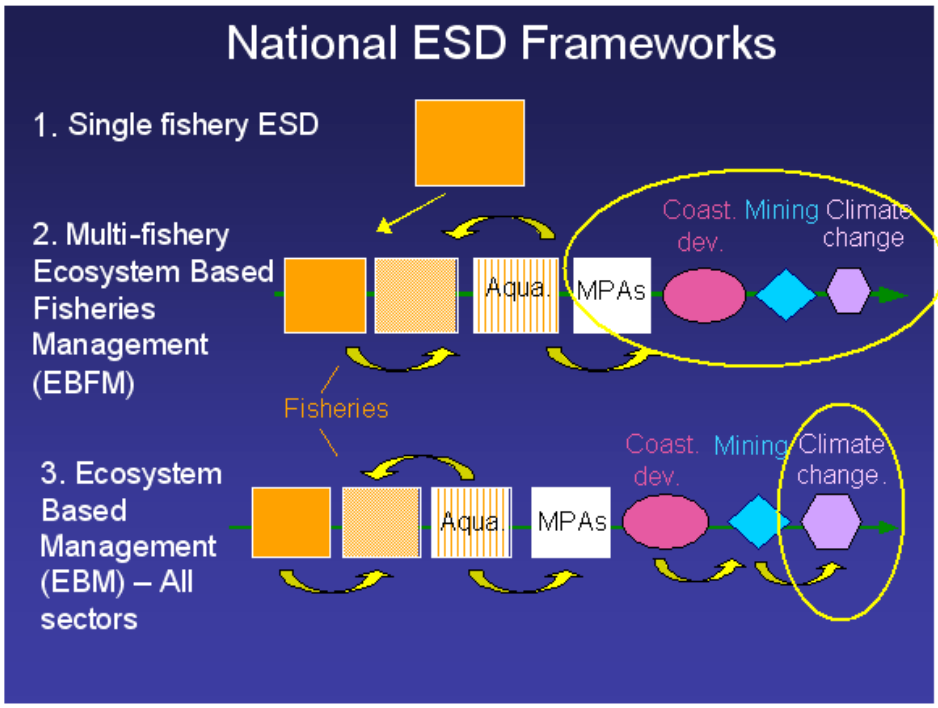

Figure 1. Relationship between the three ESD framework levels. The elements included in the gold ovals represent the difference in external drivers between EBFM compared to EBM – modified from Fletcher (2006). Abbreviations have been used for aquaculture (Aqua.), Marine Protected Areas (MPAs) and coastal development (Coast. Dev.).

Although the EBFM framework can consider elements that are managed by other agencies or jurisdictions, it is clearly not possible to effectively manage the outcomes, or be held responsible, without the authority to manage the impact. This doesn't mean that these elements should be ignored in the EBFM process; rather they must be taken into consideration for planning actual management actions.

The three types of issues to be considered by the Department of Fisheries are those that the Department can manage, influence or react to:

MANAGE These issues come under the direct legislative responsibility of the Department (e.g. the amount of abalone taken in the commercial fishery). Regulations and management plans are generated to deal explicitly and directly with these issues for which the Department must take full responsibility.

INFLUENCE These issues are not under the legislative responsibility of the Department and therefore cannot be managed directly, yet because they come under the legislative responsibility of another Agency or Department, their actions may be influenced by input into their decision-making process.

REACT TO Issues generated by the external environment that cannot be managed or influenced by the Department. However, because these issues affect factors for which the Department is responsible, processes for dealing with these issues should be developed (Fletcher 2008).

If the Department does not have the power to regulate or manage an activity, there is no point (and no basis) for establishing objectives, performance levels and the necessary management arrangements. However, if the risk of an activity is found to be medium, high or severe, then an appropriate management response is to have a clear process to refer this to the responsible agency.

During the EBFM process other external drivers are also considered, such as the current global recession, as these may cause significant change for some export fisheries and consequently impact the social and economic outcomes. In such situations, alternative management arrangements that do not impact stock sustainability may be considered if they could assist in alleviating these issues. In addition, if pollution or reduced water quality were an issue in estuaries, the impacts of this would be considered in decision-making for estuarine fisheries. However, as water quality does not come under the jurisdiction of the Department of Fisheries, the only action taken may be to encourage better management of outfalls and pollution by the relevant authority. Because the EBFM process has a high level of stakeholder input and the justifications reported, there is a readily understood, transparent reporting framework with which to explain the risks and potential impacts.

Expanding the scope from a single-fishery assessment to a broader regional EBFM approach poses a number of logistical difficulties. Chief among these is the potential to rapidly become extremely complex given that it would cover all ecological assets (captured and non-captured species, habitats, ecosystems) and the sustainability, social and economic issues relevant to these assets (Fletcher, 2008). Managers have, understandably, been highly concerned that implementing EBFM could result in a dramatic increase in the number of management issues they will then have to deal with, without increased resources, potentially leading to an overall poorer outcome. In addition, detailed data regarding all aspects of the ecological assets and the issues are generally not available. Such deficiencies often raise unrealistic expectations among stakeholders, and the fear among management agencies, about the prospect that significant resources have to be spent before EBFM can be implemented. To be successfully implemented, the initial EBFM process must be able to distil the complexity and knowledge requirements to a level that is acceptable from the management perspective (i.e. non-threatening and able to be dealt with in timeframes relative to both fisheries management and political cycles) without the expectation that all data deficiencies and uncertainties will be rectified (Fletcher, 2008, Garcia, 2010).

Fortunately, these concerns and expectations can be alleviated using a risk-based approach to determine the appropriate levels of management response. Similarly, the levels of knowledge available for an issue only need to be appropriate given the risk level and the level of precaution adopted in the management arrangements. It needs to be made clear to stakeholders that implementing EBFM does not automatically generate the requirement to collect more ecological, social or economic data or the development of complex models.

For many fisheries in WA, the implementation of EBFM may not change fisheries regulations or management substantially. Pragmatically, only assets that have a moderate to severe risk of change as a result of fishing activities, or issues that may impact the sustainability of fisheries (i.e. ecologically, economically or socially) are likely to generate additional management, monitoring or other actions being undertaken.

2.0 Outline of the EBFM process

2.1 Background

The process for implementing EBFM is based on the National ESD reporting and assessment framework of wild capture fisheries in Australia (Chesson, 2000, Fletcher et al., 2002, 2005). The EBFM framework is a step-wise, risk-based assessment process that generates reports on all relevant ecological assets for an individual fishery, including impacts on the target species and the broader ecosystem, and the potential social and economic issues (or expected outcomes), as well as current governance systems.

To help deal with the confusion identified during the consultation process regarding the meaning of terms, ecological resources were termed "assets", social or economic concerns or expected outcomes were termed "issues" and together these assets and issues were the "components" of interest to the stakeholders. These "components" make up the EBFM component trees (see section 2.2). The risk assessment of components was based on the steps outlined in the International Standard Risk Management guidelines (AS/NZ 4360, 2004; AS/NZS ISO 31000:2009) and is fully consistent with the Ecosystem Approach to Fisheries (FAO, 2003).

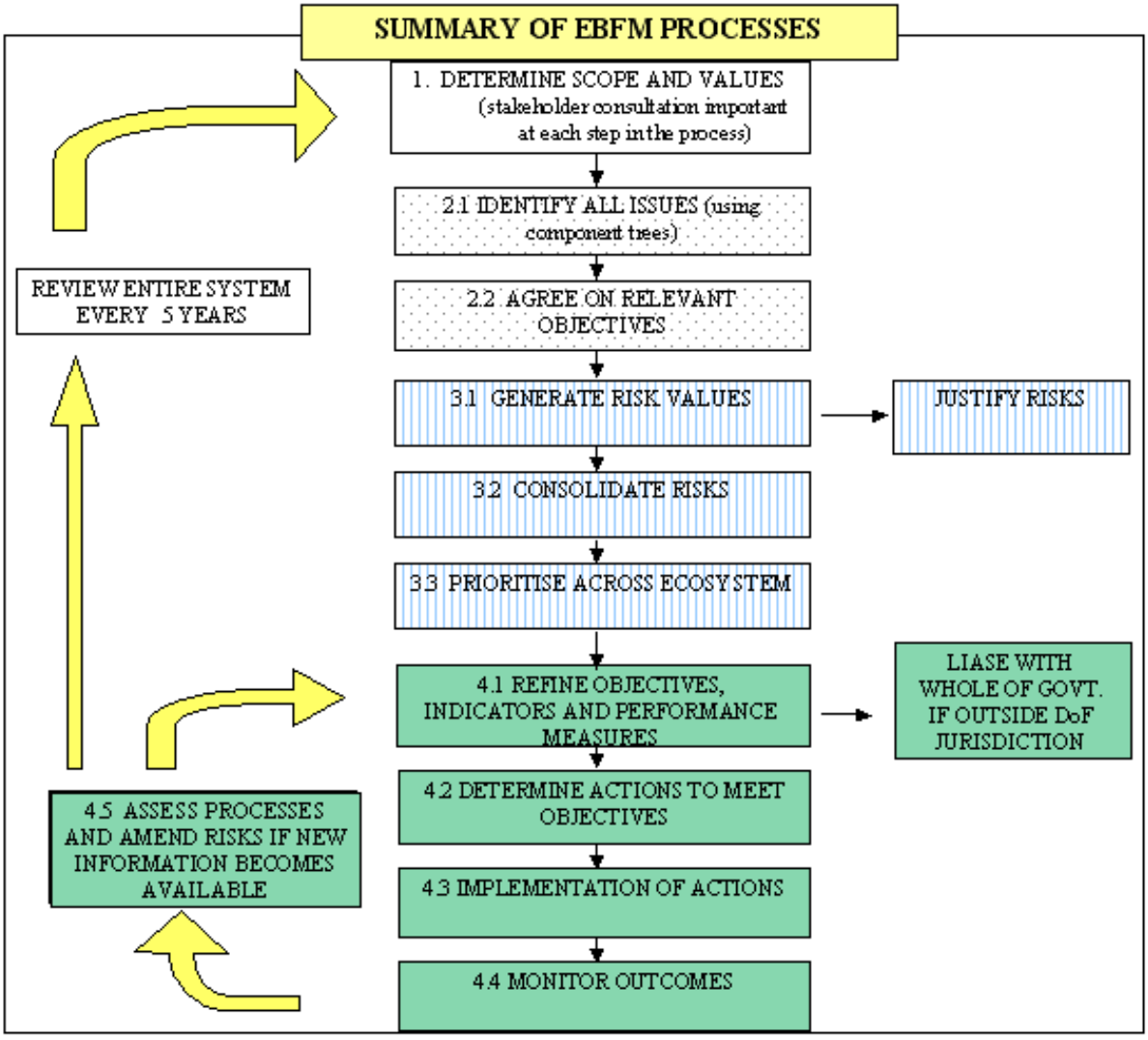

Figure 2. Outline of the EBFM Process.

Step 1 – Determine the scope of the assessment and community values to achieve.

This study focussed on implementing EBFM for a region termed the West Coast Bioregion (WCB), one of four marine bioregions recognized by the Department of Fisheries in Western Australia. Implementing EBFM for the WCB required developing a very clear description of each of the relevant fisheries and other activities that are being managed in this region. This includes the geographic boundaries of the area that will be encompassed and developing a very clear description of each of the relevant fisheries and other activities that are being managed in this region. For the WCB example, the region encompassed for EBFM was a 1000 km stretch of coastline in the south west of WA from Kalbarri (27° S) in the mid west; south to Augusta (115° 30' E); out to the 200 m depth contour; including all fishing related activities that occurred in those waters (DoF, 2011).

The scoping process must also generate a shared understanding of the relevant social, economic and ecological values desired by the various stakeholder groups. Essentially, what does the WA community want to achieve from undertaking management of the region's resources? The values (or high level objectives) can include ecological sustainability, food security, social amenity and economic development. Understanding which of these values is the most important has major implications for what should be managed and how best to manage it. In the West Coast case study, the primary objective was ecological sustainability with social and economic outcomes taking a secondary level and food security was not considered relevant.

The broader regional scope of EBFM, required documentation of the roles and responsibilities of each of the relevant agencies and stakeholders involved. Given that the main intersection of EBFM with EBM will be at the level of the ecosystem, to successfully integrate EBFM with broader EBM or other regional marine planning processes, agreement must be obtained by all relevant agencies on the specific ecosystems present within the region.

The final part of this step was to document the roles and responsibilities of each of the agencies and stakeholders involved. This involved discussions with stakeholders and, importantly, obtaining agreements from other government agencies in multi-agency forums to clarify jurisdictional arrangements or objectives.

Step 2 – Asset and Issue Identification

Using the agreed scope and values for the West Coast Bioregion, the next step was to identify all the potential assets (ecological) and issues (social, economic, governance and external drivers) across each of the five EBFM components (dashed line, Figure 3). The component tree structure sets out the elements/values that need to be considered for EBFM, which includes the environmental (ecological assets), social and economic assets as well as the ability to achieve management outcomes (institutional governance and external drivers). The assets and issues identified across each of the five EBFM components were reported in the form of detailed component trees for each of the lower branches (e.g. ecosystem structure & biodiversity, captured 'fish' species etc.) of the West Coast Bioregion tree below (Figure 3).

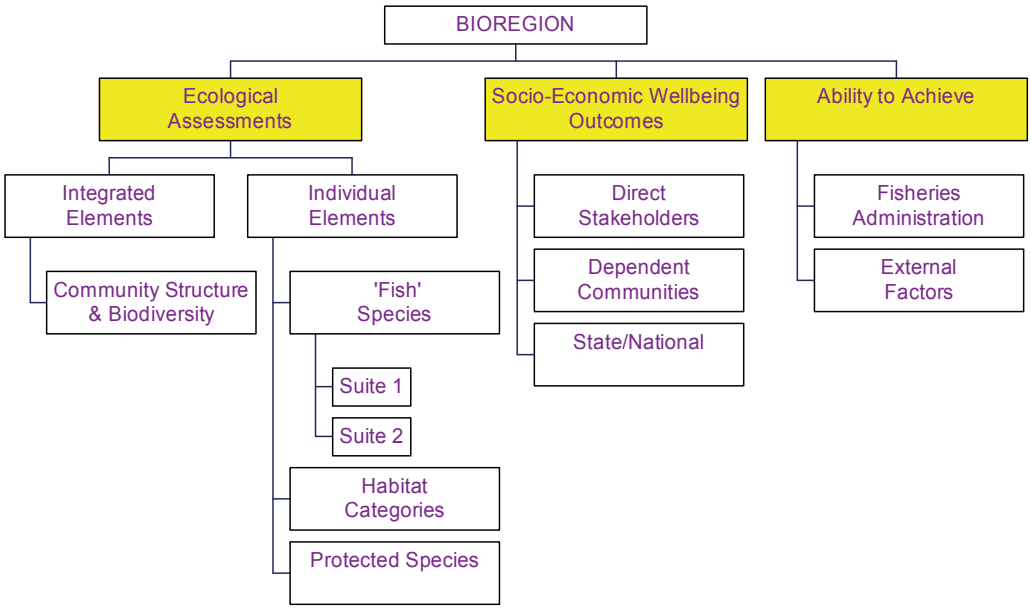

Figure 3. EBFM Component Tree Structure.

These trees help to structure the assignment of issues into a hierarchy of related groups, which assists with their later consolidation. The use of the generic component trees within this framework maximises consistency and minimises the chances of missing issues (Fletcher, et al., 2005). These trees can also be beneficial for implementing EBFM or EBM in other regions as they can be tailored to suit individual circumstances.

A series of workshops with the participation of relevant stakeholders examined each of the high level EBFM components and specifically tailored each of the detailed trees by adding relevant assets and issues not already included and deleting those that were considered by the group to be irrelevant (not to be confused with having minimal knowledge).

The major difference in the EBFM component tree structure compared to the individual fishery assessments is that the EBFM process has the ecological assets as the primary focus for management, rather than the activity of fishing as the primary focus. In addition, the EBFM tree has a separate Ecosystem Structure and Biodiversity branch, which recognises that each of the individual assets that are directly or indirectly impacted (e.g. habitats, target species, protected species) combine together to form ecosystems. These higher-level assets usually link to the activities and objectives of other stakeholders and agencies through EBM and the broader community.

Objectives to be achieved, given any local, regional or national requirements or global attitudes ,were determined. These objectives could have been based on ecological concerns, economic realities or social attitudes (see Table 1), with some assets having more than one associated objective.

Step 3 – Prioritising issues

A three-part prioritisation process based on risk assessment principles was used to determine what issues needed direct management actions, and the level of action that should be taken from a whole of agency perspective. Table 1 details the common levels of risk that were used in this process.

A number of different risk assessment methods are available for use in prioritising issues (Scandol et al., 2010) and some of these methods can operate with minimal levels of data and can be completed within a workshop environment. The determination of the most appropriate risk assessment methodology (or priority setting process) in any one circumstance may vary based upon the level of information available and the type of issue being examined. The risk methodology used in this case study was based on the approach used in the National ESD Framework (Fletcher, 2005) which has subsequently been modified for use in the assessment of a broader range of objectives (Fletcher, 2010).

Individual Risks - The risks associated with each objective (see Table 1) for each individual asset or issue were examined separately using formal qualitative risk (consequence x likelihood) or problem assessment processes outlined in Fletcher (2005, 2009). These qualitative risk analysis methods are based on the Australian & New Zealand and International Standard Risk Analysis (Standards Australia, 2000, 2004; IEC/ISO 31010, 2009), and involve the assessment of all issues against the specific objectives and outcomes that the fishery is trying to achieve by examining the potential impacts (consequences) that may result to these objectives and the likelihood (probability) that a particular level of impact will actually occur – which when combined together calculates the risk level.

As risk is now defined as "the uncertainty associated with achieving objectives" (AS/NZS ISO 31000: 2009), a lack of specific data can be explicitly incorporated into the calculation of the relevant consequence and likelihood scores such that the calculation of risk could be completed with whatever data were available. These methods enabled the analysis of risk (using a five year time horizon) for the objectives related to species, habitat and community structure/ecosystem sustainability, plus social and economic risk outcomes to be completed (see Appendix 1 for details of consequence and likelihood tables).

Each issue was placed into the appropriate combination of consequence and likelihood levels (Figure 5) based upon the information available and the collective wisdom of the people involved in the process. If more than one combination is considered appropriate, the combination with the highest risk score should be chosen (i.e. this takes a precautionary approach).

The combination was based on the risk over a defined time period - not the risk of change occurring at any point in the future. As this process is assessing risks to objectives based on a management plan, a convenient time frame to use is the timeframe of the management plan - which was considered to be in the vicinity of five years.

In the formal system described previously, the risk level for each issue is calculated as the product of the scores for consequence and likelihood combination chosen as being the most appropriate for the issue. The possible values are between 1–16 (Figure 5).

		Consequence Level			
		Minor	**Moderate**	**Major**	**Severe**
Likelihood		1	2	3	4
Remote	1	1	2	3	4
Unlikely	2	2	4	6	8
Possible	3	3	6	9	12
Likely	4	4	8	12	16

Figure 4. Risk Matrix. (see appendix 1 for details and descriptions of the consequence and likelihood levels)

Table 1. Risk categories, descriptions and likely management responses (modified from Fletcher 2008).

Risk Category	Risk Value	Description	Likely Reporting Requirements	Likely Management Response
Negligible	1 - 2	Not an issue	Minimal	Nil
Low	3 - 4	Acceptable; no specific control measures needed	Justification required	None specific
Medium	6 - 8	Acceptable; with current risk control measures in place (no new management required)	Full performance report	Specific management and/or monitoring required
High	9	Not desirable; continue strong management actions OR new and/or further risk control measures to be introduced in near future	Full performance report	Increases to management activities needed
Severe	12 - 16	Unacceptable; major changes required to management in immediate future	Full performance report	Increases to management activities needed urgently

Consolidating risks – The number of individual risk values generated across the EBFM framework for the entire bioregion was too large for use in undertaking sensible management planning. Furthermore, many of the individual assets, issues and objectives were already the subject of specific management actions and planning processes at the individual fishery level. To ensure that the EBFM process recognised and preferably added value to the existing fishery level activities, not merely duplicated them, it was necessary to combine issues and risks to regional or category level assets.

The consolidation of the individual risks into broader asset categories utilised the branch structure present in the component trees (Figure 5). In addition, the consolidation of risks corresponds with an existing Departmental process whereby all captured species are assigned to one of a relatively small number of 'species suites' that are consistent with the key ecosystem sub-branches (e.g. nearshore, inshore, offshore etc. – see Department of Fisheries 2009). The same principles were applied to each of the other trees in the framework with the risks for each branch of the component trees consolidated in two ways:

- For ecological assets, specific indicator species or components were identified with the risk value assigned to the entire 'suite' of species or functional group using the highest risk value of any of the indicator species. This reflects that many fishery management arrangements operate at the entire suite level rather than only affecting a single species;
- For the non-ecological issues, the consolidated risk value was the average of the risk ratings for each of the elements in the sub-branch and, where relevant, each sub-branch within a branch. Thus, a hierarchical approach was used such that consolidation could operate at a number of different levels within each tree.

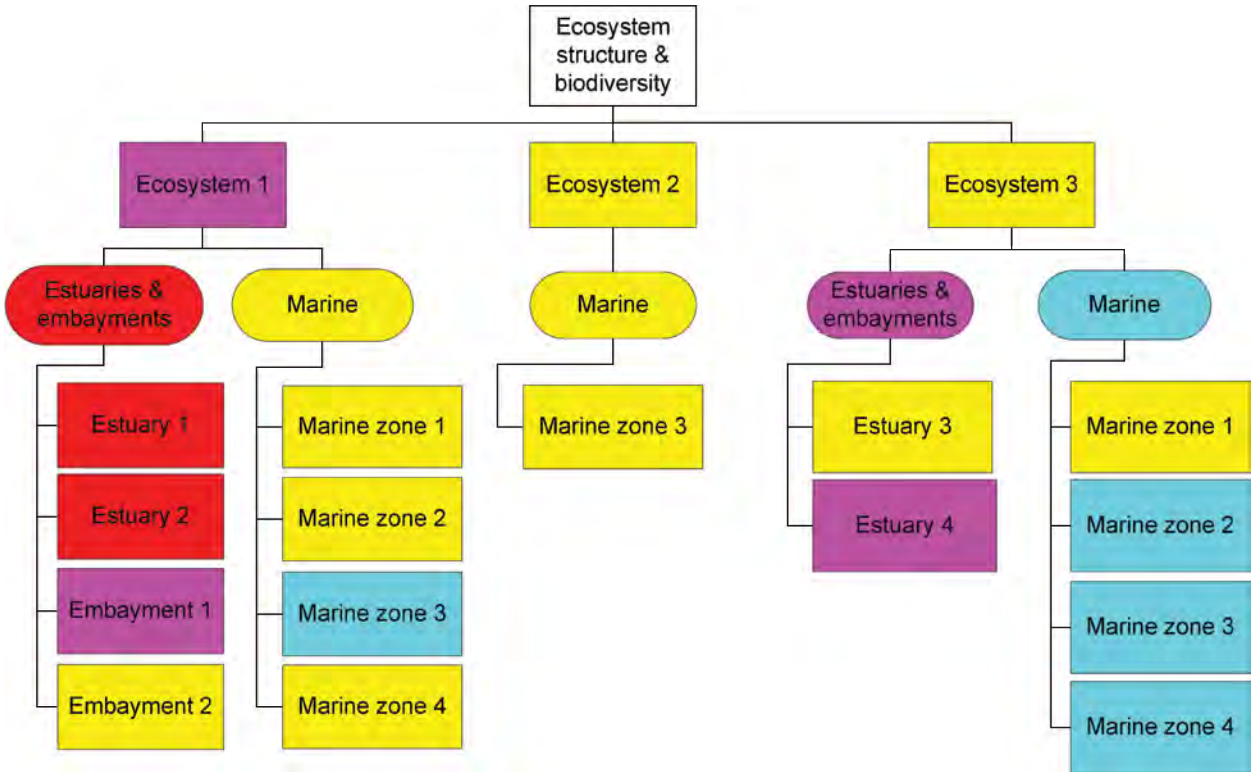

Figure 5. Generic ecosystem structure and biodiversity component tree showing three larger ecosystems, which break down into smaller systems and components at the sub-branch levels. The consolidation of individual risks occurs at the mid-tree level (ovals). Sub-branch risks are consolidated into these components. Here the average risk has been used during consolidation as no specific indicator for each ecosystem has been identified.

Agency/bioregional priority setting – The final, and arguably most important part of the EBFM process was to generate a whole of agency priority for each of the consolidated ecological assets within the bioregion. These agency priorities include the associated social and economic risks and can be used to prioritise agency investment.

The integration of the various risk and value scores into Departmental priorities was achieved using a simple multi-criteria function including risk, Gross Value of Product (GVP) and social amenity. The criteria for assigning the GVP and social amenity scores are located in Table 2. The priority scores were based on the qualitative risk assessment process with the criteria for the value scores modified from those developed to assess the value of research proposals (Fletcher et al., 2003). All of the scoring included the level of current activities or management controls that are in place or underway. Hence, some of the scores appeared to be relatively low because of the current high level of controls that operate.

Table 2. Criteria used to assess the relative economic (Gross Value Product) and social amenity value associated with each ecological asset in the West Coast Bioregion.

SCORE	Risk	Economic Value	Social Amenity
0	None	No Commercial use	n/a
1	Negligible	< $1 million	Minimal – there is no recreational fishing for the asset and no specific broader community interests.
2	Low	$1 – 5 million	Some – the asset may be caught recreationally &/ or there is some specific interest in the asset by the broader community.
3	Moderate	$5 -10 million	Important – this is an important asset locally &/or the use or existence of the asset is important to the broader community
4	High	$10- 20 million	Major – the asset provides a major source of the catch by recreational fishers for the entire region &/ or the asset generates major interest for some of the general community.
5	Severe	> $20 million	Iconic - this is a primary asset targeted by recreational fishers across the region &/or it is an asset that is considered iconic by most in the general community

Agency Priority = ('Stock' Risk – External Impact)((Economic Risk*GVP) + (Social Risk*Social Amenity))*

The Agency Priority Formula utilises the various risk and value scores associated with each asset and recognises that the level of Departmental activity should be mostly related to the current ecological risk for the asset. It also recognises that if the majority of this stock or ecological risk is generated by factors that are outside Departmental control (e.g. pollution), the overall priority for direct Departmental activity is likely to be reduced accordingly. A formula for use within an 'EBM' assessment would differ, as the roles of all management agencies would be included and this 'discounting' would not be required.

In addition to the ecological risk, the formula recognises that the priority for undertaking activities will be affected by the value the community places on each asset. This value will be based on the direct economic benefit (GVP) and from indirect benefits such as social amenity, importance to recreational fishers, existence value for non-users. The reason for independently assessing the risk and the value for the social and economic elements is that the individuals involved may clearly be facing a high risk of impact to their objectives, which can be explicitly recognised, but if the overall value to the community is low, this is likely to reduce the priority to expend significant agency resources. Thus, an asset will generate a high score and priority if its ecological sustainability risk is high, plus it is valuable economically and/or socially to the community.

Step 4 – Generating management systems

- Where direct actions are required, develop clear management systems that include operational objectives and the ability to assess performance.
- At periodic intervals assess processes and amend risks if new information becomes available.

These two activities were beyond the scope of this case study.

2.2 General operating procedures

Further information on the application of each of these steps and the basic ESD framework are available from documents located on the Australian EBFM website (www.ebfm.com.au).

The generally broad scope of the issues covered within the EBFM framework requires that the operational procedures for undertaking an EBFM process must involve substantial stakeholder consultation plus expert input from scientists and managers. The information that can be considered within the process can be sourced implicitly or explicitly using a combination of published information, unpublished records and 'corporate knowledge' from the participants and other relevant experts. Thus, all types of information are considered.

To function effectively, the EBFM process will generally require a dedicated executive/ administrative team to manage the consultation processes (e.g. workshops) and also the information flow (e.g. record keeping, generating interim and final reports).

2.3 Work plan and EBFM report structure

The remainder of this report was the result of a series of workshops, meetings and other consultation processes (Table 3). A large amount of material and information was generated for reporting, much of which is located within the appendices. Thus, this EBFM report has been structured around generating a relatively high-level document that can be used by the fisheries management agencies as part of their planning processes and also as the basis for negotiations/ discussions with other relevant agencies.

Meetings and workshops

Table 3. EBFM-related meetings, topics discussed and stakeholder consultation. Abbreviated names are Western Australian Department of Fisheries (DoF), WA Department of Environment and Conservation (DEC), WA Department of Water (DoW), National Oceans Office (NOO), Western Australian Marine Science Institution (WAMSI), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Department of Environment, Water, Heritage, and the Arts (Commonwealth, DEWHA), University of Western Australia (UWA), Australian National University (ANU), Australian Bureau of Agricultural and Resource Economics (ABARE), National Heritage Trust (NHT) and Western Australian Fishing Industry Council (WAFIC).

Meeting	Topics discussed	Number of meetings held	Attendees / stakeholders
2006			
EBFM Working Group	Embedding EBFM in a fisheries strategic policy and management framework – steps forward, external consultation process	1	DoF staff
Abrolhos Island Risk Assessment workshop	Appropriate risk levels for assets	1	External stakeholders and DoF staff
2007			
EBFM steering committee	Terms of reference, appropriate scale of ecosystems, objectives and role of committee, assets, values and responsibilities, risk assessment	8	DoF staff
EBFM bioregions meeting	Spatial scale of bioregions	2	DoF, DEC, NOO, CSIRO, WAMSI
Component tree workshop and meetings	Ecosystems, 'assets' and components to include in EBFM reporting	7	DoF staff, WAMSI
EBFM scoping	Project objectives, progress and scope	1	DoF, Murdoch University, WAMSI
Various WAMSI meetings	Node 4 Project progress	18	WAMSI, DoF, CSIRO
WAMSI show and tell	WAMSI projects	1	Various attendees, WAMSI, DoF, CSIRO, Universities etc.
WAMSI launch and Node 5 symposium	WAMSI projects	2	Various attendees, WAMSI, DoF, CSIRO, Universities etc.
EBFM workshop	What is EBFM? Further development of draft component trees	1	Marine Policy Stakeholder Group, DoF, DEC Marine Science Group, WAMSI, DEWHA
EBFM presentation for IFM	Explanation of EBFM process and expected outcomes	1	DoF staff
Ningaloo data		1	DoF, CSIRO
Ningaloo modelling workshop	Ecosystem modelling	1	DoF staff, CSIRO, universities

Meeting	Topics discussed	Number of meetings held	Attendees / stakeholders
Coastal and Marine Reference Group	How EBFM will work	1	DoF, CSIRO, Coastal and Marine Ref. Group
EBFM assets, responsibilities and objectives	Legislative responsibilities, commercial and non-commercial assets, external factors, acceptable impacts	1	EBFM Steering Committee, DoF Supervising Scientists, WC Regional Manager
The EBFM framework and linkages to Regional Marine Planning	How EBFM could be used in the regional marine planning process	1	EBFM steering committee, DEC, DEWHA
EBFM Social aspects	Why study social aspects of fisheries? How study social aspects? Integration of social aspects into policy and management.	1	Jackie Schirmer- ANU/ Forestry CRC, Murdoch University, DoF staff
Sustainable Marine Ecosystems: Ecologically Sustainable Development for the Marine State's Fisheries, socio-economic and fisheries presentation	Social and Economic assessment methods- project objectives and discussion	2	Simon Vieira-ABARE, UWA, Murdoch University, EBFM steering committee
EBFM and WAMSI	What are EBFM and WAMSI, what are their roles and objectives?	1	DoF staff
EBFM database	Process to set-up online database for EBFM	5	DoF staff
EBFM communications	How to communicate EVFM objectives effectively	2	DoF staff
South Coast regional marine planning	Marine planning	1	DoF staff, regional attendees
EBFM and NHT Coastal links, and NRM and EBFM	EBFM and NHT Coastal and NRM links	2	WAMSI, DoF, NHT
EBFM assets	EBFM assets and links with DoW	1	DoW, DoF
EBFM and pearling	What is EBFM? How is it important for pearling	1	DoF staff
Qualitative modelling workshop	Modelling for EBFM	1	DoF, Murdoch University, University of Tasmania, CSIRO
2008			
Senior Regional Managers meeting	EBFM process, objectives and qualitative modelling	1	DoF staff
Ecological risk assessment for EBFM	Appropriate risk levels	1	DEWHA, Conservation Council, DEC, South Coast NRM, WAFIC, The Wilderness Society, UWA, Recfishwest, EBFM steering committee

Meeting	Topics discussed	Number of meetings held	Attendees / stakeholders
EBFM steering committee	Develop plan for West Coast Case Study, cost-benefit analysis, update communications committee, draft social and economic policy, EBFM web-based search portal, EBFM report	6	DoF staff
Regional meeting-Geraldton (Gascoyne)	Discussion of EBFM concepts, objectives and qualitative modelling	1	Regional DoF staff
Social and Economic methodology workshop	Potential assessment methods, costs and requirements	1	ANU, ABARE, Murdoch University, WAFIC, DEWHA, UWA , DEC, Curtin University of Technology, EBFM steering committee
Regional meeting -Albany(South Coast)	Discussion of EBFM concepts, objectives and qualitative modelling	1	Regional DoF staff
Social policy group	Discussion of objectives and draft social and economic policy	1	DoF staff
2009			
EBFM steering committee	Discussion and identification of governance components, social and economic policy, EBFM report	1	DoF staff
Gascoyne/South Coast/ North Coast Risk assessment workshop	Appropriate risk levels for EBFM components in these bioregions	2	DoF staff (including regional managers)
External risk assessment workshop (Gascoyne/South Coast/North Coast)	Appropriate risk levels for EBFM components in these bioregions	1	Conservation Council, DEWHA, DEC, The Wilderness Society, WAMSI, Recfishwest, DoF Staff

3.0 The West Coast Bioregion

3.1 About the bioregion

The marine environment of the West Coast Bioregion between Kalbarri and Augusta is predominantly a temperate oceanic zone, and is heavily influenced by the Leeuwin Current, which transports warm tropical water down the continental shelf. As a result of this current, the fish stocks of the region are typically temperate. The Leeuwin Current is also responsible for the existence of the unusual Abrolhos Islands coral reefs at latitude 29° S and the extended southward distribution of many tropical species along the west and south coasts.

The most significant impact of the clear, warm, low-nutrient waters of the Leeuwin Current is on the growth and distribution of the temperate seagrasses. These form extensive meadows in all protected coastal waters of the West Coast Bioregion in depths of up to 30 m and act as major nursery areas for many fish species as well as the large western rock lobster (*Panulirus cygnus*) stock. Weaker counter-currents on the continental shelf, such as the Capes Current, occur during summer and influence the distribution of many of the coastal finfish species.

The West Coast Bioregion is characterised by exposed sandy beaches with a limestone reef line approximately 5 kilometres off the coast. Sea floors further offshore on the continental shelf are typically composed of coarse sand interspersed with low limestone reef, which are remnant of old shorelines.

The only significant marine embayments within the bioregion are Cockburn Sound and Geographe Bay. There are four significant estuarine systems – the Swan/Canning, Peel/Harvey and Leschenault estuaries and Hardy Inlet (Blackwood estuary). All of these are permanently open to the sea and generally form an extension of the marine environment.

3.2 Summary of fishing and aquaculture activities

The principal commercial fishery in this region targets the western rock lobster, which is Australia's most valuable single-species fishery with a long-term annual catch of 11,000 t and a value of $300 million. There are also significant commercial fisheries for other invertebrates, including scallops and abalone. Commercial fishers take a range of finfish species including sharks, dhufish (*Glaucosoma herbraicum*), snapper (*Pagrus auratus*), baldchin groper (*Choerodon rubescens*) and emperors (*Lethrinus* spp.) using demersal line and net methods. Beach based methods such as beach seining and near-shore gillnetting, and hand-hauled nets are used to capture whitebait (*Hyperlophus vittatus*), mullet (various species) and whiting (*Sillago* spp.). Species targeted by recreational fishers in estuaries include black bream (*Acanthopagrus butcheri*), flathead (*Platycephalus* spp.) and blue swimmer crabs (*Portunus pelagicus*) while herring (*Arripis georgianus*), tailor (*Pomatomus saltatrix*) and mulloway (*Argyrosomus hololepidotus*) are targeted from beaches.

The West Coast Bioregion, which contains the major population centres of Western Australia, is the most heavily used bioregion for recreational fishing (including charter based fishing). The range of recreational fishing opportunities includes estuarine, beach and boat fishing either in embayments or offshore for demersal and pelagic/game species. Many of these resources are shared between the commercial and recreational sectors.

The principal aquaculture development activities in the West Coast Bioregion are the production of blue mussels (*Mytilus edulis*) and marine algae (*Dunaliella salina*) for beta-carotene production, and the emerging black pearl industry based on the production of *Pinctada margaritifera* at the Abrolhos Islands. The main mussel farming area is in southern Cockburn Sound, where conditions are sheltered and the nutrient and planktonic food levels are sufficient to promote good growth rates. Owing to the generally low productivity of the Western Australian coastline under the influence of the Leeuwin Current, areas outside embayments (where nutrient levels are enhanced) are unsuitable for bivalve aquaculture.

3.3 Fisheries management in West Coast Bioregion

Most commercial fisheries within this region have been under some form of limited entry management that restricts access to a specific number of fishers and/or their effort/catch levels for some time. This includes the commercial rock lobster fishery where there are a limited number of pot units available among other methods of limiting effort. Similarly, a number of the larger demersal finfish fisheries have time-gear access limits to regulate the total levels of capture and those of the key indicator species. Fisheries such as abalone and deep sea crabs use quotas to limit commercial catch levels. Most of these fisheries are also subject to various time and spatial closures, as well as other regulations such as size limits for species that can be retained. The small trawl fisheries, in particular, are heavily restricted in the areas where they can fish with much of the continental shelf in this region permanently closed to trawling (Figure 6a).

Recreational fishing in this bioregion is coming under increasingly strong levels of management. Bag and size limits are still the main mechanism for restricting catch, but the use of time closures is now being applied to abalone, lobsters, and demersal scalefish.

3.4 Ecosystem management in West Coast Bioregion

The marine benthic habitats and their associated biodiversity are largely protected along most of the West Coast from any physical impact of commercial fishing due to the extensive closures to trawling. These closures inside 200m depth were introduced in the 1970s and 1980s, in recognition of the significance of extensive areas of seagrass and reef as fish habitat (Figure 6b). The extent of these areas means that over 50% of the West Coast Bioregion inside 200 m depth could be classified as a marine protected area with an IUCN category of IV (Table 4).

Fish habitat and biodiversity protection is also provided within individual marine protected areas along the west coast including:

- Fish Habitat Protection Areas (FHPAs) at the Abrolhos Islands, Lancelin Island Lagoon, Cottesloe Reef, and Kalbarri Blueholes;
- Reef Observation Areas within the Abrolhos Islands FHPA and closures to fishing under s.43 of the Fish Resources Management Act 1994 at Yallingup Reef, Cowaramup Bay, the Busselton Underwater Observatory, and around the wrecks of the Saxon Ranger (Shoalwater Bay) and Swan (Geographe Bay); and
- Marine conservation areas proclaimed under the Conservation and Land Management Act 1984 at Jurien Bay, Marmion, Swan Estuary, Shoalwater Islands, and the proposed Capes Marine Park between Cape Leeuwin and Cape Naturaliste (Figure 6b).

The Australian Government's Department of Environment, Water Heritage and the Arts (DEWHA) is also undertaking a Marine Bioregional Planning process for Commonwealth waters between Kangaroo Island, South Australia and Shark Bay. The draft South West Marine Bioregional Plan (MBP) was released in late 2011 and includes a series of proposed marine protected areas within the Commonwealth waters off the West Coast. This is not detailed in this report.

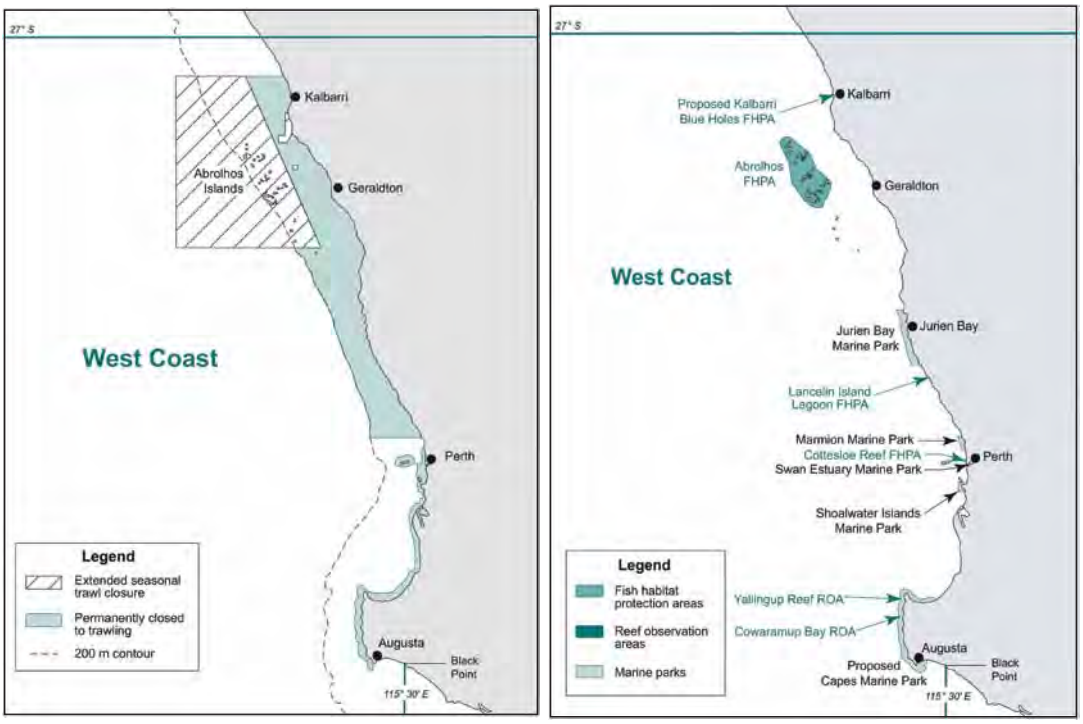

Figure 6. a: Map showing areas of permanent and extended seasonal closures to trawl fishing in the West Coast Bioregion. b: Map showing current and proposed marine protected areas in the West Coast Bioregion.

Table 4. The areas and proportions of the West Coast Bioregion making up continental shelf waters (<200 m depth) where habitats are protected from the physical disturbance of trawl fishing. The areas which are formally closed to trawling would be equivalent to meet the IUCN criteria for classification as marine protected areas as category IV. The area of habitat effectively protected refers to the area where trawling doesn't occur.

Total Area of Shelf	Area of shelf equivalent to IUCN marine protected area <= category IV (%)	Maximum area of actual trawling activity	Total area of habitat effectively protected (%)
19,600 sq nm	11,000 sq nm (56%)	300 sq nm	19,300 sq nm (98%)

4.0 Identification of the scope

The first and arguably most important step in EBFM is to agree on the scope of what will be managed within the system. Where are the boundaries and what elements are to be managed? This is important to clarify as management systems can operate at many different spatial scales and it is necessary to avoid confusion and therefore increase the efficiency of the process.

4.1 Appropriate spatial scales for applying EBFM in Western Australia

Large scale units

The marine waters of Western Australia have previously been categorised in various ways to meet different objectives or criteria including ecological, geomorphologic, jurisdictional or a combination of these criteria. The Department of Fisheries utilises a set of boundaries that divide the State into a number of marine regions, termed bioregions. These include the North Coast, Gascoyne Coast, West Coast and South Coast bioregions (Figure 7). It is recognised that within each of these broad scale bioregions there will be a number of smaller ecosystem units.

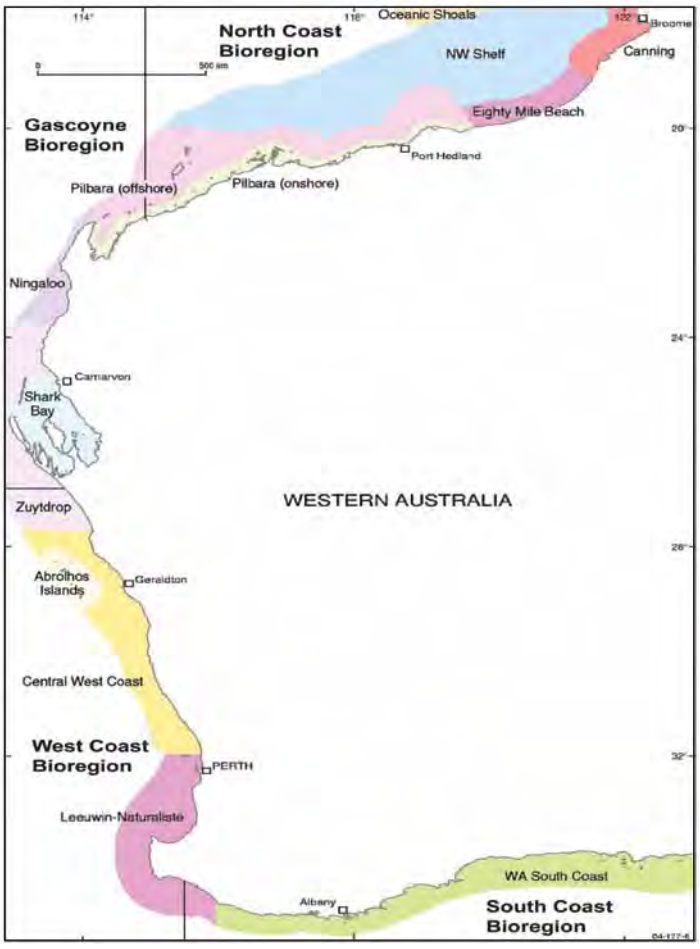

Figure 7. Map showing the IMCRA ecosystems (coloured regions) and the Department of Fisheries regional boundaries (black lines).

To help achieve EBFM and to better integrate this process with other regional initiatives, agreement on the appropriate spatial extent of ecosystems in Western Australia was achieved across all the key WA government agencies that have an operational or policy interest within

the marine and coastal regions. For the purposes of EBFM and other regional initiatives, it was agreed by the WA Interdepartmental Committee (IDC) that the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) v3.3 regional boundaries (Figure 7) would be used as the basis for defining the primary-level marine ecosystems in Western Australia. Because these boundaries were developed collaboratively by State and Commonwealth Government agencies this should also facilitate better integration of State and Commonwealth regional marine initiatives.

West Coast Bioregion

The West Coast Bioregion was seen as a priority region and as such was the first region to be considered in the Department of Fisheries EBFM initiative.

The ecosystem divisions for the West Coast Bioregion (Figure 7) were defined by IMCRA v3.3. as:

- West Coast;
- Leeuwin-Naturaliste;
- Abrolhos Islands.

Regional scale units

The Department of Fisheries manages activities within particular ecosystem/management areas that correspond to the general distribution of 'suites' of species (DoF, 2011). Consequently, to make the ecosystem units appropriate to the scale of management, further spatial divisions were made based on the following functional distributions of species:

- Estuaries and Embayments;
- Nearshore, which included waters from the shoreline to an approximate depth of 20m;
- Inshore demersal, which includes the benthic and lower layers of the water column from a depth of approximately 20m to 250m;
- Offshore demersal, which includes the deeper demersal waters from a depth of around 250m to the Australian EEZ (Exclusive Economic Zone);
- Pelagic, including the upper layers of the water column from the nearshore zone to the EEZ.

The additional spatial boundaries described above link closely to the management units used for finfish in WA and the Management Plan boundaries for functional species distribution and zoning and will improve management outcomes under EBFM.

Values

It must be ensured that the effective management of one objective does not cause unwarranted problems in the performance of another objective. There may be situations whereby managing to optimise one objective can result in poor performance in another. In such situations a compromise will need to be made, preferably by explicitly determining which of the objectives should have precedence over the other.

The main values that have been identified as being relevant to the West Coast Bioregion are shown in Table 4.

Table 4. Values and high level objectives for the West Coast Bioregion.

	Value	High Level Objective
1	Species Sustainability	Keeping biomass levels above levels where recruitment could be affected.
2	Ecosystem Sustainability	Ensuring that any impacts on ecosystem structure and function are kept at acceptable levels.
3	Economic Outcomes	The economic benefits to the community are optimised.
4	Social Amenity	The social amenity (i.e. non-economic benefits) derived by the community is optimised.
5	Social Impacts	Social impacts and negative attitudes associated the management of these resources are minimised.

5.0 Identification, assessment and consolidation of assets and issues

5.1 West coast ecosystem structure and biodiversity assets

The IMCRA ecosystems listed above form the first tier in the section of the EBFM framework dealing with the ecosystem (i.e. Community Structure and Biodiversity). These were further categorised to the regional scale units mentioned above (e.g. estuaries and embayments, nearshore etc.).

To make the component trees relevant to the West Coast Bioregion, these regional scale units were further divided into specific areas, such as rivers or estuarine systems (Figure 8) and can again be divided into levels appropriate for monitoring and reporting for specific management arrangements.

The West Coast and Leeuwin-Naturaliste ecosystems divide approximately along the Perth trench. This division would notionally place the Swan River into the West Coast ecosystem and Cockburn Sound and the Peel Harvey estuary into the more southern (Leeuwin-Naturaliste) ecosystem. Given the close proximity and considerable linkages between these 3 systems, the Swan Canning and Peel Harvey estuarine systems as well as Cockburn and Warnbro Sound embayments have been included in the West Coast ecosystem for the purpose of the study.

During the risk assessment process, the risk of broad-scale ecosystem change due to any impact on each identified ecosystem (i.e. Swan Canning, Peel Harvey, nearshore, offshore demersal) was assessed. For instance, the impacts of fishing, pollution, coastal development and sand mining were included in the assessment of different risks in Figure 8.

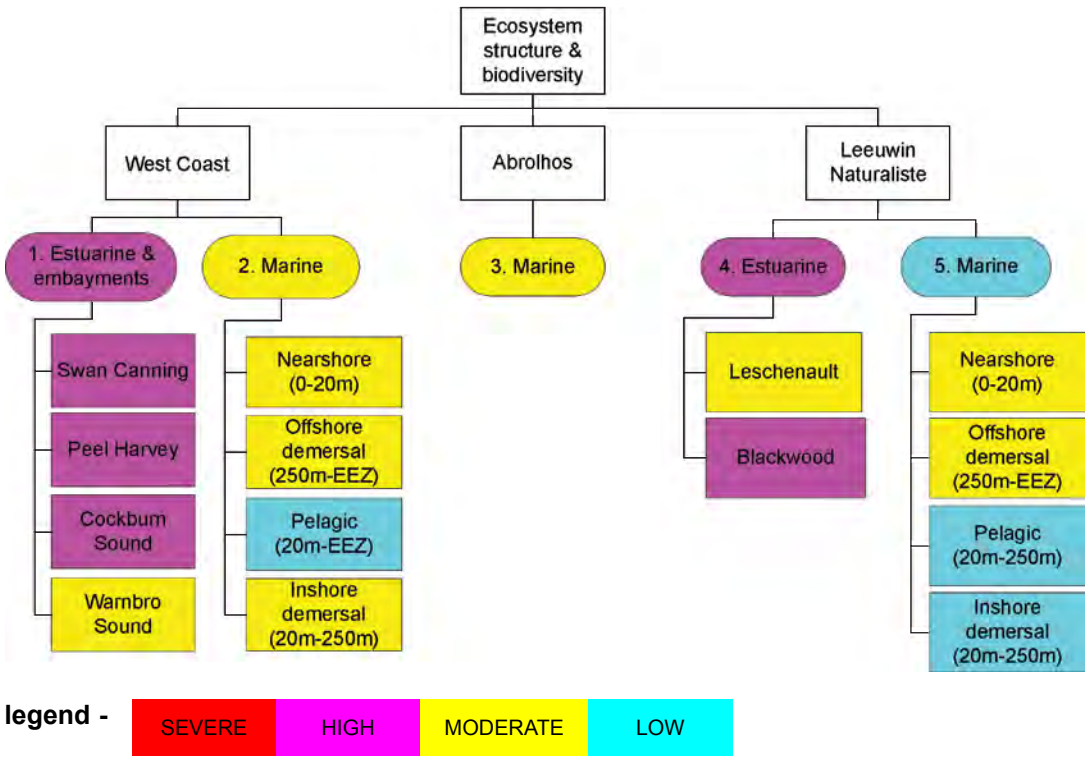

Figure 8. Ecosystem structure and biodiversity individual risks. Ovals represent the level at which sub-branch components were aggregated in the consolidated tree. Numbers indicate components that form part of the multi-criterion assessment (Table 5).

Abrolhos Islands marine LOW - MEDIUM Risk

The Abrolhos Islands are managed within a 'Fish Habitat Protection Area', and are not currently considered to be at major risk from fisheries related activities. This risk level was assessed based upon the acceptance that while there has likely been a change in the relative composition of some finfish species there does not, appear to have been either a loss of biodiversity or a noticeable change in the types of communities present. This ecosystem will be especially vulnerable to climate change impacts due to the unique combination of macro algae and coral.

West coast marine LOW – MEDIUM Risk

An assessment of community structure and trophic level of all commercially caught fish species over the past 30 years through an FRDC funded study found no evidence of systematic changes that could be viewed as evidence of an unacceptable impact of fishing on this ecosystem (Hall and Wise, 2011).

A recently completed FRDC funded project provided critical information on the relationships between rock lobster abundance, size distributions and benthic habitat characteristics in deep water, and preliminary data on the trophic role of rock lobster in deep water ecosystems.

West coast estuaries - HIGH – SEVERE (non-fishing) Risk

The estuaries and embayments within this area have been identified as being at severe risk, due to external factors (water quality issues due to high nutrient runoff from surrounding catchment), which have the potential to affect fish communities. Poor water quality within the Peel – Harvey and Swan-Canning estuaries, and Cockburn Sound are of particular concern.

Leeuwin-Naturaliste - marine LOW Risk

The risks of significant impacts on the marine communities in this region are relatively low.

Leeuwin-Naturaliste estuaries HIGH Risk (non –fishing)

External factors such as water quality issues in the Blackwood Estuary, due to high nutrient run-off from surrounding land, as well as acid sulphate soil contamination are of concern to sustainable fish stocks.

5.2 Captured 'fish' species assets

This tree (Figure 9) includes all 'fish' species captured where 'fish' is understood to be those animals described under the Fish Resources Management Act (1994) and does not include protected species under State and Commonwealth legislation.

The suites of species (e.g. estuarine, nearshore, demersal and pelagic) have been used because the allocation of species into 'suites' means that managers can readily consider the impacts of changes in operations of fisheries. In addition, it will mean that decisions can be made more rapidly as a matrix of all suites within a bioregion will be generated. Some of the species in the captured fish component tree have then been further divided into stocks or ecosystem groups (e.g. Australian herring, king prawns). For each species, the risk assessment covered a broad range of elements including issues such as concerns with abundance, distribution, genetic changes, along with any impacts of discarding by a fishery, or any other impact on the species by other sectors (e.g. illegal fishing).

Finfish estuarine - SEVERE Risk

West coast estuaries are highly modified, and often degraded, environments. In these estuaries, the impacts of environmental factors on fish stock abundances are likely to be at least as important as fishing pressure.

Management of fish communities in west coast estuaries requires a collaborative effort between fishery and habitat managers.

Inshore demersal - SEVERE Risk[1]

Concerns for the suite of demersal species (which includes dhufish, pink snapper, baldchin groper) were confirmed following recent reviews of the stock assessments completed for the three indicator species.

Near-shore demersal - HIGH Risk

There are increasing concerns for Australian Herring, tailor and skipjack trevally and whiting in the nearshore region given the potential for recreational fishing levels to increase due to increased management controls on popular inshore demersal species.

Offshore Demersal - MEDIUM –HIGH Risk

Some of the key indicator species in this deepwater location are vulnerable to overfishing. Overlaps in catch also exist with Commonwealth trawl vessels.

Pelagic LOW Risk

There is now minimal capture of pelagic fish in this bioregion.

Crustaceans estuarine (Crabs) MEDIUM - HIGH Risk

The stocks of crabs in Cockburn Sound have been at depleted levels for the past few years but are now in the process of recovery since the closure of fishing occurred in 2007. Stocks in other regions of the West Coast are being reviewed.

Shelf (Lobsters and prawns) MEDIUM Risk

Despite recent low recruitment levels the strong management that is being applied to the rock lobster fishery should ensure the stock levels of key crustaceans in this region, western rock lobsters and prawns are both currently at appropriate levels.

Molluscs nearshore - MEDIUM Risk

The stocks of abalone are conservatively managed with strong management controls on both commercial and recreational fishers.

1 Note this risk has subsequently been reduced given the 50% reductions that have occurred to the catch levels of all sectors that captured this suite.

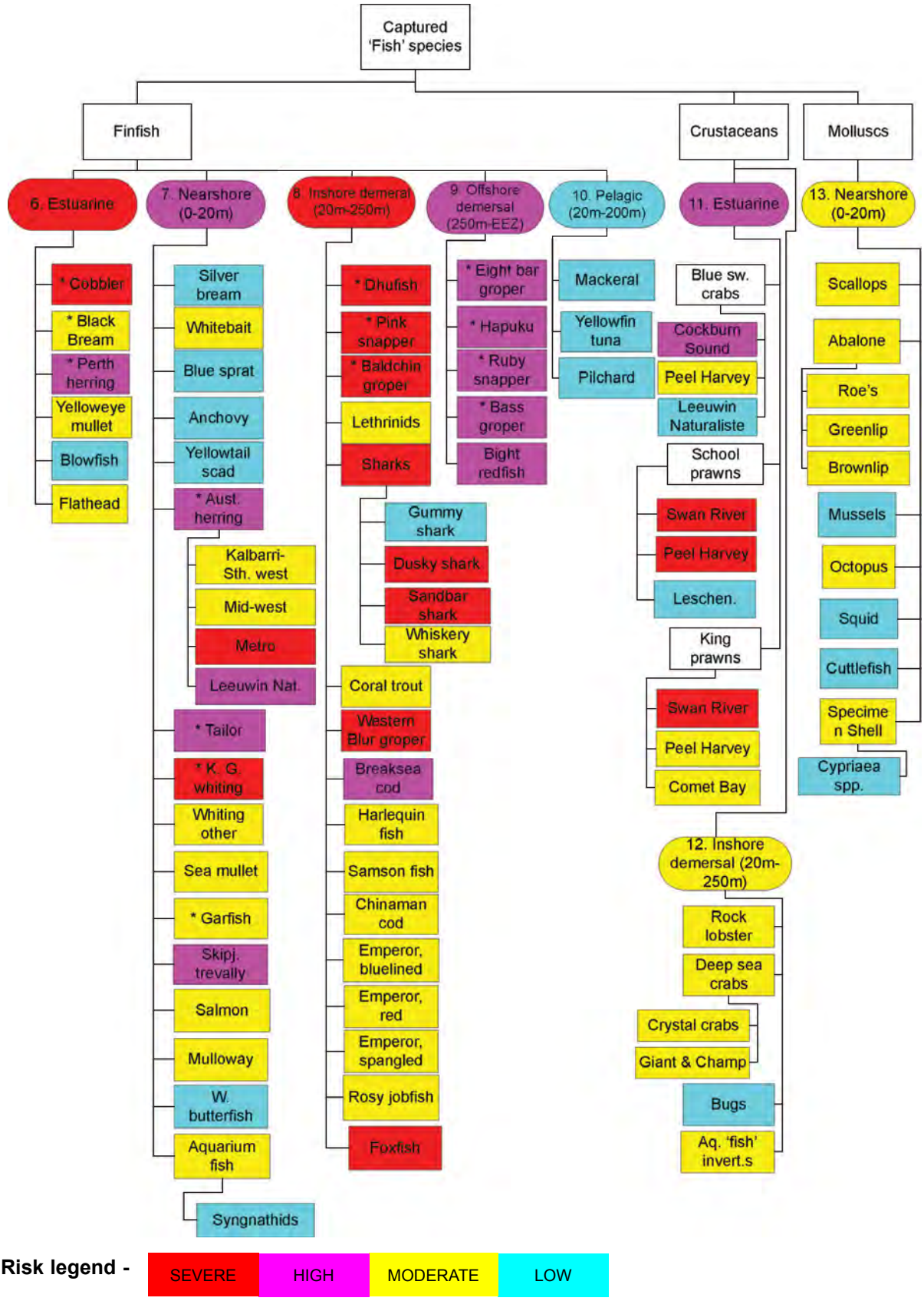

Figure 9. West Coast Bioregion – Captured species risks, ovals represent consolidated risks. Numbers indicate components that form part of the multi-criterion assessment (Table 5).

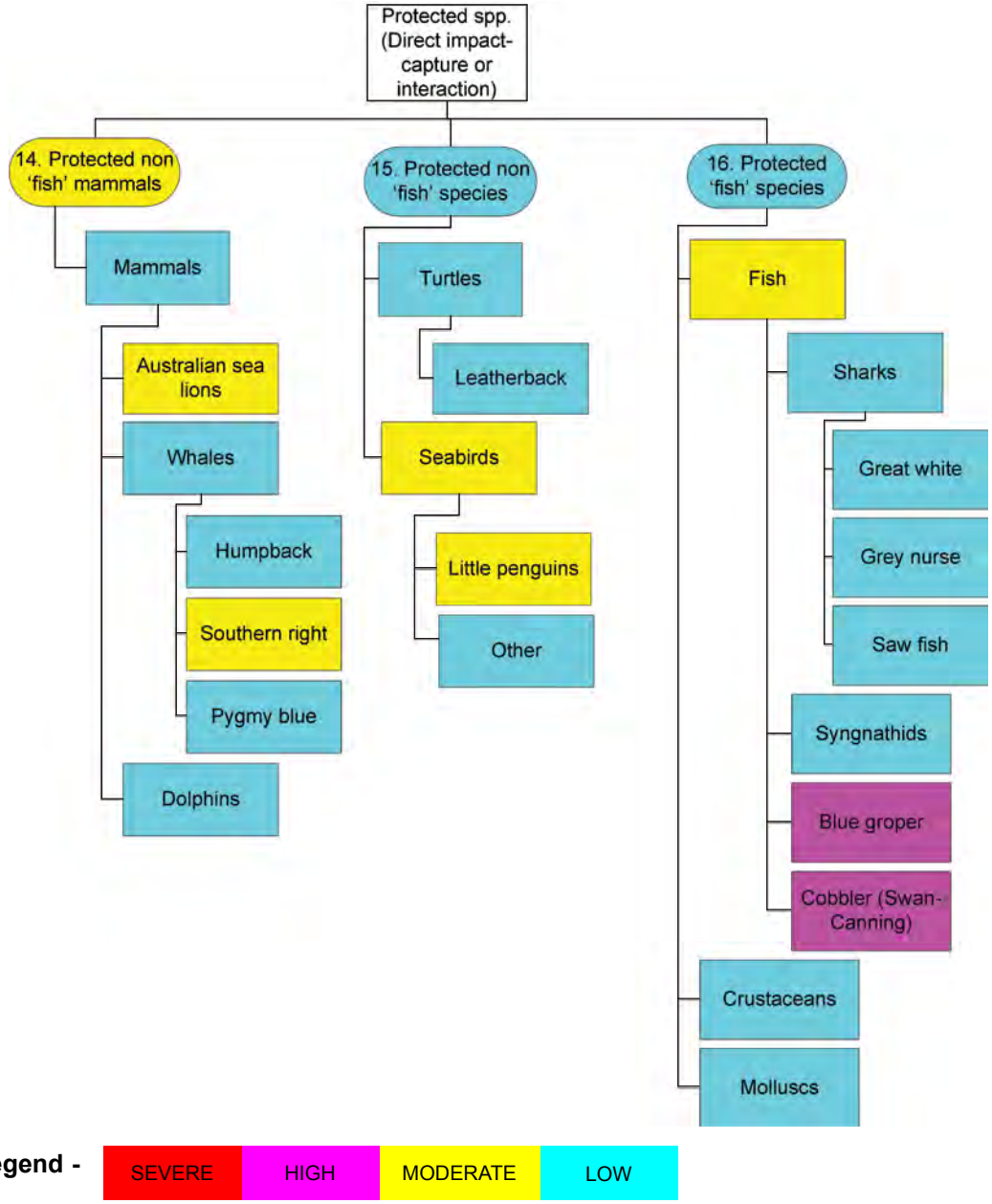

Figure 10. West Coast Bioregion – Protected species risks. Ovals represent the level at which risks were consolidated. Numbers indicate components that form part of the multi-criterion assessment (Table 5, p.49).

5.3 *Protected species assets*

Protected non 'fish' species (Figure 10) are managed under a range of State legislation (Wildlife Conservation Act and Regulations 1950, Conservation and Land Management Act 1984) and Commonwealth legislation (Environment Protection and Biodiversity Conservation Act 1999 known as the EPBC Act and the Wildlife Protection Act 1982). Under Commonwealth legislation (generally applied to waters outside State waters or 3nm) it is an offence to kill, take, trade or move protected species without a permit.

The protected non 'fish' include a large number of marine animals, including sea birds, turtles, sea snakes and mammals. Deliberately causing interference to cetaceans carries additional penalties.

As fishing can occasionally result in unavoidable accidents or incidents, all interactions with protected species under the EPBC Act must be reported. In the West Coast Bioregion there are some mammals, few reptiles and only a small number of other protected species that interact with fishing activities. There are also minimal fisheries in the West Coast that produce bycatch (Richard Campbell, pers. comm.).

Certain 'fish' species are protected under State legislation (Fish Resources Management Act 1994) and Commonwealth legislation (Environment Protection and Biodiversity Conservation Act 1999). Protected fish species include all pipefish, seahorses and sea dragons, many shark species, some finfish species and a small number of crustaceans and molluscs.

The decision to examine protected species at the species, group or higher level depends upon what is considered appropriate for the region in question. If a large number of species is identified with similar risk profiles, these species may be aggregated to a higher level (Fletcher 2008).

The risk assessment process for protected species identified risk due to interactions with fisheries, whether by direct capture or indirectly through disturbance or provision of food through bait.

Protected non 'Fish' species turtles LOW Risk

There is minimal impact of any fishing activity on any turtle species within this bioregion.

Seabirds LOW -MEDIUM Risk

Little Penguins are considered at risk from fishing and boating (boat strikes) in this region.

Mammals (sea-lions) LOW Risk

Sea lion exclusion devices (SLEDs) required for rock lobster pots near sea lion breeding islands has reduced the level of risk.

Australian Sea Lions and Southern Right Whale interactions may increase in future with increasing numbers.

Protected 'Fish' species fish LOW-MEDIUM Risk

Blue groper (Rottnest Island), and Cobbler (Swan Canning), White Sharks.

5.4 Benthic habitat categories

The Benthic habitat categories (Figure 11) have been broken into functional distribution areas followed by habitat types and further divided into the ecosystems of the West Coast Bioregion. This is to enable cross-referencing between each of the component trees when determining management priorities and assessing residual risk.

The benthic habitat categories include:

- Seagrass;
- Sand;
- Rocky Reef, which is generally algal-dominated in the West Coast Bioregion;
- Coral Reef;
- Sponge areas; and
- Mangrove communities.

As information is limited for many of these habitats, data has been combined for many of the areas. Over a short time frame (5 years) and a long time frame (20 years) the risk of unacceptable change has been estimated (see Risk Assessment section). Risk to benthic habitats from any source, such as sand mining, pollution and sedimentation, was included in the risk assessment.

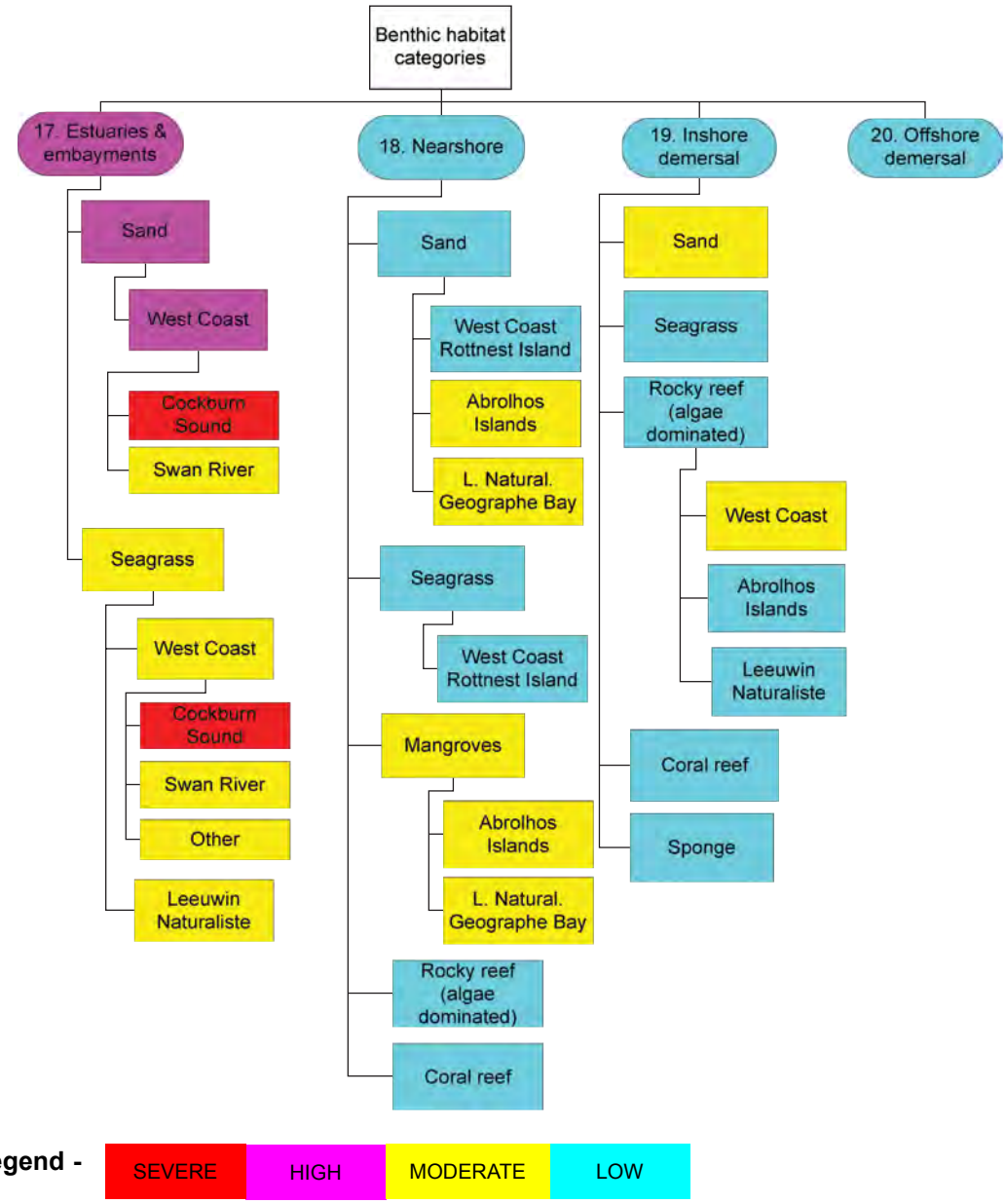

Figure 11. West Coast Bioregion – Habitat risks, consolidated risks are the ovals at the top of the branches. Numbers indicate components that form part of the multi-criterion assessment (Table 5).

Estuaries and embayments sand HIGH Risk (non-fishing)

Many sand habitats in estuarine and embayment habitats are threatened by factors such as poor water quality, direct loss of habitat through coastal infrastructure and physical disturbance (e.g. dredging), sedimentation and smothering by algae.

There are minimal impacts of fishing on these habitats.

Estuaries and embayments seagrass MEDIUM Risk (non- fishing)

Seagrass habitat threatened by non-fishing related activities (coastal infrastructure and associated dredging, direct habitat loss, turbidity).

Nearshore sand LOW Risk

Minimal direct impacts and high recovery rates.

Nearshore seagrass LOW Risk

No destructive fishing methods allowed in these areas. Most likely impacts from developments.

Estuaries and embayments sand HIGH Risk (non-fishing)

Many sand habitats in estuarine and embayment habitats are threatened by factors such as poor water quality, direct loss of habitat through coastal infrastructure and physical disturbance (e.g. dredging), sedimentation and smothering by algae.

There are minimal impacts of fishing on these habitats.

Estuaries and embayments seagrass MEDIUM Risk (non- fishing)

Seagrass habitat threatened non-fishing related activities (coastal infrastructure and associated dredging, direct habitat loss, turbidity).

Nearshore sand LOW Risk

Minimal direct impacts and high recovery rates.

Rocky reef LOW Risk

Minimal direct impacts and high recovery rates.

Coral reef LOW Risk

Minimal direct impacts.

Offshore demersal LOW Risk

Minimal direct impacts.

5.5 General environment impacts

This tree (Figure 12) details the risk associated with general environmental impacts that could occur from fishing operations. These risks are not to be confused with the external drivers which are impacts not related to fishing. Many of these impacts may not appear particularly critical at this point; however, with the increasing focus on carbon emissions and carbon trading they are likely to become more important. Assessment and reporting by fishery on environmental performance, including carbon emissions may be necessary in the coming years.

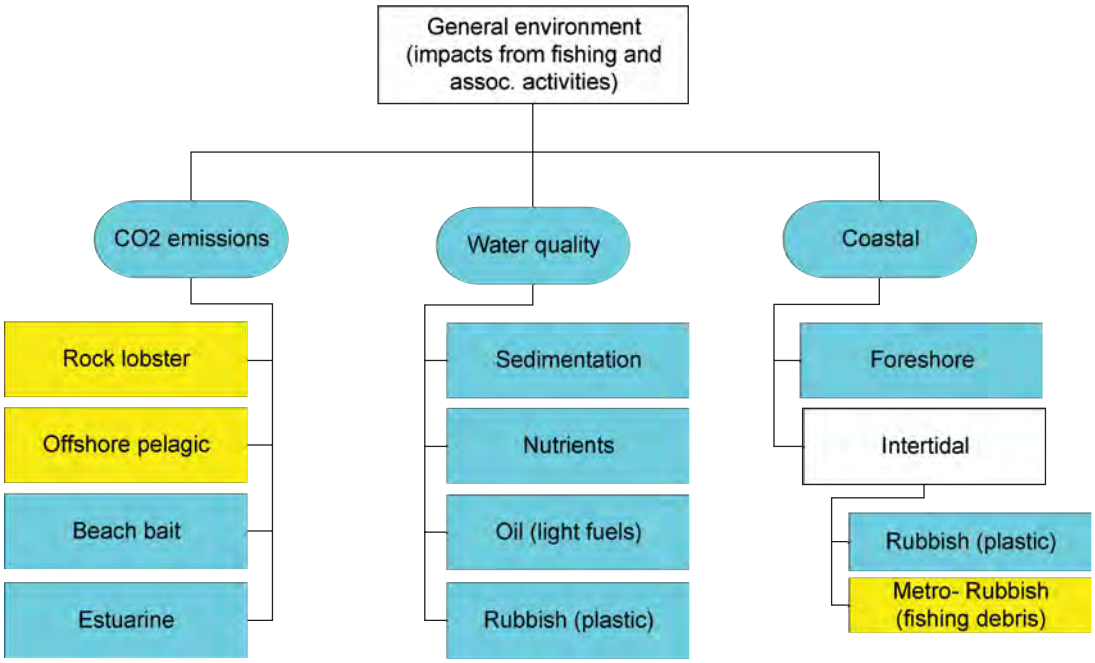

Figure 12. General environment component tree.

CO2 Emissions: This includes the potential for the fishery to contribute to greenhouse gas emissions and their notional carbon footprint. Although WA fisheries have not been formally assessed for their CO2 emissions, it is assumed that those fisheries with powerful vessels, working offshore and exporting their product would have a larger carbon footprint than those using dinghies from the beach and selling product locally.

Water quality: This component includes the impacts on water quality that could come from aquaculture, fishing, or fishing related activities such as fish processing. It includes the possible accidental spillage of fuel or oils, particularly if appropriate protocols or codes of conduct are not in place. The release of fishing debris into the water column including bait and bait packaging and sullage from fishing vessels can also impact water quality. Sullage has the potential to be a pollutant in heavily used anchorages, whether for commercial or recreational vessels. Some aquaculture activities may impact on nutrient loads and sedimentation issues may arise as a result of fishing boat harbour or aquaculture facility construction.

Coastal Impacts: These components are impacts on the coastal environment from fishing and fishing-related activities. This tree has been further divided into the foreshore (above high water mark) and intertidal areas (between the high and low water mark). The foreshore impacts could include beach erosion from 4WD vehicles accessing fishing points or launching fishing boats. It may also include environmental impacts from the construction of fishing boat harbours. In the intertidal areas, fishing debris and rubbish washed up from vessels and left by recreational fishers could all be issues for consideration.

5.6 Social and economic issues

It should be outlined first that because the social and economic values were found to have different objectives, their assessments were kept separate during this case study. This division lead to better focus on the social and economic issues and less confusion when assessing the risk. To better link the social and economic issues with fishery management priorities,

the trees were further divided into those associated with the direct stakeholders and those of indirect stakeholders. The indirect stakeholders include the indigenous, regional and statewide communities.

5.7 Social issues

The Social Issues (Outcomes) trees (Figure 13 and 14) covers both the potential social impacts (both positive and negative) of the fishery on the participants (commercial, recreational, charter, customary and aquaculture), the wellbeing of the local or regional communities associated with each fishing activity and the general WA community. The risk of change to the social outcome was assessed during the risk assessment.

5.8 Social issues (outcomes); direct stakeholders

Direct Stakeholders refer to those fishers who are directly associated with a particular fishing activity, whether this is through a commercial fishery, the recreational sector or charter industry, and whether the person is a customary user or operates within an aquaculture industry.

For consistency with the other component trees, the direct stakeholder groups were divided into those associated with finfish, crustaceans and mollusc fisheries and further into their functional spatial groups (Figure 13). Not every fishery within the West Coast Bioregion is represented on the tree, however, the list can be expanded at any point, particularly if there is a perceived issue in a fishery that is not listed.

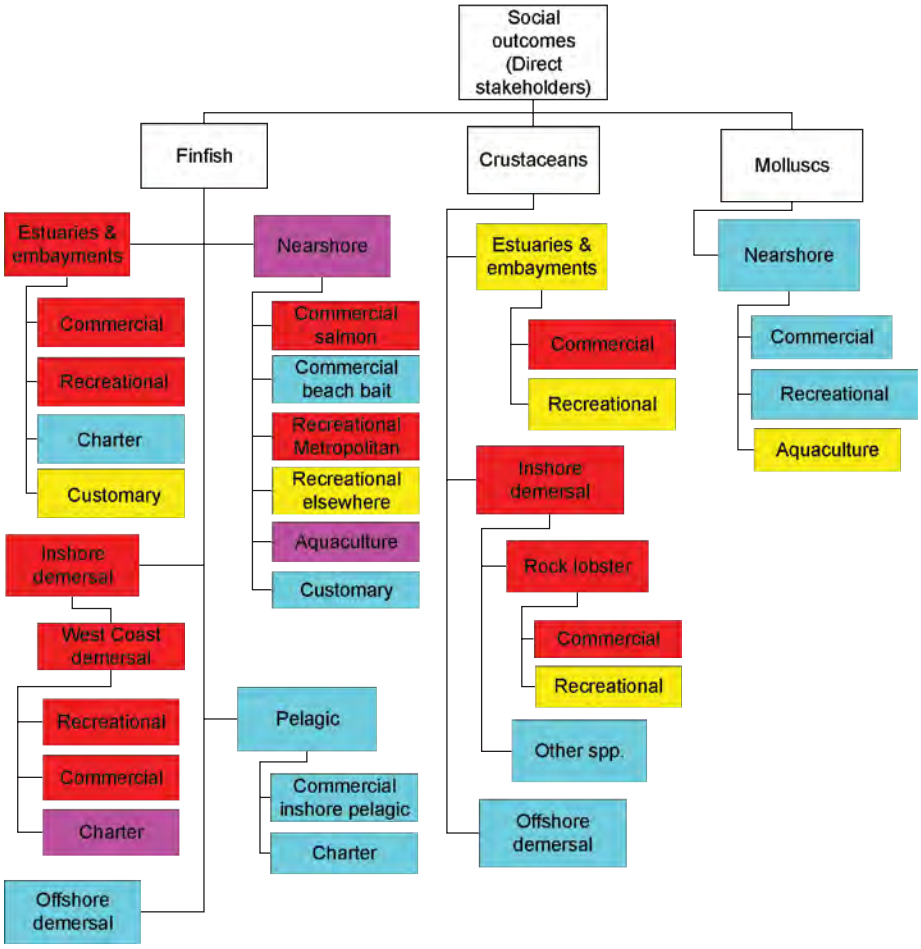

Figure 13. Detailed component tree for social issues (outcomes) for direct stakeholders.

5.9 General social outcomes; (indirect stakeholders)

Indirect stakeholders include those people in industries indirectly reliant on some aspect of fish or fishing as well as the communities associated with fishing. It also covers issues that may be important to communities across the State including the attitudes of fish consumers, perceptions and attitudes of the community towards the fishing as well as the cultural and heritage values that are a part of a fishing community. Similarly to the social outcome tree for direct stakeholders, the risk of change to a social outcome was assessed.

Indigenous Communities

This outcome relates to indigenous communities within the West Coast Bioregion that are associated with the marine environment and fishing activities. Access to fishing grounds, the value of catching fish for cultural and social reasons, as well as customary rights for indigenous communities are all considerations in this element.

Regional Communities

The reliance on and participation of regional communities (both direct and indirect) in fishing activities is an important factor in considering the risk to these components. Across each of the broad community groupings listed below, there are a number of factors to be considered when assessing the importance of the fishing industry to a community and the possible impact of changes to a community as a result of changes to a related fishery.

As social and economic information is often collected by town or community, the 'regional community' boundaries for the West Coast study follow population related areas rather than the marine ecosystem boundaries. The boundaries include:

West Coast; Metropolitan; and Leeuwin-Naturaliste.

West Coast: Communities north of the Perth metropolitan zone but within the West Coast Bioregion that are associated with the marine ecosystem and fishing activities. The main communities include Kalbarri, Port Gregory, Horrocks, Geraldton, Dongara, Leeman, Green Head, Jurien Bay, Cervantes, Lancelin, Ledge Point, Seabird, Two Rocks (for population numbers see Huddleston 2006).

Metropolitan: Communities within the greater Perth metropolitan zone associated with the marine ecosystem and fishing activities. The metropolitan area extends from Two Rocks to Dawesville and includes Mindarie, Hillarys, Fremantle, Woodman's Point, Kwinana, Warnbro and Mandurah.

Leeuwin-Naturaliste: The communities from Dawesville south and including the Capes (between Cape Leeuwin and Cape Naturaliste). The main towns include Bunbury, Busselton, Yallingup and Augusta.

The values to be considered may include maintaining the support and recognition of the fishing industry or the opportunities for community members to go recreational fishing in mining towns.

State-wide Communities

Cultural/heritage values: These values indicate the intrinsic importance of fishing within communities. For example, whether the continuation of fishing in a town with a long history of fishing is important to community members and visitors to the region is an indication of the

cultural/heritage value of fishing. Whether people enjoy visiting fishing ports and value the availability of locally caught fresh fish provides an indication of the associated cultural and heritage values.

Existence values: This is a value people derive from the very existence of the marine ecosystem. It includes the value or benefit derived from observing the ocean and marine life without being directly involved in fisheries or fishing activities. It can also include the value those who have no connection to the marine environment but like to 'know it is there!'

Perceptions/attitudes: These refer to broad-scale community understanding, thoughts and feelings regarding fishing and include views on all fishing sectors, including commercial, recreational, aquaculture and customary fishing. These views may change over time to be more or less accepting of fishing and also to reflect an increased understanding or knowledge of a particular sector or issue.

Seafood Consumers: People who eat fish but do not necessarily catch their own fish. Where they purchase their fish (fish monger, supermarket or restaurant) and what is selected in terms of species, quality and price are all relevant factors. The choice of local fish or imported product appears to be an increasing market driver, as does the consideration of sustainable fishing or other environmental accreditations.

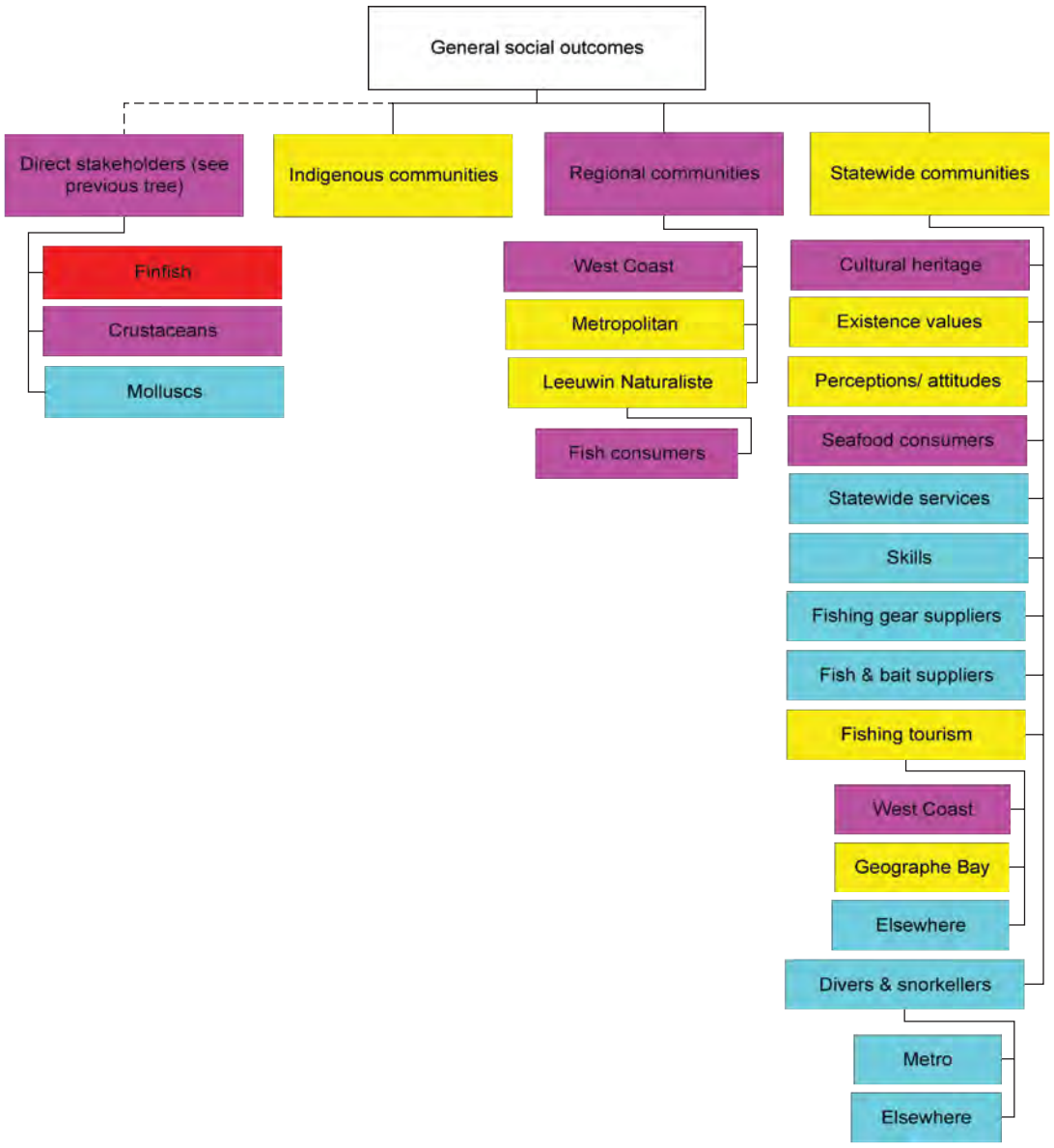

Figure 14. Detailed component tree for general social issues (outcomes). The dashed line related to direct stakeholders indicates that these elements were dealt with in a previous tree.

State-wide services: All generally available services, such as electricity and acceptable communications (i.e. internet, phone and mail). In addition, state-wide services includes the maintenance and availability of roads as well as the availability of transport/freight provisions for incoming and outgoing seafood products and fishing gear. This value also includes boat ramps, jetties, fishing boat harbours and mooring areas.

Skills: Refers to skills provided to commercial fishers to aid their fishing ventures or their movement into alternative employment.

Fishing gear suppliers: Businesses that sell fishing gear (tackle) to commercial and recreational fishers in the West Coast Bioregion.

Fish and bait suppliers: Businesses that sell fish and bait to the commercial and recreational sector as well as the general public.

Fishing Tourism: Businesses that include fishing, which might be affected by changes in the marine environment and fisheries. This value would include businesses such as caravan parks, jetty kiosks, boat hire etc.

Divers and Snorkellers: People who may live in the local area or specifically visit an area to participate in diving. They are often looking for areas of high biodiversity, large animals and charismatic species.

5.10 Economic outcomes

Economic evaluations tend to focus on 'net economic benefits', which use prices and markets to describe benefits to an individual group or community. Compared with social evaluations this allows a relatively straightforward approach to the measurements and comparison of benefits across uses (Vieira et al, 2000).

The 'Economic Outcomes' trees (Figure 15 and 16) cover the potential economic impacts (both positive and negative) of the fishery on the fishing industry as well as that of the local or regional communities that are associated with fishing. The component tree is broken into two main branches; one dealing with the fishing sectors and their associated communities (direct stakeholders and dependent communities) and the other; local communities directly or indirectly affected by the industry (indirect stakeholders and general community).

5.11 Economic outcomes: Direct stakeholders

The tree for this group (Figure 15) includes the commercial, charter, and aquaculture participants. It does not include the indigenous or recreational sector because there should be no financial gain from fishing activities for these participants.

The tree has been divided based on the species groups (finfish, crustaceans and molluscs) that are being captured and then the relevant suites (estuarine, nearshore, inshore demersal and offshore demersal) within which they are captured. This links the economic benefits directly back to the status of the captured species outlined above.

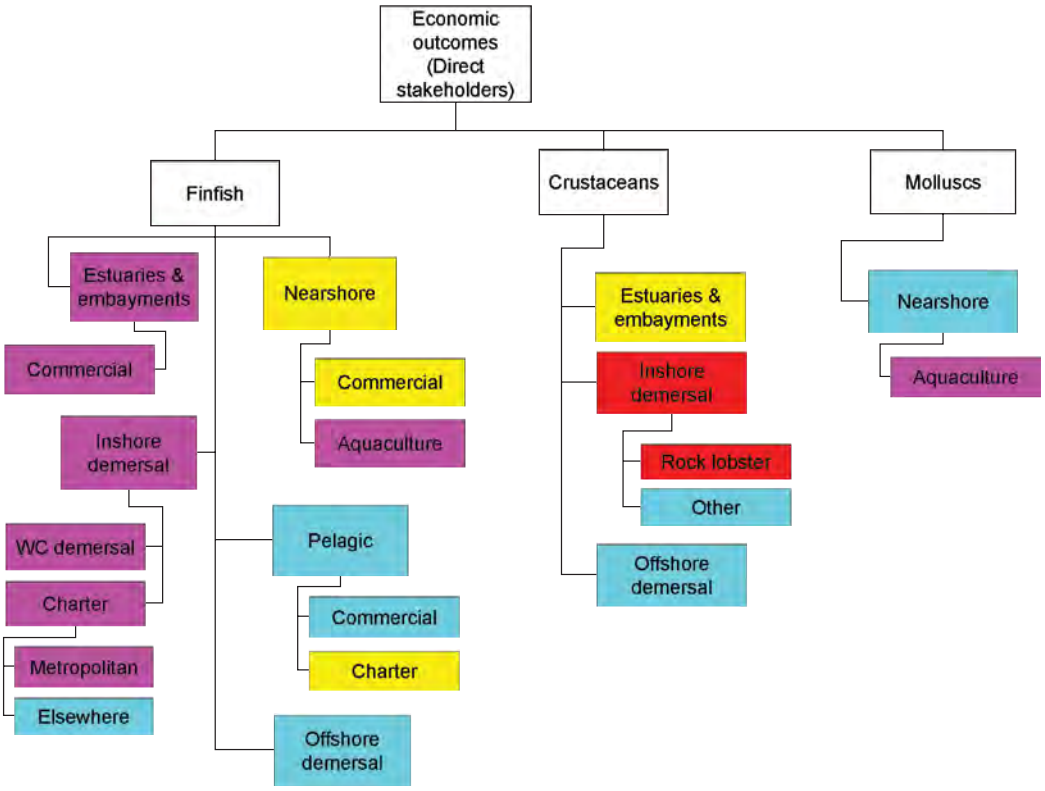

Figure 15. Detailed component tree for economic issues (Outcomes); Direct stakeholders.

5.12 Economic outcomes: Indirect stakeholders

Regional Communities

Economic values may include the maintenance of fishing-related profits or general employment within a community, which might be impacted by changes in fishing.

Statewide

Seafood processors: This value represents fish processing facilities, their owners and employees in the West Coast Bioregion.

Infrastructure: Physical components of the community, such as harbours and wharves, which exist primarily to service commercial and recreational fishing and also benefit the general public.

Seafood restaurants and food outlets: Businesses that sell seafood product (mostly cooked), through restaurants and food outlets.

Boat builders: Businesses that manufacture and sell boats in the West Coast Bioregion.

Diving operators: Tour operators that cater for SCUBA diving and snorkelling, not including fishing.

Boat sellers: Businesses that sell new and second hand fishing boats.

Seafood consumers: Were described above in a social context; however, in an economic context seafood consumers may want to access local seafood product at affordable prices.

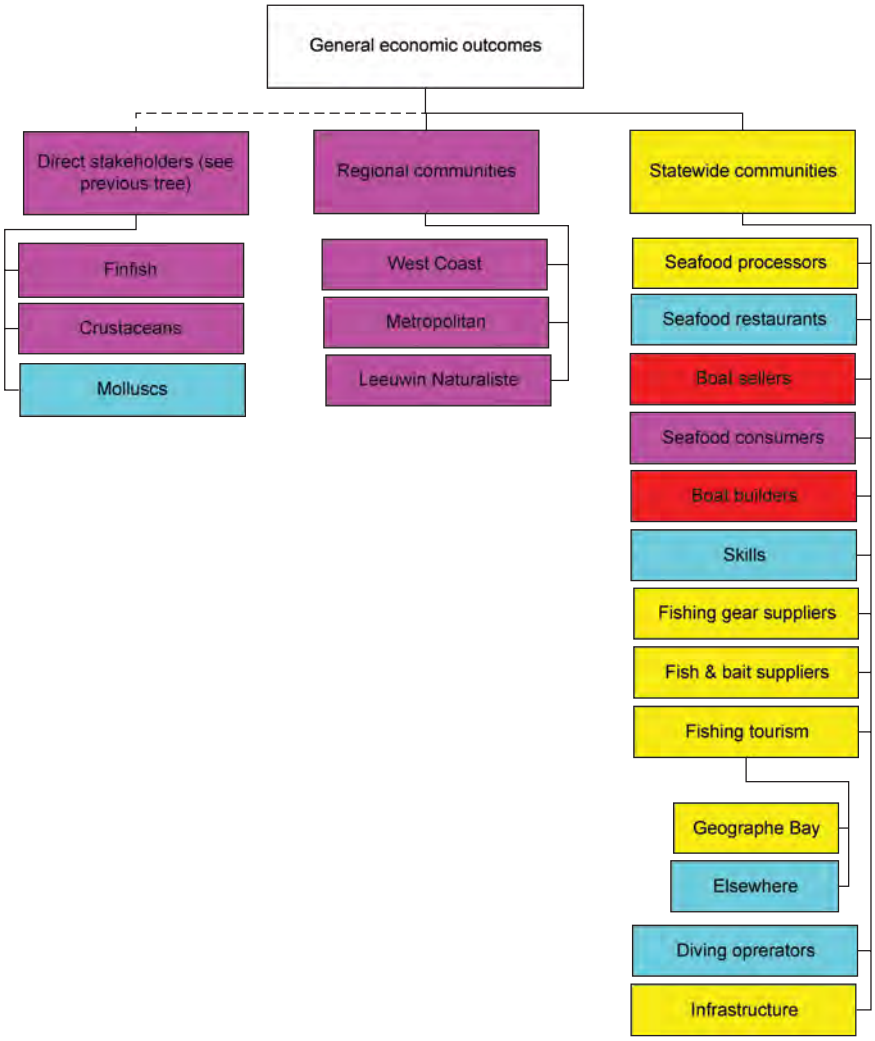

Figure 16. Detailed component tree for general economic outcomes. The dashed line refers to those elements that have been dealt with previously.

5.13 Institutional governance

Institutional governance covers some of the most important aspects when considering EBFM. It questions whether all the ESD and EBFM principles underpinned by legal, institutional economic and policy frameworks are capable of responding and taking appropriate pre-emptory and remedial actions (ESD 2002).

The elements in the institutional governance tree (Figure 17) cover all the legislative, administrative and bureaucratic processes that need to be completed to enable the issues in the previous trees to be dealt with effectively (Fletcher et al, 2002). It is designed to consider all the management processes within the Department of Fisheries. External linkages are also included such as consultation with key stakeholders and conservation NGOs, interactions with other State and Commonwealth Departments, and linkages with Universities and funding bodies (Figure 16).

In a broad sense, the Department of Fisheries undertakes policy development as well as implementation. Policy development is driven by fishery managers and is associated with specific

research to underpin policy decisions. Policy (and legislative) implementation can be influenced by stakeholder input as well as other Government Departments (Metcalf et al. 2009). External factors such as political processes can also influence the development and implementation of policy (Metcalf et al. in prep) and are covered in the 'General External Drivers' tree (Figure 18) not in the Governance tree. The management processes can be further split into research (with associated monitoring for specific fisheries) and compliance in order to undertake all aspects of policy implementation and associated legislative requirements including that for specific fishery Management Plans.

Each element of the institutional governance tree (Figure 17) relates specifically to part of the governance process. The Department of Fisheries is loosely divided into the management areas of Policy, Research and Compliance. The external linkages impacting on these processes have been divided into interactions with stakeholders and other State and Commonwealth departments.

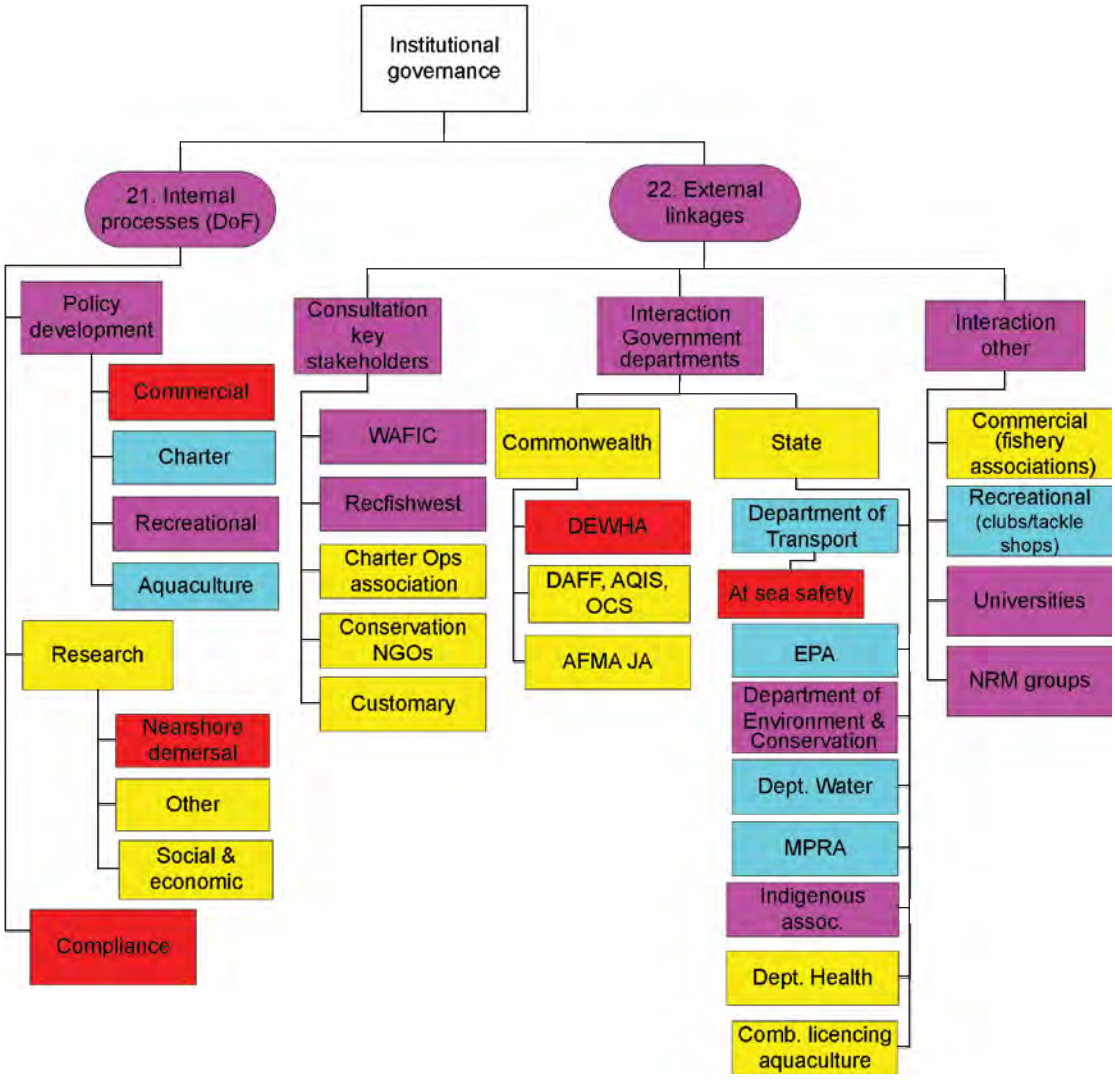

Figure 17. Institutional Governance detailed component tree. Ovals represent the level at which risks were consolidated.

DoF Management Processes

Policy development: The commercial, charter, recreational and aquaculture sectors are all covered under policy development. This area relates to the availability and comprehensiveness

of Management Plans within fisheries, or a comprehensive policy for each sector. It also relates to appropriate levels of resources available to develop and implement policy effectively.

Research: Research in the Department of Fisheries focuses on the gathering of new information and long-term monitoring to assess stock levels, monitor breeding stocks and undertake environmental assessments. It also deals with fishing and fishing-related activities, in particular those related to managing any impacts of fishing on the ecosystem. This element is related to the available resources to carry out these functions effectively. Although the Research Division is loosely divided systematically, the component tree reflects some fishing sectors as well as areas that may be at risk or are of developing interest.

Compliance and education: This value relates to upholding the regulations under the Fish Resources Management Act (1994) within the Department of Fisheries. Although the Division is divided regionally, the elements have been divided into the commercial, recreational, charter and aquaculture sectors. Within these groups, individual fisheries have been illustrated to provide examples of varied compliance needs related to specific fisheries. The question is whether compliance is adequate in the fishery to deal with the Regulations and arrangements in the Management Plan.

Consultation

Key Stakeholders: The key fishery-related stakeholders gather information from their constituents and input into the Department by way of formal consultation processes and comment into draft policy. The effectiveness of this input is often a measure of policy uptake.

Interaction; Government Departments: The Department of Fisheries interacts with State and Federal Government Departments at many levels including demonstrating sustainability of all export fisheries to the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) and the licensing of aquaculture facilities by the State Department of Environment and Conservation (DEC). There are also inter-jurisdictional arrangements (e.g. the Offshore Constitutional Settlement), as well as State and Commonwealth processes (e.g. marine parks) that require considerable input and interaction.

Interaction; Other: Not all groups that interact with the Department are listed in the Institutional Governance tree. Other organisations that may sit outside the main stakeholder groups and formal consultation pathways are listed under 'Interaction Other.' This includes groups in the commercial and recreational fishing community, which form and disband depending on their priority issues and other funding bodies that could have different funding priorities from the Department and indirectly influence policy.

The institutional governance tree is likely to be similar for all ecosystems within a bioregion.

5.14 General external drivers

The General External Drivers tree (Figure 18) has been designed to capture the major issues that are/or may impact on the ecosystem as well as the performance of fisheries and fishing-related activities. These impacts may reduce or improve the performance of a fishery but are not as a result of fishing and are generally beyond the scope of the Department of Fisheries.

Although not able to be controlled directly, these external issues still need to be taken into consideration, as they are likely to affect what management is possible. The strength or otherwise

of the external drivers will also affect the strength of management and priority of resource allocation for research and monitoring.

For example, if the breeding stock of an exploited species was under threat in a particular ecosystem, one management measure may be to reduce or ban fishing, and provide further research if there was a lack of information available. If, on reflection, it was clear that there were significant external drivers adversely impacting the ecosystem and fish stock, the management responses may be of little value and would have to be modified appropriately.

In an EBM scenario, these external drivers and their mitigating management measures would be considered by the responsible jurisdictions. However, in an EBFM approach, only those measures within the legislative control of the fisheries agency can be dealt with.

There are two major types of issues in the External Drivers tree. The first are impacts that arise from changes to the environment such as climate and water quality. These impacts may be natural or anthropogenic; however, there may not be a single cause or a direct source. The other group are clearly anthropogenic and impact directly on fisheries or ecosystems. For example, introduced pests and diseases, coastal developments and political processes are included in these anthropogenic issues.

For consistency with the other trees and to increase the relevance to fisheries management, the External Drivers have been divided into the functional spatial groups described in the 'captured' species component trees.

Climate: This element impacts all management areas. Sea surface temperature, ocean currents and precipitation have long been acknowledged as impacting on species distribution and recruitment. Natural variability in the strength of the Leeuwin Current has been recognised as having a strong link to the recruitment levels of many fish and crustacean species in WA (Lenanton et al., 1991), with precipitation and cyclone events affecting prawn catches (Vance et al., 1985). More recent data suggesting changes to sea surface temperature (Caputi et al, 1995, Feng et al., 2003) may increase the uncertainty of these linkages and require a more conservative approach with a greater adherence to the 'precautionary principle' when setting management targets.

Water quality: Water-based activities can have major impacts on water quality including increased sediment loads, pollution, nutrient enrichment and increased acid sulphate soils. The areas of impact are generally the most populated areas along the coast or around estuaries and embayments. Oil spills in valuable fishing areas were also included in the external drivers tree. The Abrolhos Islands and surrounds is an area that has been considered for a 'particularly sensitive sea area' nomination for this reason.

Other Human Use: Coastal developments are particularly prevalent in estuaries and embayments and may impact on or remove important fish nursery areas, as well as affecting the quality of water with increased nutrients, exposure of acid sulphate soils, removal of wetlands, sedges and other natural water filters.

Introduced Pests and Diseases: The introduction of exotic species into the marine environment is a major threat to native biodiversity and ecosystem health (Padilla et al, 1996) as well as the fishing and aquaculture industries. Exotic pest species are most often transported between regions by ships in ballast water or as hull fouling organisms. They can also be deliberately introduced, although this is more common in freshwater and inland waterways. Pest species can

also escape from aquaculture facilities, although strict Licensing and Regulations in WA seeks to minimise this risk.

WA has a vast coastline and there have been over 102 species of marine algae and animals introduced of which over 60 of those species are thought to be introduced through human activity. As the port facilities on the coast are considered likely areas of risk for introduced marine species, these areas have been listed in the component trees.

Exotic diseases may be carried in the water column (e.g. Gaut, 2001) although this is likely to be only over short distances. WA pearling and aquaculture facilities are spaced accordingly to reduce this risk of transmission. Translocated species are a common cause of vectors of exotic diseases, but diseases also spread into new areas through the accidental entry into the wild of aquaculture and ornamental species. Spread of disease can also occur through bait and "fouling" organisms on vessel hulls. Issues are more likely to occur from disease agents that occur in local populations without incident, however, become problematic if moved to different areas where they can cause significant disease outbreaks (Huang et al., 1994).

Political Processes: External processes at a Commonwealth, State and local government level, can impact fisheries and fishing activities at many levels. For example, all fisheries are unable to export their seafood product unless they have demonstrated they are sustainable to a Commonwealth Department. The implementation of Commonwealth Marine Parks can result in commercial and recreational fishing restrictions and/or closures. The implementation of fishing restrictions or additional reporting also requires increased fisheries compliance.

Local government plays an important role in the planning and development of the coastal strip and access to fishing locations through the provision of boat ramps and jetties. Local government can also restrict fishing access in certain areas, including that of commercial fishers fishing directly from the beach (R. Lenanton, pers. comm.).

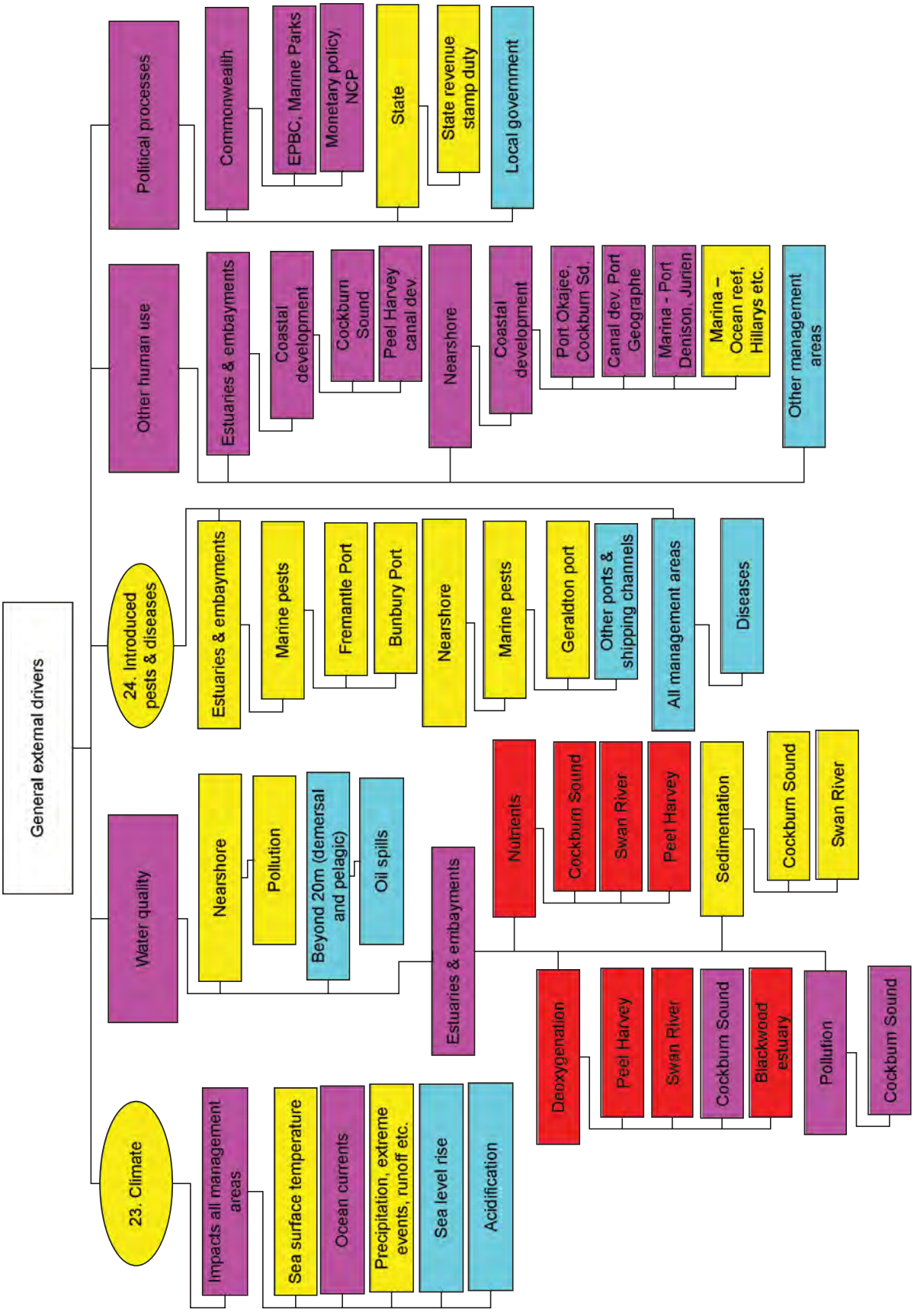

Figure 18. General External Drivers detailed component tree. Ovals represent the level at which risks were consolidated.

6.0 Determining whole of agency priorities

6.1 Background

As there are a large number of component trees (11 for the West Coast Bioregion) with many elements (e.g. captured 'fish' species >80), the full reporting of each asset that has a risk rating other than negligible (medium, high and severe) is onerous and in some cases of little value, as the summary information is available elsewhere. Amalgamating or consolidating the risk values provides a useful summary of priority. Risk areas as well as allowing for crosschecking of outcomes and impacts in the same functional groups.

It is important to record all of the elements identified by stakeholders, their risk ratings and the justifications used in calculating the rating. As the process being undertaken is Ecosystem Based Fisheries Management (EBFM) rather than Ecosystem Based Management (EBM), the amalgamation of risk and the spatial groupings have been designed to complement the way fish stocks are managed in WA.

The consolidation process reduced the large number of individual issues down to a smaller number of assets and issues; however, the remainder was still considered too large to be of direct use within a whole of agency planning and priority setting process. Moreover, as many of the individual ecological, social and economic components are interrelated they needed to be integrated prior to undertaking any agency planning to ensure that a truly holistic approach to management was taken.

The Department's primary objective is to ensure the sustainability of the ecological assets from which economic or social outcomes and benefits can be generated through implementing appropriate management. Consequently, determining the priority for assigning Departmental resources to an area must first take into consideration the direct risks to the stocks or environment involved. Following this process, the risks to and levels of economic and social outcomes derived from the use of this asset by the various direct and indirect stakeholders must be considered. Using this concept, there were only 22 consolidated ecological assets and 2 additional consolidated governance categories to use as the basis for determining the Departmental wide priorities within the West Coast Bioregion (see Table 5).

6.2 Results

The simple multi-criteria system was used to integrate the various risk and value scores associated with each of the 22 ecological assets and 2 governance categories from the ecological, economic and social perspectives and generate a single score that was used to compare priorities across the entire bioregion (Table 4)[2]. The priority scores ranged from about 102 down to 4, providing a relatively large degree of discrimination among assets. Of the 24 regional level categories, the scoring suggested that there were five with urgent priorities, two with high priorities and six within each of the medium, low and very low priorities.

The highest score was generated for Captured Species - Shelf Crustaceans, which is dominated by the rock lobster fishery, the largest and most valuable fishery in the State. The high score reflects that this fishery is currently facing a number of significant issues (e.g. low recruitment, export market downturn etc., Department of Fisheries 2009). These include recent reductions in

2 When the EBFM process is completed in other bioregions, comparison of priorities across the entire state will be possible.

recruitment levels and hence major reductions in the allowable catches to ensure the breeding stock levels are not impacted. In addition, the income levels for the fishers are being affected by relatively low prices due to overseas market conditions and high exchange rates. These conditions are exacerbating the impacts of increased costs associated with fuel and labour and generating significant social issues for the catching and processing sectors as well as flow on impacts to dependent communities and service groups. Substantial increases in effort are now underway to understand the cause(s) of the low recruitment, plus examine ways to make the fishery more profitable within the bounds of the lower acceptable catches.

A very high score was also generated for the inshore demersal finfish suite of species. This suite is caught by three separate commercial fisheries, is a major component of a recreational charter fishery and is the primary target group for the boat-based recreational fishing sector. Consequently, to ensure that all the EBFM objectives for this bioregional level asset are attained requires successful management actions to be taken within a number of separate but interconnected fisheries.

To deal with declining stock status of the indicator species, intensive management activities have been implemented over the past three years across all relevant fisheries to reduce their level of capture of the entire suite by 50% (Wise, et al., 2008). This includes a formal process to determine explicit levels of access to the resource among the various commercial and recreational sectors (DoF, 2010). These actions have generated significant economic and social impacts for the commercial industry through restrictions on which licensees had access to the fishery, the imposition of commercial closures to some zones and reductions in the total access levels allowed. Similarly, the imposition of the strong measures (including licences, closed seasons and reduced bag limits) to sufficiently reduce the recreational catch generated an intense level of public debate.

At the lower end of the priority scale, the pelagic finfish suite received only a very low priority. This suite has had relatively minor levels of fishing for the past decade due to poor markets and difficulties in their capture at economically viable rates. Consequently the risks to the stocks are currently low to negligible (and hence no additional risks for other trophic levels), plus there is minimal commercial activity/risk and effectively no recreational capture of species in this suite.

The outcome for the West Coast ecosystem structure and biodiversity was both a moderate risk and priority score. This was based on an assessment of the community structure and trophic levels of all commercially caught fish species over the past 30 years. This assessment found no evidence of systematic changes, which would be evidence of an unacceptable impact on the ecosystem. Given that the main elements within this ecosystem that were considered to be at risk were already the subject of intense management, there was no need for additional management activities apart from the establishment of an ongoing monitoring scheme. This monitoring scheme would have sampling locations both within and outside of areas closed to fishing and is currently being carried out by the Western Australian Marine Science Institute (WAMSI).

6.3 Implications

In most of the 24 categories, the total scores and the priorities are consistent with both the levels of ecological risk and the current levels of activity being undertaken by the Department. In some cases, however, severe risks associated with the benthic habitats in estuarine/embayments did not result in a high Departmental priority because nearly all of the risk is generated by activities (e.g. harbour dredging, sedimentation) that are managed by other agencies. Similarly, the priority for

finfish within estuaries is not as high as expected just from the risk level, because the majority of the risk to these stocks is generated by external factors, such as coastal development resulting in sedimentation/loss of habitat, agricultural run-off etc. The Department has already banned the capture of those stocks most at risk and works with the other agencies that are responsible for catchment management to try and influence improvements to water quality outcomes.

One area where there appears to be a mismatch between the priority score and the current level of Departmental activity is for introduced pests and diseases. This scored a medium to high priority but currently there are very few resources assigned to this issue. Having been identified, this situation is now being addressed through both budgetary reprioritisation of existing resources and from submissions to government to cover this expanding risk area.

Table 5 Outcome from the multi-criteria assessment for the evaluation of ecological assets in the West Coast Bioregion in 2009[3]. The risk scores used are the outcomes of the consolidated risk assessments. The criteria for scoring GVP and Social Amenity are located in Table 3.

ASSET /ISSUE	Stock/ Environ Risk	GVP	Economic Risk	Social Amenity	Social Risk	Other Human External Impacts on Stock/ Env. Risk	Total Score and Overall Current Priority
12. WC Crustaceans - Shelf (Lobster)	3	5	5	3	3	0	**102 Urgent**
8. WC Finfish - Inshore Demersal	5	2	4	4	4	1	**96 Urgent**
7. WC Finfish – Nearshore	4	1	3	5	4	0	**92 Urgent**
22. WC Governance - External Linkages	2	5	4	5	4	0	**80 Urgent**
21. WC Governance - Internal Processes	2	5	4	5	4	0	**80 Urgent**
3. WC Ecosystem – Abrolhos	3	5	3	5	2	0	**75 High**
11. WC Crustaceans - nearshore/ estuarine	4	2	3	5	3	0.5	**73.5 High**
23. WC External - Climate Change	3	5	3	5	2	1	**50 Medium**
24. WC External - Introduced Pests & Diseases	3	3	1	3	4	0	**45 Medium**
13. WC Molluscs – nearshore	3	4	2	3	2	0	**42 Medium**
2. WC Ecosystem – Marine	3	5	2	5	2	1	**40 Medium**
6. WC Finfish – Estuarine	5	1	3	4	4	3	**38 Medium**

3 Note these risks and priorities have been updated since these were developed in 2009.

ASSET /ISSUE	Stock/ Environ Risk	GVP	Economic Risk	Social Amenity	Social Risk	Other Human External Impacts on Stock/ Env. Risk	Total Score and Overall Current Priority
14. WC Protected species - non fish – mammals	3	1	1	3	3	0	**30 Medium**
1. WC Ecosystem – Estuarine	4	3	3	4	4	4	**25 Low**
9. WC Finfish -Offshore Demersal	4	2	2	1	1	0	**20 Low**
19. WC Benthic - Inshore Demersal	2	5	1	4	1	0	**18 Low**
17. WC Benthic - Estuaries	5	1	3	3	4	4	**15 Low**
4. LN Ecosystem Estuarine	4	3	2	3	3	3	**15 Low**
5. LN Ecosystem marine	2	1	1	3	2	0	**14 Very Low**
15. WC Protected species - non fish – non mammals	2	1	1	4	3	1	**13 Very Low**
18. WC Benthic - Nearshore	2	3	1	4	2	1	**11 Very Low**
20. WC Benthic - Offshore	2	1	1	2	1	0	**6 Very Low**
16. WC Protected species - fish	1	1	0	3	2	0	**6 Very Low**
10. WC Finfish- Pelagic	2	1	1	1	1	0	**4 Very Low**

Integrating EBFM into departmental planning and reporting

Following the completion of the EBFM based assessment for the West Coast Bioregion, the value of this approach was reviewed by the Corporate Executive group within the Department and it was agreed that the Department's Risk Register, which is the basis for the budget planning process, would be revised using the set of EBFM ecological assets from each of the State's Bioregions (of which the West Coast is one) as the primary categories. This system will be updated annually based on the outcomes of the previous year's activities and any resulting shifts in risk/value scores for determining the budget priorities for the following year.

The measurement of the Department's performance in managing these regional level ecological assets has already begun with the current status and summary of activities for the West Coast assets now included in the Annual Reports to Parliament (e.g. see DoF, 2011). This reporting is expected to become more comprehensive over the next five years.

7.0 Summary EBFM outcomes

The following set of tables summarises the status and risk levels for each of the consolidated assets in 2009[4]. The table also outlines what current activities are underway plus the Departmental level of relative priority for this issue for future activities. For example, an ecosystem/value may be determined to be at high risk due to substantial non-fishing impacts. The priority for future Department of Fisheries activities for this value would be lower than if the risk was due to fishing-related activities (see 'Residual risk' and 'Agency priority setting formula'). Note these risks are based on a five year future horizon, not necessarily the same rating as for current status.

4 This table is now updated annually and reported in the State of Fisheries and Aquatic Resources Report – some risk scores have therefore changed

7.1 Ecosystem structure and biodiversity

Objectives - HIGH LEVEL - Maintain healthy functional ecosystems
SPECIFIC FISHERY - Manage cumulative fisheries impacts at acceptable levels

Ecosystem	Risk Level	Status	Current Activities	Priority for future Department of Fisheries Activities
Abrolhos Islands	Marine LOW - MEDIUM	The Abrolhos Islands are managed within a 'Fish Habitat Protection Area', and are not currently considered to be at major risk from fisheries related activities. This risk level was assessed based upon the acceptance that while there has likely been a change in the relative composition of some finfish species there does not, appear to have been either a loss of biodiversity or a noticeable change in the types of communities present. This ecosystem will be especially vulnerable to climate change impacts due to the unique combination of macro algae and coral.	There are a number of research programs in this ecosystem. These include monitoring of the health of coral communities at the Abrolhos Islands. This program, utilises permanent coral transects located at each of the island groups, will collect important baseline information on coral communities, allowing researchers to quantify whether lobster fishing with pots results in damage to sensitive coral habitats, and to determine the vulnerability of coral communities at the Abrolhos to climate change. Surveys of the community structure of finfish are also underway as part of the WAMSI initiative.	Score – 75 High

Ecosystem	Risk Level	Status	Current Activities	Priority for future Department of Fisheries Activities
West Coast	Marine LOW – MEDIUM	An assessment of community structure and trophic level of all commercially caught fish species over the past 30 years through an FRDC funded study found no evidence of systematic changes that could be viewed evidence of an unacceptable impact of fishing on this ecosystem. A recently completed FRDC funded project provided critical information on the relationships between rock lobster abundance, size distributions and benthic habitat characteristics in deep water, and preliminary data on the trophic role of rock lobster in deep water ecosystems.	Further ecological research in deep waters, supported by WAMSI and the FRDC, will compare fished and unfished areas using a deep-water reference area. A key objective of this project will be to enable potential ecosystem impacts of lobster fishing to be quantified. Development of sampling methodologies to effectively monitor benthic habitats in fished and unfished areas. Major experimental and modelling based projects are underway at Jurien Bay by CSIRO and ECU through WAMSI node 1.	Score – 40 Moderate
	Estuaries HIGH – SEVERE	The estuaries and embayments within this area have been identified as being at severe risk, due to external factors (water quality issues due to high nutrient runoff from surrounding catchment), which have the potential to affect fish communities. Poor water quality within the Peel – Harvey and Swan-Canning estuaries, and Cockburn Sound are of particular concern.	The Port of Fremantle provided funding to the Department to assess the potential impacts of a proposed new outer port development in Cockburn Sound on important aspects of the biology of the native fauna, and user groups in the vicinity. A final report was recently prepared and combined with associated studies undertaken by other organisations on aspects of the proposed development. These aspects included modelled changes to circulation patterns in Cockburn Sound, and potential impacts to penguin and dolphin populations, to allow for a full risk assessment of the proposed development. Murdoch University is undertaking a number of ecosystem based studies and modelling work within the Swan River and the Peel Harvey and Leschenault estuaries as part of the WAMSI node 4.	Score – 25 Low

Ecosystem	Risk Level	Status	Current Activities	Priority for future Department of Fisheries Activities
Leeuwin-Naturaliste	Marine LOW	The risks of significant impacts on the marine communities in this region are relatively low in this region.		Score – 14 Very Low
	Estuaries HIGH	External factors such as water quality issues in the Blackwood Estuary, due to high nutrient run-off from surrounding land, as well as acid sulphate soil contamination are of concern to sustainable fish stocks		Score – 15 Low

7.2 Captured fish species

Objectives – HIGH LEVEL - Maintain at levels that are consistent with ecosystem function.
SPECIFIC FISHERY- Maintain spawning biomass of all captured species at least above the level that minimises the risk of recruitment over fishing.

Species Assemblage	Risk level	Status	Current Activities	Priority for future Activities
Finfish	Estuarine SEVERE	West coast estuaries are highly modified, and often degraded, environments. In these estuaries, the impacts of environmental factors on fish stock abundances are likely to be at least as important as fishing pressure. Management of fish communities in west coast estuaries requires a collaborative effort between fishery and habitat managers.	With reduced levels of commercial fishing in these estuaries, the research focus has shifted to gather a greater level of information from the recreational sector and fishery-independent sources. Research to monitor the status of the fish stocks in this fishery is based on fishery-independent surveys of annual recruitment, monthly CAES returns provided by industry and voluntary recreational logbooks.	Score – 38 Moderate

Species Assemblage	Risk level	Status	Current Activities	Priority for future Activities
Finfish	Inshore Demersal SEVERE	Concerns for the suite of demersal species (which includes dhufish, pink snapper, baldchin groper) were confirmed following recent reviews of the stock assessments completed for the three indicator species.	Strong management actions have now been taken on both commercial and recreational sectors. Determining the appropriate catch shares for commercial and recreational users is now under consideration through the IFAAC process. There is ongoing monitoring of the age structure of the indicators and the catch levels of each catching sector. Work on the stock structure and oceanographic influences is also underway by WAMSI projects.	Score – 96 Urgent
	Near-shore Demersal HIGH	The are increasing concerns for Australian Herring, tailor and skipjack trevally and whiting in the nearshore region given the potential for recreational fishing levels to increase due to increased management controls on popular inshore demersal species.	Two new NRM and FRDC funded projects have begun to examine the status of the key indicator stocks in this suite of species. These will compliment the work that is has been underway monitoring recruitment of key species over the past 10 years.	Score- 88 Urgent
	Offshore Demersal MEDIUM – HIGH	Some of the key indicator species in this deepwater location are vulnerable to overfishing. Overlaps in catch also exist with Commonwealth trawl vessels.	Management arrangements for to cover fishing in these depths, especially for recreational sector, are in the process of being finalised.	Score – 20 Low
	Pelagic LOW	There is now minimal capture of pelagic fish in this bioregion.	Low level monitoring of catch levels only are needed.	Score – 4 Very Low
Crustaceans	Estuarine (Crabs) MEDIUM - HIGH	The stocks of crabs in Cockburn Sound have been at depleted levels for the past few years but are now in the process of recovery since the closure of fishing occurred in 2007. Stocks in other regions of the West Coast are being reviewed.	Research funding (DBIF) was obtained in 2007 to (a) assess recovery of blue swimmer crab spawning stock and recruitment in Cockburn Sound (b) examine the genetic difference between the Cockburn Sound stock with that in Warnbro Sound and the Swan River; (c) undertake a 12 month recreational survey in the Peel-Harvey estuary; (d) assess the status of the crab population in the Peel-Harvey estuary (e) undertake commercial monitoring in the West Coast Estuarine, Warnbro Sound and Mandurah-Bunbury fisheries. Using the data collected the Cockburn Sound is reviewed annually. Management in the Mandurah region will be reviewed in 2010 to determine when the research results are available.	Score – 73.5 High

Species Assemblage	Risk level	Status	Current Activities	Priority for future Activities
	Shelf(Lobsters and prawns) MEDIUM	Despite recent low recruitment levels the strong management that is being applied to the rock lobster fishery should ensure the stock levels of key crustaceans in this region, western rock lobsters and prawns are both currently at appropriate levels.	In addition to the long standing comprehensive monitoring of the lobster fishery, new research projects are looking at identifying factors affecting the low western rock lobster puerulus settlement in recent years. Including genetics, oceanographic studies and modelling. Extensive changes have been made to the management of the commercial lobster fishery to ensure that the spawning stock remains at acceptable levels into the future.	Score – 102 Urgent
Molluscs	Nearshore MEDIUM	The stocks of abalone are conservatively managed with strong management controls on both commercial and recreational fishers.	Long-standing research monitoring and strict management arrangements are likely to continue for both sectors. Explicit access allocations to each sector have been determined through the IFM process completed in 2009.	Score – 42 Moderate

7.3 Protected species

Objectives – HIGH LEVEL - Fisheries are conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species.
SPECIFIC FISHERY - Cumulative impacts of all WA fishing activities do not generate unacceptable impacts.

Protected fish species	Risk level	Status	Current Activities	Priority
Protected non 'Fish' species	Turtles LOW RISK	There is minimal impact of any fishing activity on any turtle species within this bioregion.	Monitoring interactions only. All major fisheries have been assessed under Part 13 of the Commonwealth EPBC act to ensure they are not capturing unacceptable levels.	Score - 13 Low
	Seabirds LOW -MEDIUM RISK	Little Penguins are considered at risk from fishing and boating (boat strikes) in this region.	Monitoring interactions only All major fisheries have been assessed under Part 13 of the Commonwealth EPBC act to ensure they are not capturing unacceptable levels.	
	Mammals LOW RISK	Sea lion exclusion devices (SLEDs) required for rock lobster pots near sea lion breeding islands has reduced the level of risk. Australian Sea Lions and Southern Right Whale interactions may increase in future with increasing numbers.	Implementing SLEDs into the Abrolhos Islands in addition to the area around Jurien Bay colony is under discussion. Monitoring interactions continues. All major fisheries have been assessed under Part 13 of the Commonwealth EPBC act to ensure they are not capturing unacceptable levels.	Score – 30 Moderate
Protected 'Fish' Species	Fish LOW-MEDIUM RISK	Blue groper (Rottnest Island), and Cobbler (Swan Canning) White Sharks.	Bans on the capture and retention of these species has already occurred. All major fisheries have been assessed under Part 13 of the Commonwealths EPBC act to ensure they are not capturing unacceptable levels.	Score - 6 Very Low
	Crustaceans No RISK			NA
	Molluscs LOW RISK	Few species in this category.		NA

7.4 Benthic habitats

Objectives – HIGH LEVEL - Maintain healthy and productive habitats
SPECIFIC FISHERY - Ensure direct impacts on habitats from fishing are maintained at acceptable levels.

Benthic Habitat	Risk level	Status	Current Activities	Priority
Estuaries and Embayments	Sand HIGH (non–fishing)	Many sand habitats in estuarine and embayment habitats are threatened by factors such as poor water quality, direct loss of habitat through coastal infrastructure and physical disturbance e.g. dredging), sedimentation and smothering by algae. There are minimal impacts of fishing on these habitats.	Review and comment on any applications submitted to EPA on potential impact on these habitats.	Score -15 Low
	Seagrass MEDIUM RISK (non- fishing)	Seagrass habitat threatened non-fishing related activities (coastal infrastructure and associated dredging (direct habitat loss, turbidity).	Review and comment on any applications submitted to EPA on potential impact on these habitats.	
Nearshore	Sand LOW RISK	Minimal direct impacts and high recovery rates.	Review and comment on any applications submitted to EPA on potential impact on these habitats.	Score – 11 Very Low
	Seagrass LOW RISK	No destructive fishing methods allowed in these areas. Most likely impacts from developments.	Review and comment on any applications submitted to EPA on potential impact on these habitats.	
	Mangroves MEDIUM RISK (non-fishing)	Mangrove communities at Abrolhos Islands.	Review and comment on any applications submitted to EPA on potential impact on these habitats.	
	Rocky Reef LOW RISK	Minimal direct impacts and high recovery rates.	Work from the rock lobster ecosystem studies will provide information about this habitat.	
	Coral Reef LOW RISK	Minimal direct impacts.	Permanent coral transects located at each of the Abrolhos island groups, will collect important baseline information on coral communities, allowing researchers to quantify whether lobster fishing with pots results in damage to sensitive coral habitats.	

Benthic Habitat	Risk level	Status	Current Activities	Priority
Inshore demersal	All Habitats LOW RISK	Minimal direct impacts.	Work from the rock lobster ecosystem studies will provide information about this habitat.	Score – 18 Low
Offshore demersal	All Habitats LOW RISK	Minimal direct impacts.	Nil	Score – 6 Very Low

8.0 Discussion

8.1 General

The purpose of this case study was to assess whether the EBFM framework can assist natural resource management planning for the optimal management of marine resources at a bioregional level. It was also the intention to ensure that the planning structures, to meet the legislative responsibilities of the Department of Fisheries, were being undertaken in a holistic manner. The EBFM framework that was developed through this case study was ultimately successful in meeting both of these objectives because a pragmatic, management-focused approach was taken.

Undertaking an EBFM process that covered an entire bioregion could have easily become too complex to be of any practical value for management. The system needed to develop the mechanisms to integrate the issues identified and information gathered into a form that could be used by a management agency. In particular, a risk-based approach had to be used so that automatic collection of more data and/or the expectation for direct management of all identified issues did not occur unless such actions were necessary.

The EBFM framework also had to accommodate the expectations of stakeholders in a realistic manner. This initially involved capturing all relevant issues of concern (or perceived concern) for the West Coast Bioregion at the level of interest of the various stakeholder groups. While this large number of individual elements were ultimately consolidated into regional level assets, the details were not lost but are subject to periodic review (see Appendix 1 for details). Moreover, these assessments will generally form the basis of detailed work plans for the projects designed to address the risks associated with the relevant consolidated asset. The framework deals with the multi-fishery nature of the issues because it is able to integrate the existing management arrangements and information available at the individual fishery level, and not merely replicate processes. Finally, clearly determining the relative priority of issues, allows for a more efficient use of government resources because any expenditure on research, compliance or policy projects, which is currently directed towards low-risk elements, could (and should) be redirected towards higher risk elements.

The EBFM framework outlined here assesses the risks and priorities associated with having effective management at the regional level. It does not ascertain what precise management approaches might be applied to the specific risks identified. This step should remain part of the individual fishery plans and risks must also be viewed as critical to achieving broader objectives. The two processes: risk assessment and the determination of management approaches are not independent processes.

Given the large scale of the region and the potentially limitless issues that could be covered, the approach taken to apply the EBFM principles was necessarily pragmatic. The decisions on what would be the specific consolidated assets and categories determined by the process sometimes had to involve compromises, but the alternatives probably would not noticeably affect the overall outcome. Similarly, some of the risk and value scores could be refined, but generally not by a degree that would materially change the overall priority for an asset. Finally, the scoring system used for the prioritisation of departmental risks had to be sufficiently simple so it could be applied in all circumstances. If the system was too complex it was unlikely to have been adopted.

The formula developed to generate the priorities was appropriate for our circumstances given the legislative responsibilities within the Fisheries Act. The details of this may not be appropriate in all circumstances, such as if the one agency is responsible for all marine matters or where a different emphasis has to be placed on social or economic outcomes. We have now changed the calculation to enable a whole of government (EBM) score to be generated in addition to the EBFM score for use just by the Department of Fisheries.

The process of explicitly articulating how priorities are effectively determined was itself a very useful exercise as this step had previously used an implicit process and is likely to have been applied inconsistently. A valuable outcome was the recognition that we had already been implicitly discounting the risks generated by activities under other legislative management systems when determining Departmental priorities. Hence, this was not only useful for setting our internal priorities for direct management actions but also for discussions with other agencies plus government about whether the current jurisdictional and management responsibilities are appropriate.

The application and consolidation of the EBFM framework to identify and assign risks for the West Coast Bioregion and then consolidating these up to a level that was practical for management, has not only assisted in improving the planning processes, but has also revitalised the approach to identifying and managing the risks across the entire portfolio of the Department. It has reinforced the formal adoption of risk management principles as the appropriate basis for natural resource management agencies (Fletcher 2008; Fletcher et al., 2010).

Following the successful completion of the EBFM process for the West Coast Bioregion (which effectively took 2 years to complete), the same principles have subsequently been applied to the other bioregions in Western Australia. Now that a clear format has been generated and there are detailed examples from the West Coast to use as a guide, the time taken to undertake these assessments has been substantially shorter (a few months). Updating the risks is now planned to occur on an annual basis as a formal part of the Departmental planning cycle.

At the beginning of the study there was a high degree of misunderstanding of EBFM across the agency and therefore a high level of scepticism whether this process would generate any useful outcomes and even concern about its potential drain on resources. The high level of scepticism continued largely until the steps that consolidated the issues down to a smaller group of asset categories and the methods to integrate the ecological social and economic factors into a single analysis to produce meaningful whole-of-agency priorities were developed. Without these it is highly likely that the outcome from this case study would have just been seen as another research project that involved high levels of data collection and consumed more than its fair share of resources, staff and stakeholder time, yet delivered nothing useful.

It is significant that none of the individual processes used within this EBFM framework are particularly novel or complicated. The combination of relatively simple steps has, nonetheless, proven particularly powerful and effective in generating regional level management outcomes, an accomplishment that has previously proven to be extremely difficult to generate.

The next phase in the development of this process is to identify the mechanisms to further engage other agencies involved in the management of activities within the marine environment and to determine how their processes can link to the EBFM framework.

8.2 Conclusion

The application of the EBFM framework has not only assisted the Department of Fisheries in improving its planning processes for natural resource management, but has also revitalised the approach to identifying risks within the Department. Because the EBFM framework was applied in a manner that formally captured all relevant elements of concern (or perceived concern) for the West Coast Bioregion, this allows more efficient use of government resources when addressing natural resource management issues. For example, expenditure on research or policy projects directed towards low-risk elements could (and will) be redirected towards higher risk elements.

Evaluating whole of agency risk

Prioritising risks using a meaningful and transparent method is fundamental to any management process. Using the ESD/EBFM process of risk assessment, each asset or issue under the jurisdiction of the Department of Fisheries can be assigned a score as a result of the ecological, social and economic risks generated from the risk assessment process.

Other issues identified using the EBFM process, such as institutional governance and external drivers, can also contribute to the ranking and provide a notional score that can be used to prioritise whole of agency risk. In a cost effective manner, this framework can be used to deal with whole of agency issues by assessing risk and identifying priorities.

This study found that taking an 'ecosystem approach' did not require having detailed understanding of the ecosystems or the construction of complex ecosystem models. Instead, it only required the efficient and systematic consideration of each ecological asset in the region and their associated stakeholder outcomes, to identify those assets that most require direct management to deliver the 'best' outcomes for the community. The critical steps in achieving EBFM are therefore being able to clearly identify the ecological assets, linking these to social and economic outcomes that they may generate and objectively assessing their risks and overall priority for management action.

The simple set of steps we developed to implement EBFM in WA has enabled adoption of a fully regional, ecosystem based approach without material increases in funding. It has successfully replaced the previous, disjointed planning systems, with a single, coordinated risk based system that is already generating efficiencies for the use of Departmental (government) resources. Having a cost effective process means that EBFM can be applied in all circumstances, not just in those regions of the world where a large amount of resources and scientific data are available.

Given the success of this approach to the West Coast (e.g. Fletcher, et al., 2010), this EBFM framework has now been applied to all six bioregions in WA and the resulting priorities are now used as the basis for annual budget setting by the Department (Fletcher et al., 2011). This has therefore been a highly successful project, the outcomes of which have already seen major changes to the operations and planning processes used by the Department. The generation of regional level planning strategies as the overarching basis for fisheries management, combined with the wider adoption of the same set of steps at a national level to implement EBM should facilitate more efficient linkages and harmonisation with other government policies and processes. Consequently, we have found that there have been significant positive benefits from the implementation of an EBFM approach, more than merely meeting some long forgotten central agency political commitment.

Cost benefit

In round figures the development and trialling of the EBFM framework cost a total of approximately $500,000 over a two year period, with an additional $300,000 over a further three years. This latter period included the successful application of this framework to each of the other five bioregions.

The primary component of this cost has been the need for 2 dedicated staff to manage the process over the first two years, followed by one person to continue the refinements, consultations and extensions to all areas over the subsequent 3 years. Consequently, the cost per bioregion became relatively low and now the framework has been developed and implemented in each bioregion it is a relatively inexpensive process to update on an annual basis. A key point here is that without a strategic investment in trialling the EBFM framework there would still be ongoing confusion over how to assign priorities across the agency.

A critical area that will be informed by the EBFM process is the debate around implementation of marine parks, and no-take areas. The risk assessments undertaken have shown that the regions or areas at highest risk in terms of ecosystems are the estuaries. Conversely, the marine habitats and ecosystems of the West Coast Bioregion are mostly all rated as being at low risk by the EBFM process, which reflects the lack of any significant negative impacts on the majority of marine waters in this bioregion.

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10.0 Appendices

Appendix 1 detailed EBFM reports

Ecosystem structure and biodiversity

Background

The regional ecosystem divisions for the West Coast Bioregion located within continental shelf areas as outlined above in Figure 7 include:

- West Coast;
- Abrolhos Islands; and
- Leeuwin-Naturaliste.

The Fisheries Department, through the Offshore Constitutional Settlement, has jurisdiction for all these bioregions extends out to 200 nautical mile EEZ boundary. Thus the functional fisheries divisions within each of these ecosystems can include (where relevant) estuarine, embayments, nearshore, inshore demersal (20m-250m), offshore demersal (250m – EEZ) and pelagic (20m – EEZ) areas.

West coast ecosystem structure and biodiversity

Description

The IMCRA boundary for the (Central) West Coast ecosystem includes the waters from Kalbarri south to the Perth trench (Figure 7). The West Coast is a temperate oceanic zone, with oligotrophic waters that are heavily influenced by the seasonal flow of the Leeuwin Current. This warm body of water of tropical origin flows most strongly during the winter months of April to September (Pearce and Walker 1991). The strength of this current varies annually depending on the value of the El Nino-Southern Oscillation (ENSO). The strength of the Leeuwin Current has been shown to have a major influence on a number of marine species including the western rock lobster (Caputi et al., 1996).

It is recognised that there have been few, broad-scale ecological studies within the marine ecosystems of this region (Bellchambers et al, 2010). There are, however, a number of projects currently being undertaken or have been recently completed (see descriptions following) that will provide baseline descriptions of the communities and assemblages within this ecosystem. As such, setting explicit reference points for the management of ecosystem structure and biodiversity within these areas have not yet been undertaken but will be possible given the results from a number of WAMSI projects and other initiatives.

Marine

Nearshore: The nearshore ecosystems (<20 m) are comprised largely of limestone reefs covered with a range of macroalgae. Sand areas have seagrass and sponge habitat. Bellchambers (2009) reviewed the available literature and described the region as being characterised by limestone reefs running parallel to the coastline between one and ten kilometres offshore (Semeniuk and Searle, 1986). The kelp *Ecklonia radiata* dominates these reefs (Phillips et al., 1997; Wernberg et al., 2003a, Wernberg et al., 2003b) and forms extensive kelp beds (Steinberg and Kendrick,

1999). Other algae occurs on these reefs, often associated with *E. radiata* and on small patches of reef (Kendrick et al., 1999, Vanderklift and Kendrick, 2004).

Bellchambers (2009) noted that the macroinvertebrate fauna (0.5 mm-20 mm) present in these shallow water ecosystems included various crustaceans, molluscs, polychaetes, and echinoderms, which are highly abundant (Edgar, 1990; Edgar and Shaw, 1995). These macroinvertebrates are commonly consumed by higher order consumers, such as fish and lobsters (Joll and Phillips, 1984; Jernakoff et al., 1993; Edgar and Shaw, 1995), suggesting that these macroinvertebrates may be important for supporting near-shore food webs.

The nearshore region includes Rottnest Island which has a variable coastline characterised by limestone reef systems, cliffs and intertidal platforms that can extend from a few metres to 200m in width (Playford 1988). There are also a large number of sandy bays. A marine reserve covers around 3 810 ha (Rottnest Island Authority 2003) to depths of 20-30m and is characterised by limestone reef, seagrass beds and sandy areas (Smallwood et al., 2006).

As a result of the influence of the Leeuwin current, the waters around Rottnest Island are warmer than those along the mainland coast which provides the conditions for the relatively high level of coral and tropical fish species found around the island (Hutchins, 1991). Of the 420 fish species recorded in the waters surrounding Rottnest Island, about 20% are endemic to WA and over 90 are tropical species (Hutchins, 1979).

Inshore and offshore demersal: Recent research (Waddington et al., 2010) has demonstrated that significant algal and sponge assemblages occur in the deep-water coastal ecosystem of the west coast and suggests that benthic primary production is a significant contributor to production in these ecosystems. The sponge and algal assemblages described in the study have significant biomasses of macroinvertebrates, which are sufficient to support secondary production in this region (Waddington and Meeuwig, 2010). Macroinvertebrate biomasses observed in deep-coastal ecosystems are low compared to shallow water ecosystems in this region (data converted from Lenanton et al., 1982; Robertson and Lucas 1983) and are likely to reflect the oligotrophic nature of this region (Cresswell, 1991; Johannes et al., 1994). A recently completed FRDC funded project provided critical information on the relationships between rock lobster abundance, size distributions and benthic habitat characteristics in deep water, and preliminary data on the trophic role of rock lobster in deep water ecosystems.

While the ecosystem processes influencing observed abundances of macroinvertebrates are not presently known (and may involve bottom-up and/or top-down processes), the description of benthic communities provided in the recent FRDC study and various WAMSI Node 4 projects provide a useful basis for future investigation of such ecosystem processes.

Estuaries and embayments – HIGH Risk

The West Coast Region includes estuaries and embayments that are surrounded by the largest density of the population in Western Australia and are therefore very important for social reasons.

Swan Canning estuary: This estuary has been described as the ‘heartland of Perth and there are numerous comprehensive descriptions available for fish fauna (Seddon, 1972, Shaw 1988, Brearley, 2005). Increasing population surrounding the estuary, has given rise to catchment clearing, foreshore degradation, pollution, high nutrient (excessive nitrogen and phosphorus) drainage inputs and more recently acid sulphate soils, algal blooms and deoxygenation leading to fish kills. For these reasons, in February 2000, the Swan River was closed to fishing, boating

and swimming for the first time. More recently, concerted management and clean-up programs have been undertaken and nutrient report cards are available (see www.swanrivertrust.wa.gov.au) for the system.

The Peel Harvey Estuary: This estuary is 80kms south of Perth and comprises the largest inland water body of south-western Australia (Brearley, 2005). This connected shallow water system has an extensive catchment area and, prior to eutrophication, provided ideal conditions for seagrass growth (*Halophila ovalis* and *Ruppia megacarpa*). In the 1970s, increases in nutrients from surrounding agricultural land led to eutrophication in the Peel Harvey estuary followed by significant macroalgae and blue-green algae growth. To alleviate this algal problem a number of strategies were adopted, including the construction of the Dawesville Channel to increase tidal flow and flush nutrients out to sea. The result was a more tidal marine system and changes to the fish and crustacean fauna (R. Lenanton, pers. comm.). There are extensive descriptions of the Peel Harvey estuarine environment prior to the Dawesville channel construction (see Brearley, 2005). More recently, Murdoch University and WAMSI are undertaking research with a focus on the fish communities. The initial results of this study suggest that fish communities are reverting back to pre-Dawseville Channel composition.

Cockburn Sound is a shallow coastal basin lying approximately 20km south of Perth and covering an area of approximately 124 km^2. Water depths range from sandy shallows to approximately 20m in the central basin (Cockburn Sound Management Council, 2007). In the first comprehensive environmental study of Cockburn Sound, a significant deterioration in water quality was found as well as the loss of over half the seagrass beds and a large variety of contaminants from industrial discharges. Although water quality was improved since this finding, further studies have indicated a decline. The Southern Metropolitan Coastal Waters Study 1991-1994, reported that contaminated ground water was found to be the main nutrient input, mostly in the form of nitrogen. Ecosystem health appears to have stabilised in Cockburn Sound with regular and comprehensive report cards tracking the progress of environmental quality (Cockburn Sound Management Council, 2007). However, the change in fish communities suggests change within the system is still occurring. Ongoing monitoring of water quality is essential to try to determine the drivers behind these changes.

West coast ecosystem risk status: moderate (5 year timeline)

Estuaries and Embayments – SEVERE Risk

At the stakeholder workshops, the risk of significant change in estuarine systems was determined to be severe, largely because of existing habitat changes, increased nutrients, incidence of toxic algal blooms, acid sulphate soils, reduced abundances of some fish species and at times, fish kills. It was thought that these impacts were largely a result of significant anthropogenic influences and may deteriorate further from increased urban developments and fishing pressure.

Marine – MODERATE Risk

An assessment of community structure and trophic level of all commercially caught fish species over the past 30 years completed via an FRDC funded study found no evidence of systematic changes that could be viewed as evidence of an unacceptable impact of fishing on this ecosystem. The risk assessment completed as part of the MSC process for rock lobster concluded there was a moderate risk for deeper water communities, mostly from the lack of knowledge of this region.

The EBFM risk assessment workshop concluded that in the longer-term (e.g. 20 years) areas of the West Coast could undergo even greater change than present (e.g. Rottnest Island, Swan

Canning and Peel Harvey estuaries) largely as a result of climate change predictions, particularly affecting the level of coral versus kelp forest.

Legislative responsibility and primary and other relevant management authorities

The Department of Fisheries has legislative responsibility under the FRMA for much of the ecosystem structure including the three Fish Habitat Protection Areas (Lancelin Island Lagoon, Kalbarri Blue Holes and Cottesloe Reef) in the Estuaries and Embayments of the West Coast Bioregion.

Other agencies have primary management responsibility and their own specific objectives) for different areas within this ecosystem including the responsibility for marine parks in the region (Jurien Bay, Marmion Marine Park and the Swan Canning Riverpark) by the Department of Environment and Conservation (DEC). The Cockburn Sound Management Council, Rottnest Island Authority and Swan River Trust also have primary responsibility in these locations. The Department of Water is responsible for the freshwater inflow and quality of freshwater flow into estuaries, while the Department of Agriculture and Food is responsible for agricultural run-off from fertilisers and livestock as well as bank erosion due to livestock. The Planning and Development Commission as well as local governments are responsible for coastal and watershed development that may impact the estuary through the removal of foreshore vegetation and greater run-off due to an increased amount of impervious surfaces (i.e. roads, footpaths).

Objectives

The Department of Fisheries has a number of objectives at different levels relating to ecosystem structure and function.

- Regional: Maintain healthy functional ecosystems.
- Fishery: To manage fisheries and aquaculture such that only acceptable levels of impact occur on the ecosystem.
- External: To identify, describe and influence external drivers (outside DoF legislative control) that may impact on the functional ecosystems.

DoF does not have legislative responsibility for all impacts on West Coast Ecosystem Structure and Biodiversity and can only act to try to influence outcomes through other departments/ agencies regarding these impacts. Other non-DoF objectives for specific areas within the West Coast Bioregion include:

- Marine Parks: To protect natural features and aesthetic values, promote science and education, and at the same time enable recreational and commercial uses where these activities do not compromise conservation values.
- Rottnest Island Authority: To minimise environmental impacts and enhance sustainability.
- Cockburn Sound Management Council has a number of objectives relating to the environmental health of Cockburn Sound including:
  - Maintain ecosystem integrity in terms of structure (e.g. biodiversity, biomass and abundance of biota) and function (e.g. food chains and nutrient cycles).
  - Maintenance of aquatic life for human consumption, such that seafood is safe for human consumption when collected or grown.
  - Maintenance of aquaculture such that water is of a suitable quality for aquaculture purposes.

Operational objectives, indicators and performance measures

Currently under development.

Awaiting the result of a number of current research projects (see below).

Monitoring and research programs

Current:

- WAMSI Projects 4.2 and 4.3
  - Assessment of Community Structure, Biodiversity, Habitat and Climate Change and the impact of anthropogenic influences
    - Development of bioregional level assessments of the status of community structure
    - Establishment of indicator regions for long term monitoring and assessment of changes
    - Establishment of fishery dependent indicators of climate shifts
    - Cost effective ongoing, general biodiversity and habitat monitoring methods
  - Trophic Interactions and Ecosystem Modelling
    - Process based assessments of trophic relationships (Jurien Bay)
    - Ecosystem modelling of specific, high risk or priority regions
- These collaborative WAMSI projects include funding from Department of Fisheries, MU, UWA and ECU.
- SRFME/FRDC Jurien Bay project examining changes in community structure

Recently completed/ in press

- Development of a long-term program to monitor coastal communities within the Swan region (Bellchambers et al. 2009), funded by Perth Region NRM and Department of Fisheries.
- Identifying indicators of the effects of fishing using alternative models, uncertainty, and aggregation error (Metcalf et al. 2011).
- Assessment of the benthic biota of deep coastal ecosystems associated with western rock lobster (Panulirus cygnus) populations along the temperate west coast of Australia (Waddington et al. 2010)
- Abundance and size of western rock lobster (Panulirus cygnus) as a function of benthic habitat: Implications for ecosystem-based fisheries management. (Bellchambers et al. 2010).
- Securing WA's Marine Futures: Study areas in the West coast region include; Jurien Bay, Abrolhos Islands, Cape Naturaliste/Geographe Bay (Radford et al. 2008).
- Effect of western rock lobster fishing on the ecosystems off Western Australia Study areas; Jurien Bay, Lancelin and Dongara Funded by FRDC 04/049 and Department of Fisheries (Bellchambers 2010).
- Assessing community structure through fishery dependent data FRDC (Hall and Wise 2011).

Management actions (DoF)

Current:

Maintain fishing at levels such that the appropriate biomass levels of all targeted and non targeted fish species are continued.

Proposed New Actions:

Facilitate development of an agreement regarding appropriate indicators, performance measures and monitoring schedule.

Actions if performance is considered unacceptable:

Adjust management settings for individual fisheries where necessary.

Review period

Two years to coincide with the outcomes of current and relevant WAMSI projects already underway when more definitive indicators and performance measures will be available.

Abrolhos Islands ecosystem structure and biodiversity

Description

The Abrolhos Islands are one of the three IMCRA regions that fall within the West Coast Bioregion (Figure 7). Formally know as the Houtman Abrolhos Islands, they comprise a complex of reefs and islands located at the edges of the continental shelf between 28° and 29°S approximately 60 km offshore from Geraldton. The entire State waters of this region are a Fish Habitat Protection Area (FHPA), which includes highly valued marine communities and historic shipwreck sites of international importance. Within the Abrolhos Islands FHPA there are four Reef Observation Areas where taking fish except rock lobster is not permitted. There are also an exceptional array of birds, diverse terrestrial vertebrates and valuable vegetation types including mangroves and dwarf eucalyptus stands (FMP 220).

The Abrolhos Islands have an unusual geology and fall within a zone of biogeographical overlap. For instance, large tropical coral reefs are often in close association with stands of temperate algae. The Abrolhos Islands includes the most southerly coral reef system in the Indian Ocean.

The region includes high abundances of the western rock lobster and provides a large proportion of rock lobster catch for the state. Scallops and finfish communities are also important and have been targeted by commercial, recreational and charter fishers. In addition to the community diversity there is also an increasing level of ecotourism within the region.

Abrolhos Islands ecosystem risk status - Moderate

The internal and external stakeholder workshop rated the risk level over the coming five years as low to moderate risk. It was concluded that some elements of the ecosystem may have changed by a measurable amount, most notably the relative species composition of some finfish species (Nardi et al., 2004). This does not, however, appear to have been caused by either a loss of biodiversity or a noticeable change in the types of communities present.

5 years – With current management arrangements it was considered that the impacts on each of the elements of the ecosystem at the Abrolhos Islands would most likely remain the same as at current levels.

20 Years - (High Risk) – With the potential increase in ocean temperatures due to climate change and the possibility of a concomitant shift in the strength and dynamics of the Leeuwin current it was considered Possible (3) that there may be a Significant (3) change to the community structure and biodiversity in this region, which represents a High Risk for many of the identified ecosystem values at this time scale. Any sea level changes would also increase the risk from the current rating.

Legislative responsibilities

The Department of Fisheries manages the Abrolhos Islands, including the terrestrial areas, and is responsible for the facilitation of whole-of-Government Service delivery in the area. Major partners in the service delivery are the Department of Environment and Conservation, the Western Australian Museum, Western Australian Planning Commission, Department of Transport and Tourism Western Australia.

Objectives

For the Abrolhos Islands FHPA the objectives are;

- To conserve the ecosystem and cultural heritage values and,
- To enable multiple, equitable and sustainable use and development of the historical and economic values of the Abrolhos system.

The specific ecosystem structure and biodiversity values that should be maintained for this region include:

- the diversity of habitats (particularly coral reef, algae and sponge), fish and invertebrates; and
- the unique combinations of tropical, temperate and endemic marine finfish and invertebrate species.

The Department has different objectives for the different scales within the Abrolhos ecosystem.

Regional objective: Maintain healthy functional ecosystems.

Fishery objective: To manage fisheries and aquaculture such that only acceptable levels of impact occur on the ecosystem.

Operational objectives, indicators and performance measures

Currently under development.

Awaiting the result of a number of current research projects (see below).

Monitoring and research programs

Current:

There are a number of research programs in this ecosystem. These include monitoring of the health of coral communities at the Abrolhos Islands. This program, utilises permanent coral transects located at each of the island groups and will collect important baseline information on

coral communities, allowing researchers to quantify whether lobster fishing with pots results in damage to sensitive coral habitats, and to determine the vulnerability of coral communities at the Abrolhos to climate change.

There are also a large number of relevant postgraduate, WAMSI and NHT research programs that have been, or are currently, underway within the Abrolhos.

Proposed:

- Establishment of a series of reference regions within the Abrolhos Islands.
- Development of a coordinated and integrated monitoring program.

Management actions

Current:

- Explicitly manage the activities of all stakeholders that operate within the FHPA to ensure that their collective impacts do not cause unacceptable effects on the key components of the ecosystem and biodiversity of the Abrolhos Islands region.
- All recreational and commercial activities must be consistent with the level of protection required. These are outlined in detail within the draft management paper of the Houtman Abrolhos system (DoF, 2007).
- Identifying and protecting priority areas.
- Establishing the Abrolhos islands as a separate zone for the management of most fishing activities.
- Managing the commercial lobster fishery, the commercial wetline fishery, aquaculture, recreational fishing and charter boat sectors.
- Implementing specific spatial and temporal closures to each type of fishing method.
- Managing moorings.
- Managing terrestrial activities and their potential flow on impacts.
- Encouraging management orientated research into the marine environment within this region.

Proposed New Actions:

- Finalise Management plan for the Abrolhos Islands.
- Encouraging a coordinated approach to the research undertaken within the Abrolhos Islands.
- Seek funding to establish reference sites, undertake regular monitoring and surveys of the region.

Actions if performance is considered unacceptable:

- Review management plan for the Abrolhos Islands and, where relevant, the specific fisheries/ activities that generated the unacceptable performance.

External drivers

Climate change: This is predicted to have a significant impact on the oceanographic currents, temperature and chemistry of the region. Given the unique properties of the currents associated with the Abrolhos and the dominance of the Leeuwin Current as an overarching structuring

force, any changes in these could have major flow-on impacts to the ecosystem and biodiversity of the region (see 20 year risk assessment).

Management Responses/Activities: Ensure that these risks are taken into account when establishing reference sites and in drawing conclusions from any changes observed in the community structure and biodiversity of this region.

Shipping: This region is located within a highly populated shipping route. There is a potential for shipping to impact the ecology through accidents releasing oils and fuel and possibly hazardous cargo. An application for the gazetting of a 'Particularly Sensitive Sea Area' was proposed by the Department of Fisheries and although the concept received strong stakeholder support was not continued.

Management Responses/Activities: Liaise with Department of Transport and maritime authorities to ensure that the risks of shipping incidents are kept at remote or negligible levels.

Review Period

5 years

Leeuwin-Naturaliste ecosystem structure and biodiversity

Description

The Leeuwin-Naturaliste region forms the most southern ecosystem in the West Coast Bioregion. Population pressure in this ecosystem is lower than in the West Coast ecosystem and this is likely reflected in the lower ecological risks.

The area comprises the shallow semi-sheltered waters of Geographe Bay, Hamelin Bay and Flinders Bay and includes extensive seagrass meadows comprising predominantly *Posidonia* and *Amphibolis* spp (Limbourne and Westera 2006). It is thought that the exceptionally clear waters in the area allow the seagrasses to colonise deeper waters (30m) and minimise their exposure to direct oceanic swells (Kirkman and Kuo 1990).

In the more exposed areas, (Cape Leeuwin to Cape Naturaliste) there are diverse reef systems with a variety of fish, invertebrate and algal species. Recent work with Underwater Video Cameras (UVC) and Baited Remote Underwater Video Cameras (BRUVS) as part of the Marine Futures project (University of Western Australia) recorded 42 and 69 species of fish respectively as well as 220 species of algae from 20 families. These numbers are consistent with other studies recorded around the temperate Australian coast (Radford et al 2008).

Leeuwin-Naturaliste ecosystem risk status - Marine (Low)

The risks of significant impacts on the marine communities in this region are relatively low in this region.

Leeuwin-Naturaliste ecosystem risk status – Estuaries (High)

External factors such as water quality issues in the Blackwood Estuary, due to high nutrient run-off from surrounding land, as well as acid sulphate soil contamination are of concern to sustainable fish stocks in the Leeuwin-Naturaliste bioregion.

The EBFM Risk Assessment workshop concluded that in the longer-term (e.g. 20 years) the estuaries Leschenault and Blackwood would be at increased risk of ecosystem change, resulting

from increased inputs combined with reduced rainfall and freshwater flow (Leshenault) and Yaragadee aquifer issues as well as salt wedge impacts for the Blackwood estuary.

Legislative responsibility and primary and other relevant management authorities

The Department of Fisheries has legislative responsibility under the FRMA for much of the ecosystem including the Reef Observation Areas (Cowaramup Bay & Yallingup Reef). Other agencies have primary management responsibility for specific areas including the Department of Environment and Conservation (DEC), which is the Primary Management Authority for the Marine Parks in the region (Shoal Water and the proposed Capes Marine Park). The Leschenault Inlet Management Council has an advisory role to DEC.

Objectives

The Department of Fisheries has a number of objectives at different levels relating to ecosystem structure and function.

- Regional: Maintain healthy functional ecosystems.
- Fishery: To manage fisheries and aquaculture such that only acceptable levels of impact occur on the ecosystem.
- External: To identify, describe and influence external drivers (outside DoF legislative control) that may impact on the functional ecosystems.

In addition, there are other objectives for specific areas within this region.

Marine Parks: To protect natural features and aesthetic values, and promote science and education while enabling recreational and commercial use where these activities do not compromise conservation values.

Operational objectives, indicators and performance measures

Currently under development.

Awaiting the result of a number of current research projects (see below).

Monitoring and research programs

- Study of the benthic community in Geographe Bay (Laurenson et al., 1993)
- Annual research surveys of juvenile fish recruitment
- Radford et al 2008. WA Marine Futures; Benthic Modelling and Mapping Final Report (UWA)
- Limbourn and Westera 2006. A review, gap analysis and assessment of current information relating to marine and coastal environments in the SW Region.
- WAMSI study in Leschenault estuary

Proposed:

- nil

Management actions (DoF)

Current:

- Try and maintain appropriate biomass levels of all key target fish species.

Proposed New Actions

- Facilitate development of an agreement regarding appropriate indicators and performance measures.

Actions if performance is considered unacceptable

- Adjust management settings for individual fisheries if necessary

External drivers

See External driver component tree Figure 17.

Review period

Five years.

Captured 'fish' species

Background

This section outlines the current status and management of all the captured fish species within the West Coast Bioregion and provides priorities for future activities. This includes the main target species plus all the byproduct and bycatch species (except protected species which are covered in the following Section). To enable these assessments to be done in an efficient manner, the species have been divided into a series of 'suites/assemblages' (Figure 19).

The different suites were determined using a functional approach, which was based on a combination of habitat, taxonomic and biological affiliations of the species combined with the practical aspects associated with management. The are three main branches - finfish, crustaceans and molluscs which, where necessary, are further subdivided into up to four separate management areas - estuarine/embayments, nearshore, inshore and offshore. Each of the different suites/ assemblages is therefore captured either in different ecosystems and/or by using different combinations of fishing methods. This means that each of the different suites can be managed relatively independently and therefore individually prioritised. In nearly all cases the individual suites can be subdivided into more precise categories (e.g. the estuarine group can be subdivided into the different estuaries) however this level of detail was considered too great to be of value in both getting an overview at the regional level and it is also too fine to make priority decisions at the management level for establishing programs of activity within the Department.

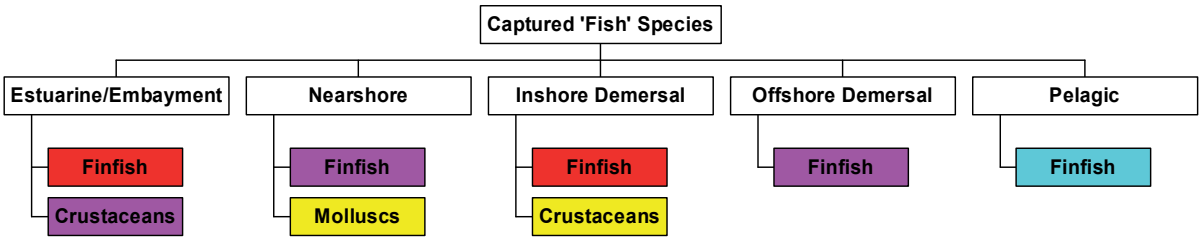

Figure 19. Summary component tree for captured species showing the overall risk level for each of the main captured species suites/assemblages in the West Coast Bioregion.

Each of the suites contains a large number of species, which means that it is not possible to quantitatively assess the status of all species. The status of each 'suite' of species is therefore determined by the status of the associated indicator species. Indicator species were chosen based upon:

- Their level of representativeness for the particular habitat, community or environmental conditions most associated with the suite;
- Their level of importance (targeted) to the commercial or recreational sector; plus, most importantly,
- Their vulnerability to fishing compared to the other species within the suite.

To ensure that there was an objectively based selection system of the indicator species for each suite, which covered each of these elements, the Department's formal multi-criteria analysis was used. If one or more indicator species is considered 'at risk' then the entire suite is considered to be at this level of risk. Where separate stocks of indicator species exist within the suite at the regional level (e.g. crabs in different estuaries), the range of risk levels is noted.

The risk level for each indicator species is initially determined irrespective of whether the cause of the risk is mainly due to fishing or through some external factor such as water quality. External factors are important to note because many of the problems identified within estuaries and embayments are not generated by fishing. The degree to which this risk is generated by external factors is recorded because it can affect the type of activities that would be undertaken directly by the Department and the Departmental priority.

Using the most targeted and vulnerable species in the suite as the indicators provides the most precautionary and robust assessment methodology. This method is also the most efficient method because in most cases the assessment of the indicator species is already a normal component of the annual assessment process and minimal additional resources are required to undertake a regional level approach. The information leading to the justifications for each suite can be found in either the current State of the Fisheries report or various ESD Report Series and the IFM Fisheries Management Reports.

Objectives

The following are the key objectives that are used to assess the status and risk for each of the suites.

High level - Maintain stocks at levels that are consistent with ecosystem function.

Specific fishery - Maintain spawning biomass of all captured species at least above the level that minimises the risk of recruitment overfishing.

Captured fish species - Estuarine/embayment

Description

General: Whilst commercial fishing was an early feature within all of the estuaries and embayments in the West Coast Bioregion, few commercial fishers now remain with increased numbers of recreational fishers targeting a variety of finfish and Crustacea. The most important finfish species captured are mullet, whiting, herring, cobbler and black bream. The most important crustaceans captured in these regions are blue swimmer crabs and river prawns.

Commercial Fisheries: The commercial fisheries that target these species include the West Coast Estuarine Managed Fishery (WCEF), which operates in the Swan/Canning and Peel/Harvey estuaries, is a multi-species fishery targeting blue swimmer crabs and many finfish species. In Cockburn Sound there is the Cockburn Sound (Line and Pot) fishery the Cockburn Sound (Fish Net) Managed Fisheries. The commercial blue swimmer crab fisheries in the West Coast Bioregion are the Cockburn Sound Crab Managed Fishery, the Warnbro Sound Crab Managed Fishery, Area I (Comet Bay) and Area II (Mandurah to Bunbury) of the Mandurah to Bunbury Experimental Crab Fishery. Blue swimmer crabs are targeted using a variety of fishing gear but most now use purpose-designed crab traps. Blue swimmer crabs are also retained by trawlers operating in Comet Bay as part of the South West Trawl Managed Fishery.

Recreational fishery: Recreational crabbing in the West Coast Bioregion is centred largely on the estuaries and coastal embayments from Geographe Bay north to the Swan River and Cockburn Sound. Blue swimmer crabs represent the most important recreationally-fished inshore species in the south-west of WA by rate of participation. The majority of recreational fishers use drop nets or scoop nets and diving for crabs is becoming increasingly popular.

Key issues: There are significant anthropogenic factors effecting the West Coast Bioregion such as changes in water quality, pollution inputs, habitat degradation and fishing pressure.

Estuarine and Embayment captured species risk status – Finfish (Severe)

Indicator species - Black Bream, Cobbler. King George Whiting, Perth Herring.

Within the suite of estuarine species, one of the indicators species is rated at severe risk (cobbler), while another (Perth herring) is at high risk.

Cobbler: (Severe) Cobbler populations are genetically unique within each west coast estuary. Despite recent increases in catch in the Peel/Harvey estuary in 2008, the breeding stock levels in the 3 main west coast estuaries appear to be very low, due to a combination of environmental factors (e.g. loss of breeding habitat), fishing pressure and the biological characteristics of this species (e.g. low fecundity, aggregating behaviour) that make it inherently vulnerable to depletion.

Perth herring: (High) While recreational fishers do not target Perth herring, the species is considered to be representative of estuarine health as it spawns in the upper reaches of the Swan River. Stocks of Perth herring are depleted in the Swan estuary and, according to anecdotal evidence, are also depleted in the Peel/ Harvey estuary.

Black bream: (Medium) Black bream populations are genetically unique within each west coast estuary. The catch rates of bream increased markedly after 1990 in the Swan/Canning Estuary suggesting recent increases in bream stock abundance in these estuaries. Following this assumption, it could be assumed that breeding stock levels are currently adequate to maintain recruitment. Environmental factors and fishing are likely to be significant sources of mortality. In all Western Australian estuaries, the legal minimum length is set above the length at maturity and therefore affords protection to each breeding stock.

King George whiting: (Medium) King George whiting use estuaries and coastal waters as nursery habitats while juvenile (aged 0 to 3+). They are most vulnerable to capture while residing in estuaries where the size at capture is considerably less than the size at maturity. Targeted recreational fishing for this species, both inshore and offshore will need to be monitored to ensure overall fishing mortality does not increase to an unsustainable level in the future. The

current breeding stock level is considered adequate. Low juvenile recruitment occurred in 2007 suggesting that there will be relatively low catches in west coast estuaries in the next 2-3 years.

Estuarine and Embayment captured species risk status – Crustaceans (Severe)

Indicator Species – Blue Swimmer Crabs, Prawns.

A number of crustacean species are no longer apparent within the Peel Harvey and Swan/Canning estuaries including school prawns (Swan and Peel) and King prawns (Swan).

Blue Swimmer Crabs: (Medium – High) There are a number of relatively separate populations of blue swimmer crabs along the west coast. The spawning stock in Cockburn Sound is now considered to be recovering following two years of fishing closures. While the crab stocks in other locations in the West Coast are currently considered to be adequate, given the collapse experienced in Cockburn Sound, there is an intensive research program currently underway to investigate their status in the Peel Harvey and Comet Bay regions.

School and King Prawns: (Severe) Prawn stocks in both the Swan and Peel Harvey estuaries are no longer at levels that produce reasonable catch levels. A recent survey failed to find any king prawns within the Swan River.

Legislative responsibility and relevant management authorities

Jurisdiction within the estuaries and embayments of the West Coast Bioregion is complex. While the Department of Fisheries has overall legislative responsibility for all 'fish' under the FRMA, within the Swan River Estuary, the Swan River Trust is the Primary Management Authority (Swan and Canning Rivers Management Act 2006). In addition, the Department of Water, Department of Agriculture and Food and different Local Governments adjacent to estuarine systems also have a variety of management roles. In Cockburn Sound, there is the Cockburn Sound Management Committee and parts of the area are under the control of the Fremantle Port Authority.

Monitoring and research programs

Current:

Finfish

- Commercial catch data where available, Recreational Angler Program (RAP), occasional recreational creel surveys.
- Specific projects are underway for cobbler, including a recruitment-monitoring program using fish traps.
- There are also larval and juvenile surveys for Perth herring underway (DoF).
- A long-term comparative survey is being undertaken in the Swan estuary (MU) and in the Blackwood Estuary.
- Factors influencing recruitment success and the growth rates of black bream are being studied.

Crabs

- Annual trawl programs conducted in Cockburn Sound provide information on the status of the spawning stock and subsequent strength of recruitment, along with data on the general crab population.

Proposed:

- Develop a commercial catch-monitoring program in Peel Harvey, Warnbro Sound and the Swan River.
- Examine the genetic relationship between the Cockburn Sound stock and those in Warnbro Sound and the Swan River.
- Develop a fishery-independent sampling program to assess the status of the Peel-Harvey crab stock.

Management actions (DoF)

Current:

- Reduced or very limited commercial fishing. Recreational bag limits.

Proposed:

- Adapting fishing catch and effort to external drivers.
- Improved liaison with catchment managers.

External Drivers

Anthropogenic influences impact significantly on the estuarine systems in the West Coast Bioregion. Nutrient input in the Swan River and Peel Harvey has been assessed as severe, as has deoxygenation and acid sulphate soils. Pollution inputs have also been flagged as an external driver, particularly in Cockburn Sound. Coastal developments including canals (Peel Harvey) have been rated as 'high risk'.

Captured fish species – Nearshore

Description

General: Coastal development and infrastructure is likely to impact the nearshore area particularly around population centres. Many of the fish species in this group are heavily targeted. The indicator species for the nearshore 'suite' include Australian herring, tailor, whiting and garfish. Some stocks (e.g. Australian herring metropolitan) are likely to be overexploited.

A number of mollusc species are also targeted in this area of the West Coast Bioregion by commercial and recreational fishers. Abalone and scallops are the most valuable mollusc species and octopus are increasingly being targeted. Scallops are fished by the commercial sector only, and found in commercial quantities in the Abrolhos and Geographe Bay areas. Abalone, whilst found all along the coast are not uniformly distributed. The most vulnerable area for abalone is off the Perth metropolitan area.

Commercial Fisheries: There are three main fisheries operating in nearshore areas of the West Coast Bioregion. The commercial abalone fishery operates with single divers working off small vessels (generally less than 9m in length). The Abrolhos Islands and Mid West Trawl Managed Fishery (AIMWTF) targets mainly southern saucer scallops while the South West Trawl Fishery (SWTMF) targets scallops in Fremantle and Geographe Bay.

Recreational Fisheries: Recreational fishing for finfish is intense in nearshore waters and is generally undertaken using line-based methods from the shore or boats.

The recreational fishery harvest method for abalone is primarily wading and snorkelling with the main focus of the fishery being the Perth metropolitan stocks.

Key Issues: The fishing pressure from the recreational sectors on nearshore finfish species is expected to increase as a result of changes to the recreational demersal fishery regulations.

Nearshore captured species risk status – Finfish (High)

Indicator Species: Australian herring, tailor and whiting.

Australian herring: (High) The Australian herring stock appeared to be at satisfactory levels in all regions when assessed in the late 1990s – and above a conservative biological limit reference point of 40% of the total virgin biomass. However, the status of the stock is now uncertain. The available information strongly suggests that the abundance of Australian herring in southwestern WA is lower than in the late 1990s, due to consecutive years of low recruitment. The reasons for low recruitment are unclear but are probably related to environmental factors. In a prolonged period of low recruitment, relatively high catches of breeding fish, especially by recreational fishers on the lower west coast, are of concern in regard to the sustainability of the fishery.

Tailor: (High) Available evidence (a significant decline in boat-based catch, anecdotal reports of low shore-based catch rates, highly variable annual recruitment) suggests that, despite recent changes to bag and size limits, the recreational exploitation rate of tailor in the West Coast Bioregion is at an unacceptable level.

Whiting: There has been no assessment on the stock status of the main whiting species in the west coast region (Yellow-finned whiting, *Sillago schomburgkii*). This is scheduled to begin in 2009/10 through the provision of funds from NRM.

Nearshore captured species risk status – Molluscs (Low to medium)

Indicator Species - Roe's Abalone, Scallops, Octopus.

Roe's Abalone: The main performance measure for the fishery relates to the maintenance of adequate breeding stocks in each area of the fishery. This is assessed using a combination of the level of quota achieved and the effort required to reach this quota, both of which reflect stock abundance. In 2008, catch and effort in most areas fished were within the agreed ranges, indicating that overall breeding stock levels were adequate.

Scallops: The annual fishing season arrangements in the AIMWTMF are set so that the majority of mature scallops are able to spawn before fishing occurs. Breeding stocks are therefore protected ensuring recruitment is dependent only on environmental conditions each year.

Octopus: The breeding stock level of octopus on the west coast is currently not assessed. Fishery catch rates in Cockburn Sound, using unbaited pipes as the method of capture, provide a relative annual index of octopus abundance. A mean annual catch rate is calculated from data supplied by commercial fishers in voluntary daily log books since 2003. The annual catch rate in Cockburn Sound has been gradually increasing since 2005, probably as a result of improved fisher knowledge and gear technology.

Legislative responsibility and relevant management authorities

The Department of Fisheries has clear legislative responsibility under the Fish Resource Management Act 1994, for all retained fish species caught in State waters (3nm) which generally includes all the nearshore waters out to a depth of 20m.

Monitoring and research programs

Current:

Finfish:

Refer to current State of the Fisheries for current monitoring and research projects.

A project undertaken as part of WAMSI 4.5.3 modelled the different behavioural changes that may occur due to the annual seasonal closure placed on demersal fishing (finfish) in 2009 (Metcalf et al. 2010). This project identified the likely behavioural responses and highlighted the need for behavioural assessments when implementing new rules and legislation.

Current – Molluscs:

Scallops: Daily monitoring of the commercial scallop fleet combined with VMS, provides real time monitoring of catch and effort. Recruitment surveys provide predictive catch information to help determine; when the season will open and close.

Abalone: Current research is focused on monitoring and stock assessment of Roe's abalone using catch and effort statistics supplied by commercial fishers and digital video imagery (DVI) surveys by industry divers, who survey selected sites with an underwater video camera.

Fishery independent surveys of the size and density of Roe's abalone across the near-shore sub-tidal reef habitat at eleven indicator sites between Mindarie Keys and Penguin Island are also completed annually.

Octopus: An FRDC project is currently underway to determine the fishing efficiency of octopus trigger pots, estimate potential harvest from octopus fisheries and calculate the effects of fishing closures on octopus predation rates on rock lobsters. This will involve estimating fishing efficiency, determining the population demographics of the targeted *Octopus tetricus*, determining sustainable harvest levels and assessing the interconnectedness of local octopus populations.

Management actions (DoF)

Current:

Finfish: Recent additional measures include recreational licences for boat fishing and a seasonal closure for recreational demersal fishing.

Abalone: The commercial Roe's abalone fishery is managed primarily through output controls in the form of total allowable commercial catches (TACCs), set annually for each area and allocated to license holders as individual transferable quotas (ITQs).

The recreational Roe's abalone fishery is managed under a mix of input and output controls. The management for the recreational sector is restrictive with a dedicated licence required to fish, and the fishery only open for approximately 6 hours per year (one hour per week for six weeks).

The sophisticated suite of management arrangements in place and the proactive management used in the Abalone Fishery have resulted in the maintenance of abalone stocks and the successful continuation of a fishery on a vulnerable species in a highly populated area.

Scallops: AIMWTMF operates under an input control system, with restrictions on boat numbers and trawl gear size as well as seasonal closures and significant spatial closures protecting all near-shore waters. The fishery operates to a threshold catch level to cease fishing for the season at an agreed minimum catch rate.

External drivers

Finfish: It is likely that factors other than fishing (e.g. the strength of the Leeuwin Current) significantly influences the migration patterns of pre-spawning herring and other inshore finfish, the distribution of spawning and the dispersal of larvae. These factors would then affect juvenile recruitment success and the catchability and abundance of adult fish in each region, which ultimately determines the total breeding stock level.

Molluscs: There is a strong relationship between the strength of the Leeuwin Current and scallop recruitment.

General: Coastal development has been assessed as a 'high' risk in the nearshore area and includes marinas, boat ramps port developments. Marine pests are ranked as higher risks in some port areas, including Geraldton.

Captured fish species - Inshore demersal

Description

General: The inshore demersal management area extends from 20m-250m depths and includes habitats such as sand, rocky reef (algal dominated), coral reef and sponge gardens. Species in the inshore demersal management area are generally associated with the ocean floor or benthos within this depth. The majority of the western rock lobster fishery operates in this region, which forms the basis of the largest fishery in WA and Australia.

There is also a high level of fishing for demersal finfish in this region especially for key target species such as the endemic Westralian dhufish and baldchin groper, pink snapper, and breaksea cod. The indicator species for the finfish within this region are all over-exploited and they have historically been targeted by the commercial and recreational sectors and are considered high value 'trophy fish'. These species are slow-growing, long lived, generally form spawning aggregations which makes them particularly susceptible to fishing mortality.

Commercial fisheries: The West Coast Rock Lobster Managed Fishery (WCRLF) targets the western rock lobster, *Panulirus cygnus*, on the west coast of Western Australia between Shark Bay and Cape Leeuwin, using baited traps (pots). With an annual production that averages about 11 000 t, this is Australia's most valuable single-species fishery.

The finfish fisheries include the West Coast Demersal Scalefish (Interim) Managed Fishery (WCDSIMF). Fishers use handlines and droplines to target demersal species. However, fishers in the West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery and the West Coast Rock Lobster Managed Fishery also catch demersal species.

Recreational fisheries: The recreational rock lobster fishery primarily targets western rock lobsters in the Perth metropolitan area and Geraldton using baited pots and scuba diving.

Recreational fishers targeting demersal finfish species fish almost exclusively from boats using lines. Demersal scalefish are also targeted by the charter boat industry in the West Coast Bioregion.

Inshore demersal captured species – Scalefish (High to Severe)

Indicator Species: Western Australian dhufish, pink snapper, baldchin groper; whiskery shark, dusky whalers.

Scalefish: Assessments of the status of scalefish stocks in the WCDSF are conducted primarily through estimates of fishing mortality (F), using a range of methods, for each of the indicator species. Estimates of F are determined separately where possible from samples collected from both the commercial and recreational sectors in each of the zones where those species are important in catches. Values of F are then compared to international benchmarks to determine the overall status of the stocks in the WCDSF.

Independent external reviews of two stock assessments (based on data collected between 2002 and 2006 and during 2007/08) have been completed. The reviews supported the Department's conclusions that overfishing was occurring of the stocks of dhufish, pink snapper and baldchin groper in the West Coast Bioregion and management actions are required to ensure sustainability. These results supported the implementation of a seasonal closure and a Fishing From Boat Licence for demersal recreational fishing in the West Coast Bioregion.

Sharks: Dusky shark. As breeding biomass is already likely to be at the minimal acceptable limit reference point (40% of its unfished level) and continuing to decline, this stock requires careful monitoring and may require additional species-specific recovery measures in the future.

Whiskery shark. The age-structured population model estimated that mature female biomass had increased by between 1.3 and 1.8% per year since 2001/02, except in 2004/05 when it estimated a 3.0% decline in the female breeding stock. This stock is recovering adequately.

Inshore demersal captured species – Crustaceans (Medium)

Indicator Species: Western Rock Lobster

Rock Lobster: The current level of egg production is near record levels and the biological management objective of ensuring that egg production of rock lobsters remains above the threshold levels with 75% confidence over the following five years will be met by the current and proposed management arrangements in spite of the record low recruitment levels that have been experienced recently. Therefore the risk to the lobster stock is at acceptable levels.

Legislative responsibility and relevant management authorities

As the Department of Fisheries has clear legislative responsibility under the Fish Resource Management Act 1994, for all retained fish species caught in State waters and for most of the fish species to the 200nm Australian Fishing Zone (AFZ) or Economic Exclusion Zone (EEZ) as part of the Offshore Constitutional Settlement (OSC).

Monitoring and research programs

Current – Lobster:

- Research activities continue to focus on the core business of assessing stock sustainability and forecasting future catch levels.
- Collection of monthly commercial catch, effort and processor data
- Commercial monitoring at six locations.

- Voluntary logbook program.
- Puerulus settlement monitoring
- Small-mesh pot
- Fishery-independent breeding stock
- Tagging of lobsters / analysis of tagging
- Monitoring of Marine Sanctuary zones at Rottnest Island.
- Stock assessment
- Development and maintenance of population dynamics model
- Economic assessment of management strategies (CRC application pending)
- Undertaking an oceanographic modelling study (FRDC-funded)
- Environmental factors puerulus settlement. (FRDC-funded)
- Novel statistical techniques (FRDC-funded)
- Colonisation of puerulus collectors (FRDC-funded)

Current – Finfish:

- Research is focused on the monitoring and recovery of the key demersal fish stocks in this suite
- Commercial catch and effort (CAES) data, Recreational Logbook Program (RAP), spawning and recruitment surveys and creel surveys.
- Monitoring age compositions and assessments of fishing mortality of dhufish, snapper and baldchin groper
- The stock structures are being examined using genetic otolith microchemistry and oceanographic techniques under WAMSI sub-project 4.4.2
- Modelling Recreational Fishing Behaviour (WAMSI 4.5.3) (Metcalf et al. 2010)

Proposed:

- Deep water settlement of lobsters
- Breeding stock survey in Big Bank region
- Oceanographic survey

Management actions (DoF)

Current – Lobsters:

This fishery is managed using a total allowable effort (TAE) system and associated input controls. The primary control mechanism is the number of pots licensed for the fishery, together with a proportional usage rate, which creates the TAE in pot days.

The recreational component of the western rock lobster fishery is managed under fisheries regulations, which impose a mix of input and output controls on individual recreational fishers. These arrangements are designed to complement the management plan for the commercial fishery

With the record low puerulus settlement in 2008/09, significant effort reductions were instigated for the whites (ca. 35%) and reds (ca. 60%) portions of the season to ensure carryover into the predicted low catch years of 2010/11 and 2011/12.

Current – Finfish:

Considerable rationalisation of the commercial fleet has been undertaken and significant reduction of recreational effort is to be implemented.

In 2009, each commercial boat in the WCDSIMF has been allocated a share of the total effort (fishing days), with a view to managing the fishery to a total allowable commercial catch (TACC). Following review of the catches each year, the number of effort days allocated to commercial fishers can be modified to ensure catch does not exceed the TACC.

Boat-based recreational fishers targeting demersal scalefish now require a boat fishing licence and each year there will be a two-month closure to fishing for those species from October 15 to December 15.

External drivers

Climate change impacting the strength of currents may be influencing larval distribution of these demersal species. For instance, there is a strong relationship between the strength of the Leeuwin Current and levels of puerulus settlement. This relationship may also be impacted by other factors including storm events and the Indian Ocean Dipole. Increases in water temperatures also appear to be affecting some of the biological parameters such as size at maturity and the size of migrating lobsters.

Captured fish species – Offshore demersal (250m - EEZ)

Description

General: The offshore demersal management area extends from 250m depth to the EEZ and may include regions off the continental shelf. Habitats included in the offshore area are rocky reef, sponge gardens and sand. Similarly to the inshore demersal area the species in the offshore demersal management area are associated with the benthos.

The indicator species for this group are the bass groper, eight bar groper (grey banded cod), hapuku and ruby snapper. Other species in this category include blue-eye trevalla and bight redfish. These deep-water demersal species are large, slow growing, long lived, have variable juvenile phases and there is limited information on their life history. They are very susceptible to overfishing and incur significant barotrauma mortality.

Offshore demersal captured species – Scalefish (High)

Indicator Species: Bass groper, eight bar groper, hapuku and ruby snapper.

These species have been commercially fished in the West Coast since the early 1990s with the catch peaking and then declining in more recent years (5 species; 2004/05 90t, 2007/08 24t). These species are also caught in the Commonwealth Western Deepwater Trawl Fishery (200m - EEZ) with anecdotal evidence suggesting that the rapid decline of some of these trawl species was a result of fishing down the spawning aggregations.

The Charter fishery has recorded some catches of this species (e.g. grey banded cod), however, anecdotal evidence suggests that there is a greater focus from the recreational sector for these large deep-water species.

These deepwater species are particularly vulnerable to overfishing, as their biology indicates that they are long-lived and would therefore have low rates of natural mortality and productivity. In addition, some aggregate to spawn and most suffer high rates of barotrauma following capture due to the great depths in which they are fished (> 250 m).

Legislative responsibility and relevant management authorities

The Department of Fisheries has clear legislative responsibility under the Fish Resource sManagement Act 1994, for all retained fish species caught in State waters and for most of the fish species to the 200nm Australian Fishing Zone (AFZ) or Economic Exclusion Zone (EEZ) as part of the Offshore Constitutional Settlement (OSC).

Those species retained in Fisheries under Commonwealth legislation and managed by the Australian Fisheries Management Authority (AFMA) include the deepwater trawl species (mostly bugs) and Western tuna and billfish fishery (big eye and yellowfin tuna, broadbill swordfish). These species are not otherwise to be taken. The Indian Ocean Tuna Commission (IOTC) provides a forum for managing tuna and billfish stocks in the Indian Ocean.

Monitoring and research programs

Current:

Commercial catch and effort data collection, creel and boat ramp surveys.

Proposed:

Preliminary risk assessment provided to managers.

Information from new recreational licensing requirements.

Management actions (DoF)

Current:

Significant closures and restrictions for both the commercial and recreational sector.

External drivers

The Commonwealth Western Deepwater Trawl Fishery fishes in waters along the west coast of Australia in waters from the 200 m isobath to the boundary of the AFZ and between approximately Exmouth and Augusta. This fishery overlaps the WCDSF and has obtained substantial catches.

The Commonwealth's South-west Marine Bioregional Plan incorporates the aim of introducing marine reserves, which are likely to contain areas closed to fishing. This has the potential to restrict access to fishing in parts of the West Coast Bioregion to all sectors, i.e. commercial, recreational and charter.

Captured fish species – Pelagic

Description

General: The pelagic management area consists of the open water from 20m depth to the EEZ. Pelagic species are not generally associated with the benthos or ocean floor, they are associated

with mid to upper layers of the water column. Several stocks are exploited including mackerel, pilchards, samson fish. Catches are relatively small and no sustainability concerns have been identified at present.

Commercial Fisheries: West Coast Purse Seine Fishery captures pilchards, sardines, Perth herring, yellowtail scad, Australian anchovy and maray.

Recreational Fisheries: There is an increasing recreational fishery for pelagic species such as Samson fish possibly due to localised depletion of traditionally more popular demersal fish species.

Pelagic captured species – Finfish (Low)

Indicator species - are still being finalised for this suite of species. At present the species in this management suite include mackerel, pilchard and samson fish. The current fishing level has been assessed as acceptable.

Legislative responsibility and relevant management authorities

The Department of Fisheries has clear legislative responsibility under the Fish Resource Management Act 1994, for all retained fish species caught in State waters and for most of the fish species to the 200nm Australian Fishing Zone (AFZ) or Economic Exclusion Zone (EEZ) as part of the Offshore Constitutional Settlement (OSC).

Those species retained in Fisheries under Commonwealth legislation and managed by the Australian Fisheries Management Authority (AFMA) include the deepwater trawl species (mostly bugs) and Western tuna and billfish fishery (big eye and yellowfin tuna, broadbill swordfish). These species are not otherwise to be taken.

The Indian Ocean Tuna Commission (IOTC) provides a forum for managing tuna and billfish stocks in the Indian Ocean (ABARE pg. 156).

Monitoring and Research Programs

Current:

See current State of Fisheries for current research and monitoring. Boat ramp and creel surveys, RAP data.

Proposed:

No additional activity in this area.

Management Actions (DoF)

Current:

See the current State of the Fisheries for management controls for each group of species.

External Drivers

Few identified for this area and group of species.

Protected species

Background

The protected species component tree has been divided into protected 'fish' species under the FRMA such as teleosts, crustaceans and molluscs as well as; protected non 'fish' species such as birds, reptiles and mammals that are protected, but not defined as 'fish' under the FRMA (Figure 20). In the West Coast Bioregion there are some mammals, few reptiles and only a small number of other protected species that interact with fishing activities. There are also minimal fisheries in the West Coast that produce bycatch (R. Campbell, pers. comm.).

Objectives:

Minimise any direct and indirect interactions with protected species.

All WA fisheries are conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species.

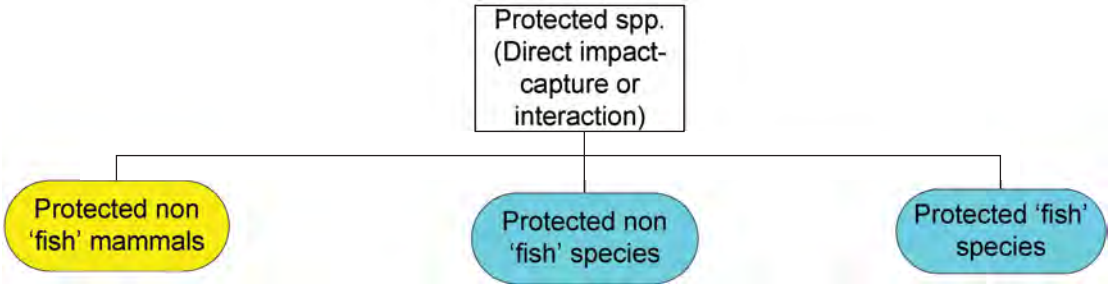

Figure 20: West Coast Region: Protected species; consolidated risk.

Protected species - Protected non 'fish' species

Description

This category refers to those species such as birds, reptiles and mammals that are protected, but not defined as 'fish' under the FRMA.

Although mostly assessed as low risk there are a number of issues that have rated a medium risk. These are likely low – medium.

Protected non 'fish' species risk status - Little Penguins (Medium)

The largest colony of little penguins, *Eudyptula minor* in WA is Penguin Island (Perth metropolitan area) that represents the northwesterly limit of their distribution. A number of potential threats have been identified and include a reduction in food availability due to increased fishing and destruction of fish habitat, collisions with watercraft including fishing vessels, oil spills and chemical contaminants such as Tributyltin (TBT) (B. Cannell, pers comm.). Although a strong link has been shown between white bait and the diets of little penguins (Lenanton et al, 2003), it is unlikely that fishing is causing a reduction in the white bait abundance as there is only very limited fishing of this species in the Perth region (Fletcher and Santoro, 2009). There has also been a reduction of commercial fishing vessels in the area as crab fishing has been banned in Cockburn Sound and there are seasonal closures in place for snapper fishing.

Protected non 'fish' mammals species risk status - Australian Sea Lion (Medium)

The Australian sea lion, *Neophoca cinerea* is Australia's only endemic as well as the least numerous seal species. It is unique among pinnipeds in being the only species that has a non-annual breeding cycle (Gales et al, 1994), it also has the longest gestation period of all pinnipeds and a protracted breeding and lactation period.

Although historical population size and range for this species is unknown, it appears that uncontrolled sealing operations reduced their numbers considerably (Gales, 1994). Population viability analyses of Australian sea lion (ASL) subpopulations have indicated that even low-level chronic incidental mortality in fisheries could lead to their extinction. The commercial fisheries identified in which bycatch of Australian sea lions may be significant were pot or trap fisheries for rock lobster (Western rock lobster and Southern rock lobster), and demersal gillnet fisheries for sharks off the Western Australian and South Australian coasts.

Sea Lion Exclusion Devices (SLEDs) are now mandatory on all WA Rock Lobster pots in use within a 25km radius from breeding colonies. It is believed that this action has solved any direct capture issues of juvenile sea lions in rock lobster pots (R. Campbell, pers. comm.). Extensive, independent (research) coverage of gillnet deployments indicated that marine mammal capture was at a rate of just over 1 per 10,000 km gillnet hours (McAuley and Simpfendorfer, 2003). As a result, in 2002 the ESD risk assessment rated Pinniped capture as low to negligible in the WCDGLF.

There is now limited gill net fishing effort on the west coast of WA (WCDGLF). Management restrictions incorporate seasonal closures (2 months inshore of the 200m isobath) and closed areas including a total exclusion in the metropolitan region. The fishery now operates at approximately 40% of peak level (1988).

The relative number of sea lions found in traps or related fishing gear (per pot lift) and other fishery interactions is used as an indicator of impacts on sea lions from the rock lobster fishery.

Performance Measure: No increase in the rate of sea lion capture occurs. The historical incident range approx 3 sea lion captures per season.

Evaluation: During the 2005/06 WRL season, no sea lion captures were reported therefore the performance measure was met in 2005/06.

The relative number of sea lions found in gill nets and other fishery interactions is used as an indicator of impacts on sea lions from the demersal gillnet fishery.

Performance Measure: No increase in the rate of sea lion capture.

Evaluation: The ecological sustainability assessment under the EPBC is valid until 26 February 2009 and will be reassessed at this time.

Legislative responsibility and relevant management authorities

These species are protected under a mix of State legislation (Wildlife Conservation Act and Regulations 1950, Conservation and Land Management Act 1984) and Commonwealth legislation (Environment Protection and Biodiversity Conservation Act 1999 known as the EPBC Act and the Wildlife Protection Act 1982). Under Commonwealth legislation (generally applied to waters outside State waters or 3nm) it is an offence to kill, take, trade or move protected species unless you have a permit. The protected or listed species group includes a large

number of marine animals including sea birds, turtles, sea snakes and mammals. Deliberately causing interference to cetaceans carries additional penalties. As fishing can occasionally result in unavoidable accidents or incidents, all interactions with protected species under the EPBC Act must be reported.

Monitoring and research programs

Current:

- Potential impact of Bycatch in the WA shark gillnet fishery (FRDC project No. 2007/059. PI R. Campbell).
- Interaction between Australian sea lions and the demersal gillnet fisheries in Western Australia R. Campbell DoF for the Centre for Applied Marine Mammal Science. In press.
- WAMSI Node 4, Project 4.4 Captured Species Assessments.

Proposed:

- Continue current activities, no additional activities proposed at this stage.

Management actions (DoF)

Current:

- Mandatory SLEDs in all Rock Lobster pots within a 25km radius of sea lion breeding colonies.
- Mandatory reporting to DEWHA of any interactions with sea lions by commercial fishery.
- DoF CAES logbook reporting of sea lions interactions.

Proposed New Actions -

- WCDGDLF will be reassessed in 2009 against the ESD conditions for the fishery.

Possible management actions by other Departments -

SARDI has in place a number of spatial management measures (including fishing closures and MPAs) and is currently developing mitigation measures to reduce possible sea lion bycatch (FRDC research project 2007/041) for the southern rock lobster fishery and gill net fisheries in SA.

Maintaining strong links with researchers at the SARDI is particularly important.

External drivers

As the majority of the Australian sea lion population occurs in South Australia (86%), with only 14% in Western Australia (Goldsworthy et al. 2008), it is important that there is strong and effective protection measures in both State jurisdictions. A SARDI risk analysis identified fisheries bycatch and climate change as the greatest risk factors to the conservation and management of Australian sea lions (Goldsworthy et al, 2008). The 'uncertainty' in this assessment was considered high for climate change because the extent and implications of climate change impacts on Australian sea lion populations are unknown. Loss of some key breeding sites to sea level rise is likely (Goldsworthy et al, 2008).

Review period

5 years

Protected species - Protected 'fish' species

Description

Under State legislation (Fish Resources Management Act 1994) and Commonwealth legislation (Environment Protection and Biodiversity Conservation Act 1999) there are a number of 'fish' species protected including all pipefish, seahorses and sea dragons, many shark species, some finfish species and a small number of crustaceans and molluscs. In Western Australia, most of the protected species are found in the southern or northern waters with few species occurring in the West Coast Bioregion. This group has been rated as low and will not be described.

Benthic habitat

Benthic habitats in estuaries and embayments were the only habitat category to be given a risk greater than low (Figure 21). As a result, only this category will be described in detail.

Background

Operational Objectives

To manage fisheries impacts such that only acceptable impacts occur to benthic habitats (Figure 21).

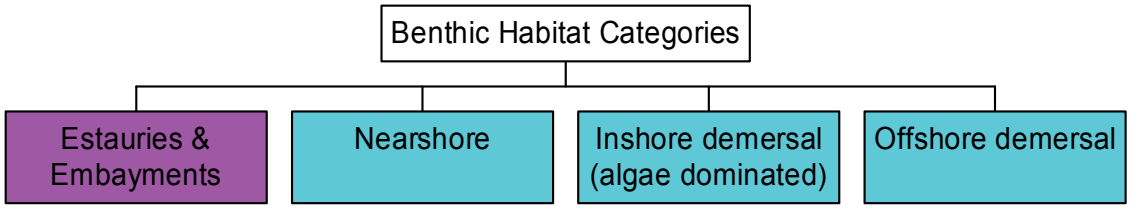

Figure 21: West Coast Region: Benthic Habitat; consolidated risk of unacceptable change in the short term (5 years).

Benthic habitat - Estuaries and embayments

Description

Estuaries and embayments are often some of the most highly impacted aquatic (marine and freshwater) areas in the world due to coastal development and nutrient run-off. The estuarine and embayment areas of the West Coast, including the Swan and Peel Harvey estuaries, have been rated as a high risk (Figure 9). The largest population areas and development in the State surround these areas. Nutrient, pollution and drainage inputs, foreshore degradation, dredging for boating channels and shell sand mining, appear to have resulted in significant benthic impacts, particularly on seagrass and sand habitats.

There is some chance for change to occur as a result of trawl fisheries for scallops in the Abrolhos, however, work in Shark Bay indicates that the impact on sandy bottoms from this type of fishing is thought to be negligible (Kangas et al, 2006). There is limited trawling in the West Coast ecosystem and no trawling in the estuaries and embayments.

Benthic habitat risk status- Estuarine and embayment (High)

Two of the habitat categories (sand and seagrass) both rated high in stakeholder assessment due to sand mining in embayments and nutrient loads and sedimentation that smother seagrass beds.

The risk was measured against unacceptable change in the short term (5 years). Any impact from fishing is likely to be low or negligible.

Legislative responsibility and other relevant management authorities

Under the FRMA, DoF has legislative responsibility for seagrass, however the Department of Environment and Conservation (formally DEP) takes management responsibility through the Environment Protection Authority (EPA) for any impacts on seagrass resulting from existing activities and when new developments are proposed. Under the Benthic Primary Producer Habitat Protection for WA's Marine Environment (EPA Report No.29 2004) only a cumulative loss of seagrass less than 5% outside Marine Parks or similar is considered acceptable. In the Swan River the Swan River Trust (Swan and Canning Rivers Management Act 2006) has responsibility for the ecological health of the River system, as does the Cockburn Sound Management Council for Cockburn Sound.

Monitoring and research programs

Current:

- No specific Department of Fisheries projects in the Swan River or Cockburn Sound relating to benthic habitat.
- No specific management actions.

External drivers

Issues affecting benthic habitats include, dredging, mining, coastal development, nutrient run-off and pollution inputs.

Social outcomes

Background

Social outcomes (direct stakeholders, Figure 22), Finfish objective:

- Maintain or improve the lifestyle for commercial fishers and access to quality recreational (and charter) fishing experiences by creating sustainable inshore demersal fisheries.
- Maintain or improve the lifestyle for commercial fishers and access to quality recreational (and charter) fishing experiences in nearshore areas by creating sustainable fisheries.

There is often conflict between commercial and recreational fishers and occasionally the general public that determines that commercial fishers may be forced out of areas by local governments (e.g. beach bait fishers). This would change their lifestyle and also increase stress and cause the loss of traditional fishing values in the region.

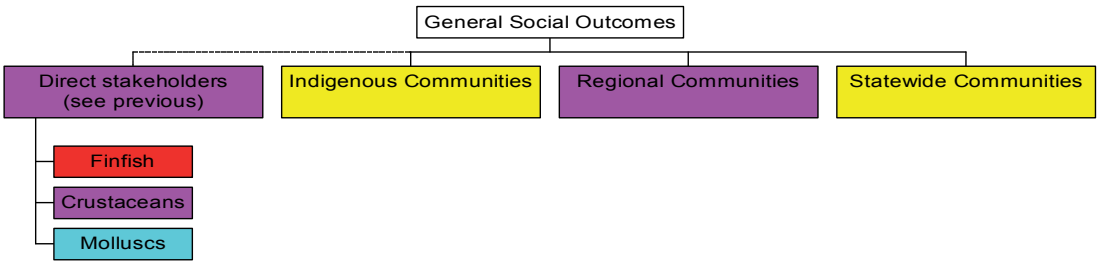

Figure 22. Social Outcomes consolidated risks.

Social outcomes - Finfish

Description

Demersal: The management that has been implemented to address the sustainability concerns a number of demersal species captured in the commercial wetline fishery and the recreational sector. The commercial management changes may have affected the smaller commercial operators that have been long-term fishers from traditional fishing families. Management changes that force these people to leave the industry can cause a very high level of stress. For those remaining in the fishery there is still the uncertainty associated with the outcomes of management, particularly the finalised package for recreational sector, including licences and seasonal closures.

Nearshore: Given the changes to the demersal fishery, it is likely that a number of recreational fishers may refocus their effort from demersal to nearshore areas. This is likely to reduce access to and quality of recreational fishing in the nearshore areas of the metropolitan zone. There is also concern that conflict between commercial salmon and recreational fishers in the Leeuwin-Naturaliste region may mean that the commercial fishers are eventually excluded from some nearshore areas (e.g. Eagle Bay). This creates stress for commercial fishers and may also reduce the quality of experience for recreational fishers.

Estuaries and Embayments: Recreational fishing pressure in estuaries and embayments is generally very high, particularly close to the metropolitan zone (i.e. Swan Canning and Peel Harvey estuaries). In some areas of the West Coast ecosystem there is considerable lobbying pressure from the recreational sector to force the commercial fisheries to leave estuaries and embayments. As a result, there is both conflict between individual recreational fishers and potential issues with localised depletions of recreationally important species. For instance, Cockburn Sound has been closed to both commercial and recreational crab fishing since 2007. Both issues may reduce the quality of recreational fishing experiences.

West Coast social outcomes risk status – Finfish (Severe)

The current risk level for social outcomes generated by finfish fishing in the west coast for both commercial and the recreational sector is severe.

Monitoring and research programs

Current:

Creel and boat ramp surveys are currently being undertaken to obtain information on recreational fishing including the species, number and size of fish captured, fishing method and area, and time spent fishing. In addition, the number of customers and species captured are recorded daily by all charter operators. This information could be used to provide an indication of access to fishing activities and quality of fishing experiences.

The DoF Community Survey is run annually and surveys approximately 500 members of the public from the Perth metropolitan area (444 in 2007, Baharthah 2008). Information regarding recreational fishing participation rates, satisfaction with fishing experiences, awareness and opinion of fishing regulations are a number of topics covered in the surveys.

A pilot study to develop a socio-economic assessment of fisheries (commercial and recreational) in the West Coast Bioregion has recently been completed (see WAMSI Node 4 Project 4.5.3 report). In addition, an assessment of recreational shore-based effort is currently underway at the Department of Fisheries.

Management actions (DoF)

Current:

A seasonal closure implemented in the West Coast region in order to protect demersal fish species such as dhufish, pink snapper and breaksea cod. In addition, new recreational licences, increased licence fees for existing licences and decreased size and bag (recreational fishery) limits have been applied to a suite of demersal fish species. It is unknown how these management strategies impact the social outcomes for fishers targeting inshore demersal fish stocks.

– Fishers targeting fish in the nearshore area are often limited by bag and size limits for particular species (e.g. pink snapper). A seasonal closure also limits the capture of a suite of demersal fish species between October 15th and December 15th.

– The capture of many species that reside within estuaries and embayments, such as black bream, are restricted by bag and size limits. In addition, some species are protected by seasonal closures, such as blue swimmer crabs.

– The metropolitan zone has been closed to the commercial wetline fishery since 2007. This fishery is subject to input controls, such as restrictions on the number of boats, size of gear and spatial closures. In addition, size and bag (recreational fishery) limits apply to a large number of demersal fish species. The seasonal closure may also determine that fishers on charter boats may no longer capture the protected suite of species during the closed period. This has unknown consequences on the economic viability of the fisheries.

External drivers

Possible management actions by other Departments. Pollution through agricultural and storm-water run-off has the capacity to alter estuarine ecosystems by increasing nutrient loads. Seasonal fresh water flushing is also very important in the Swan Canning and Peel Harvey estuaries as this freshwater input can lead to algal blooms, which in turn, deoxygenate the water and shade the environment below. Embayments may also be impacted by pollution through industrial discharge and rubbish (general and fishery-related). Agricultural and storm-water run-off are under the control of the Departments of Water, Agriculture and Primary Industries. Collaboration with these departments would be necessary for any change to occur to benefit fish stocks and fisheries. The Department of Fisheries is proactive in its endeavours to reduce fisheries-related rubbish, however, collaboration with other departments and agencies would be necessary to reduce industry discharge and general rubbish.

Review period

3-5 years.

Social outcomes - Crustaceans

Description

There are concerns for the sustainability of western rock lobster populations that have led to reductions in effort to reduce the catch. Such reductions in the fishing effort in the region has had substantial implications for employment in the fishing industry and would be expected to have significantly increased stress levels for commercial rock lobster fishers.

The daily bag and boat limits as well as the possession limits for recreationally caught western rock lobster have also been reduced (www.fish.wa.gov.au). The blue swimmer crab and prawn

fisheries are both currently subject to sustainability concerns. The Swan and Peel Harvey prawn fisheries and the blue swimmer crab fishery in Cockburn Sound have been closed to fishing (commercial and recreational) with the aim of allowing the breeding stock levels to increase. Such reductions may reduce the quality of the recreational fishing experience.

Crustaceans within the estuaries and embayments are also subject to relatively high recreational fishing effort in and near the metropolitan zone. The recreational catch of prawns used to be high in the Swan and Peel Harvey, however, the numbers of prawns significantly reduced over time (e.g. drastic reduction in school prawns). Since the instigation of Fishing Closures the recreational catch of crustaceans (prawns and crabs) has been substantially reduced.

Social outcomes (direct stakeholders), Crustaceans: estuaries and embayments objective;

Maintain or improve the lifestyle for commercial fishers and access to quality recreational (and charter) fishing experiences in estuaries and embayments by creating sustainable fisheries.

Social outcomes risk status – Crustaceans (High)

Low puerulus settlement and changes to management place the social risk with regard to crustaceans in the West Coast Bioregion at a high risk of change.

Monitoring and Research Programs

Current:

As above for social outcomes for finfish.

Management actions (DoF)

Current:

Effort, licence usage, compliance and the monetary value of each fishery are monitored by the DoF. A 50% effort reduction was placed on the commercial fishery in the West Coast Region in 2008. Courses and skills workshops are made available by DoF for people in the fishing industry and provide these employees with additional or alternative skills that may enable them to access other employment.

Current:

The southwest trawl fishery (includes the capture of prawns) is managed using input controls such as boat numbers, gear sizes and fishing areas. The commercial and recreational capture of blue swimmer crabs is governed by a series of separate management arrangements, such as input controls (vessels numbers, trap numbers), size limits and seasonal restrictions. As stated previously, the Swan Canning and Peel Harvey are closed to prawn fishing, while Cockburn Sound is closed to fishing for blue swimmer crabs.

Proposed New Actions:

The Cockburn Sound closure and status of the Peel Harvey blue swimmer crab fishery (recreational) will be reviewed following the completion of research programs in these areas.

External Drivers

Environmental fluctuations are thought to play an important role in the recruitment of puerulus to Western Australia (Pearce and Phillips 1988, Caputi et al. 2001). In addition, fluctuations in water

temperature are thought to impact growth and therefore recruitment of sized individuals into the fishery. Investigation into relationships between rock lobster recruitment and environmental factors are currently underway at the Department of Fisheries.

Fluctuations in recruitment may occur due to environmental changes, which may affect spawning and larval survival. The relationship between recruitment and catch and environmental factors are being evaluated progressively as data becomes available.

Review period

5 years.

Social outcomes - Statewide communities

Description

Western Australian communities have the expectation of access to fresh local fish as well as healthy marine ecosystems and their associated resources. Changes in the sustainability of stocks and fisheries (e.g. western rock lobster and wetline fisheries) are likely to alter perceptions of the communities with regard to fishing and fisheries management (DoF) in the West Coast Bioregion. For example, a reduction in the rock lobster fleet operating out of Jurien Bay may create negative perceptions of fisheries management. Changes to the sustainability of fish stocks and fisheries as well as alterations to the management of fisheries may determine that the availability of local seafood declines. In addition, there may be little available local seafood due to costs of processing, the value of the Australian dollar and incentives to export fish rather than sell locally.

Changes to the sustainability of fish stocks and fisheries as well as alterations to the management of fisheries may determine that the catch of local seafood declines. Low availability coupled with high demand tends to result in increased prices. In addition, when the Australian dollar is low there is an incentive to export fish rather than sell locally as exporters receive a greater profit. It only becomes profitable to sell seafood locally when the Australian dollar is very high against the US dollar. As a result, in order to compete with the profits gained by exporting seafood, local consumers would generally need to pay highly inflated prices.

Cultural and heritage values are the qualities that make a specific and definable place, area or asset important to the community. Heritage values derive from many sources, including historical associations, architectural features and the natural ecosystems within which the community reside. Cultural and heritage values may be lost or modified throughout time due to changing perceptions and attitudes, change in the use of natural resources on which the community relies as well as the use of new technologies.

Commercial and recreational fishing is undervalued in society and, as a result, the loss of at least some cultural and heritage values is likely due to increased management regulations and sustainability issues. For instance, the loss of local fishing fleets (e.g. in Fremantle) and locally caught seafood may determine that the community values associated with fishing are eventually forgotten.

The economic downturn as well as sustainability issues for a number of fish populations and increased management regulations in the West Coast region have slowed boat sales. If these trends continue for a substantial period of time, the number of boat sales may not be enough to ensure businesses remain economically viable.

Social outcomes risk status – Statewide communities (Moderate)

The risk of change to social outcomes with regard to statewide communities is moderate.

Monitoring and research programs

Current:

A stakeholder survey is undertaken by the Department of Fisheries on a regular basis. This survey collects information from all fishing sectors (commercial, recreational and charter) as well as other stakeholders, such as members of the tourist industry, universities, aquaculture and pearling.

Current:

Qualitative modelling is currently being undertaken by the DoF to investigate links between social, economic and ecological (including fishing) values. This work may help to identify areas that are particularly important in order to retain cultural and heritage values in the region.

Proposed:

Perth and regional market sales figures would indicate the proportion of fish being sold locally versus internationally. In addition, the number of local retailers selling locally caught fish is listed on the 'fish lovers' website (WAFIC, www.fishlovers.com.au). The number of retailers on this list could also be used as an indication of the availability of local seafood.

Management actions (DoF)

See above for management actions for finfish.

External drivers

An increase in 'green' or conservation thinking may change community expectations with regard to fishing activities and the management of marine resources. In addition, the media plays a large role in influencing community perceptions, which may change in response to the media as opposed to direct changes in fisheries or management.

Changes in stock and fisheries sustainability due to climate change may force the closure of fisheries or make fishing economically unviable. As a result, fishing fleets may be lost from communities and traditional fishing families may be forced to find alternative employment. If such changes in environmental factors were to occur, no change to fisheries management would be able to retain all cultural and heritage vales associated with fishing throughout the state.

During a recession boat sales are likely to slow, as recreational fishing would no longer be a priority for many families. If a recession occurs in conjunction with declining stock abundance (due to fishing, climate change or natural variation) and increased management regulations, a further reduction in boat sales may occur as people may no longer see the benefits of going fishing. Similarly, commercial fishers may not have the funds to put into buying new boats during a recession or following stock decline and management changes. As a result, the profits of boat selling businesses may be significantly reduced.

Review period

5 years.

Social outcomes - Regional communities

Description

The flow on effects from sustainability issues for species including rock lobster and demersal scalefish, which have lead to the increased management restrictions may have flow-on impacts to fisheries-related areas and the general communities in some regional areas. A paucity of local seafood may be an issue in the Leeuwin-Naturaliste as there is some level of expectation that locally caught seafood will be available to tourists visiting the area. People buying fish for sale in fish shops would then be forced to pay higher prices and either make a smaller profit or increase the sale price for consumers. When prices increase, fewer people will be willing to purchase fish and profits will be reduced. Similarly, truck drivers, tourist accommodation businesses and tackle shops may experience reduced profits.

Boat builders in the West Coast Region may be faced with economic decline due to the decline in a number of large commercial fisheries (i.e. wetline and rock lobster fishery) in the region. In addition, the recent global economic decline has reduced recreational boat sales and, likely, boat building in the metropolitan zone. The economic decline is thought to have had (and will continue to have) a severe impact on the economic viability of boat builders in the region.

The use of a seasonal closure to protect a broad suite of demersal fish species may reduce the number of fishing tourists travelling to the West Coast Bioregion. Fishing in the region may no longer be perceived as worthwhile with closures and additional restrictions in place.

Social outcomes risk status – Regional communities (High)

The social outcomes to regional communities have been identified as a high risk of change mainly due to impacts on boat building, tourism and local sales of fish.

Monitoring and research programs

Current:

The Department of Fisheries regularly collects information regarding the number and location of fish processors in the state. Change in the number of processors could be used to indicate the economic viability of fishery-related industries.

Indicators:

Trends in the number of charter clients could be used as an indication of the impact of management changes on fishing tourism.

Monitoring and Research Programs

Current:

The number of clients, catch (species and number) and location of charter trips are documented and collected by the Department of Fisheries.

Management actions (DoF)

See actions for finfish above.

External Drivers

Changes in stock and fisheries sustainability due to climate change may force the closure of fisheries or make fishing economically unviable. Reduced profits may then flow-on to fishery-related businesses.

Review period

5 years.

Economic outcomes

Economic outcomes – Finfish

Description

The sustainability of a number of commercially important demersal fish species is of concern and if recruitment continues to decline the profitability of the wetline fishery would be reduced. Similarly, if management regulations, such as effort restrictions, increase in order to aid the sustainability of the demersal fish stocks, fishery profitability will also decline. The sustainability of demersal fish stocks and changes in management regulations also impact on the profitability of the economic viability of the charter fishing industry in the region.

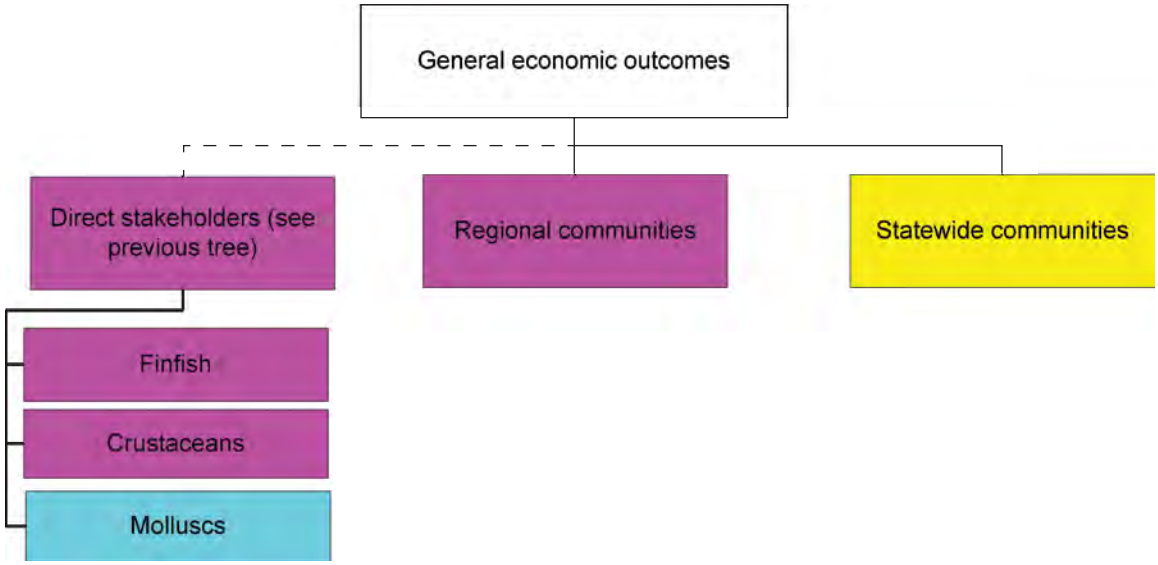

Figure 23: West Coast Region: Consolidated tree; Economic outcomes for Direct Stakeholders.

Economic outcomes risk status – Finfish (High)

The economic outcomes associated with finfish were deemed to be at high risk of change following stakeholder consultation.

Monitoring and research programs

Current:

The number of commercial and charter boats operating as well as the number of people employed (licence-holders, crew etc.) is recorded by the Department of Fisheries each year. In addition,

catch rates are also collected from these vessels throughout the year. This information could provide an indication of the economic wellbeing of the fisheries in the West Coast Bioregion.

Management actions (DoF)

Current:

None.

External drivers

The price of fish is driven by demand and may be somewhat removed from the availability of the product in the market. For instance, demand may fluctuate depending on trends in public opinion. These fluctuations in demand and price may therefore impact the economic outcome of fisheries.

Review period

5 years.

Economic outcomes – Crustaceans

Description

A decline in the sustainability of western rock lobster stocks would be expected to reduce fishery profits through reduced catch rates. In addition, the alteration of management strategies, through increased restrictions, may impact fishery profits. However, if the management regulations simply remove the latent effort from the fishery and the tonnes captured remain stable, a decline in profits may not occur. Altered management regulations may also benefit fishers with a large number of pots preferentially to those with a smaller number of pots. This may force the smaller businesses to leave the fishery.

Economic outcomes risk status – Crustaceans (High)

The risk of change in the economic outcomes for crustaceans was assessed as high following discussion with stakeholders.

Monitoring and research programs

Current:

None.

Management actions (DoF)

Current:

Effort, licence usage, compliance and the monetary value of each fishery are monitored by the Department of Fisheries. A 50% effort reduction was placed on the commercial fishery in the West Coast Region in 2008. Courses and skills workshops are made available by DoF for people in the fishing industry and provide these employees with additional or alternative skills that may enable them to access other employment.

External drivers

The price of fish (including crustaceans and shellfish) is driven by demand and may be somewhat removed from the availability of the product in the market. For instance, demand may fluctuate

depending on trends in public opinion. These fluctuations in demand and price may therefore impact the economic outcome of fisheries.

Environmental fluctuations are thought to play an important role in the recruitment of puerulus to Western Australia (Pearce and Phillips 1988, Caputi et al. 2001). In addition, fluctuations in water temperature are thought to impact growth and therefore recruitment of sized individuals into the fishery. Investigation into relationships between rock lobster recruitment and environmental factors are currently underway at the Department of Fisheries.

Review period

5 years.

Institutional governance

Background

The institutional governance tree covers some of the most important issues when considering EBFM. It considers all the legislative, administrative and bureaucratic processes to enable the issues in the previous trees to be dealt with effectively. Very little information is available regarding the institutional governance tree and the reporting is therefore brief.

The components were divided into Department of Fisheries management processes and external linkages and consultation processes (Figure 24), and were assessed as having a high risk of change.

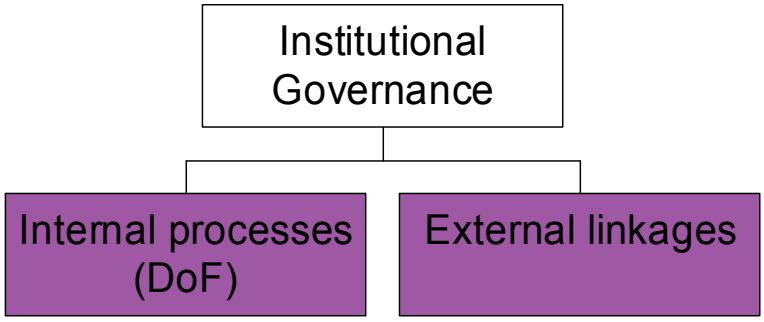

Figure 24. Consolidated risks- Institutional Governance arrangements.

The Department of Fisheries is currently undergoing considerable change in financial resourcing, staff structure and strategic direction. The external communication processes are also under review.

As these changes will significantly impact on the institutional governance and associated risks, it is not appropriate to consider these issues at present.

The Institutional Governance risks will be reviewed in 12 months.

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Appendix 2 Consequence and likelihood tables used for risk analysis of individual ecological assets.

Modified from Fletcher (2005, 2010).

Target species

Table A1 Consequence categories for the Major Target/Vulnerable species. The default objective was - *maintain spawning biomass at least above the level where it is likely not to result in recruitment overfishing*

Level	Ecological (Target/Vulnerable Species)
Minor (1)	Either not detectable against background variability for this population; or if detectable, minimal impact on population size and none on dynamics. Spawning biomass 100% - 70% unfished levels
Moderate (2)	Fishery operating at, or close to, full exploitation rate but the long-term recruitment/ dynamics are not being adversely impacted. Spawning Biomass < 70% but > Brec
Major (3)	Stock has been reduced to levels that are now directly affecting future recruitment levels or severely affecting their capacity to increase from a depleted state (i.e. recruitment overfishing). Spawning Biomass < Brec but > Brec * 0.5
Extreme (4)	Stock size and recruitment levels reduced to an extent that local extinctions or significant species range contraction > 50% have occurred. If it continues it would require listing in an appropriate endangered IUCN category and extinctions could result. Spawning Biomass < Brec * 0.5

Bycatch

Table A2 Consequence categories for the Bycatch of Protected species. The default objective was - *To maintain levels of catch of these species at acceptable levels*

Level	Ecological (Protected Species Bycatch)
Minor (1)	Essentially no protected species are impacted
Moderate (2)	The fishery catches or impacts these species at the maximum level that is accepted
Major (3)	The catch or impact by the fishery on the protected species is above that accepted but there are few additional stock implications
Extreme (4)	The catch or impact is well above the acceptable level and this is having significant additional impacts on the already threatened status.

Ecosystem

Table A3 Consequence levels for the impact of a fishery on the general ecosystem /trophic levels. The default objective was **-** *To maintain any impact on the wider ecosystem by fishing to be within acceptable levels'*

Level	Ecological (ECOSYSTEM)
Minor (1)	Some relatively minor shifts in relative abundance may be occurring but it is unlikely that there would be any measurable changes at whole of trophic levels outside of natural variation.
Moderate (2)	Measurable changes to the ecosystem components without there being a major change in function. (i.e. no loss of components or real biodiversity), these changes are acceptable. None of the main captured species play a 'true' keystone role
Major (3)	Ecosystem function altered measurably and some function or components are locally missing/declining/increasing &/or allowed new species to appear. The level of change is not acceptable to enable one or more high level objective to be achieved. Recovery measured in many years to decadal.
Extreme (4)	An extreme change to ecosystem structure and function. Very different dynamics now occur with different species/groups now the major targets of capture and/ or dominating the ecosystem. Could lead to a total collapse of ecosystem processes. Long-term recovery period may be greater than decades

Habitat

Table A4 Suggested consequence levels for the impacts on habitats. (Three levels – standard, fragile, critical). The default objective was **–** *To maintain the spatial extent of habitat impacts from the fishing activity to a comparatively small percentage of the habitat/ community***'**

Level	Ecological (HABITAT)
Minor (1)	Insignificant or barely measurable impacts on habitat(s) which are very localised compared to total habitat area. *(Suggestion – these impacts could be < 5%; < 3%; <2%) of the original area of habitat)*
Moderate (2)	There are likely to be more widespread impacts on the habitat but the levels are still considerable acceptable given the % of area affected, the types of impact occurring and the recovery capacity of the habitat *(Suggestion – for impact on non-fragile habitats this may be up to 50% [similar to population dynamics theory] - but for more fragile habitats, to stay in this category the percentage area affected may need to be smaller, e.g. 20% and for critical habitats less than 5%)*
Major (3)	The level of impact on habitats may be larger than is sensible to ensure that the habitat will not be able to recover adequately, or it will cause strong downstream effects from loss of function. *(Suggestion - Where the activity makes a significant impact in the area affected and the area > 25 - 50% [based on recovery rates] of habitat is being removed; whilst for critical habitats this would be < 10%)*
Extreme (4)	Too much of the habitat is being affected, which may endanger its long-term survival and result in severe changes to ecosystem function and the entire habitat is in danger of being affected in a major way/removed. *(Suggestion this may equate to 70 - 90% of the habitat being affected or removed by the activity; for more fragile habitats this would be > 30% and for critical habitats 10-20%)*

Social

Table A5 Suggested consequence levels for social disruptions. The default objective was *Maintenance or enhancement of appropriate social structures and outcomes*.

Level	Social Implications
Minor (1)	None, or not measurable. Includes situations where there is no direct involvement by a community in the fishery.
Moderate (2)	Some direct impacts on social structures but not to the point where local communities are threatened or social dislocations will occur
Major (3)	Severe impacts on social structures, at least at a local level.
Extreme (4)	Changes will cause a complete alteration to some social structures that are present within a region of a country

Economic

Table A6 Suggested consequence levels for economic outcomes. The default objective was **-** *Maintenance or enhancement of economic activity*

Level	Economic
Minor (1)	Possible detectable, but no real impact on the economic pathways for the industry or the community.
Moderate (2)	Some level of reduction for a major fishery or a large reduction in a small fishery that the community is not dependent upon.
Major (3)	Fishery/industry has declined significantly in economic generation and this will have clear flow on effects to other parts of the community. May result in some level of political intervention.
Extreme (4)	Total collapse of any economic activity coming from what was an industry that the community derived a significant level of their income or employment (resource dependency), including possible debts. High levels of political intervention likely.

Likelihood

Table A7 Likelihood Definitions – these were defined for the likelihood of a particular consequence level actually occurring within the assessment period (5 years was used).

Level	Descriptor
Likely (4)	A particular consequence level is expected to occur in the timeframe (Probability of 40 - 100%)
Possible (3)	Evidence to suggest this consequence level is possible and may occur in some circumstances within the timeframe (Probability of 10 - 39%)
Unlikely (2)	The consequence is not expected to occur in the timeframe but it has been known to occur elsewhere under special circumstances (Probability of 2 - 9%)
Remote (1)	The consequence has never been heard of in these circumstances, but it is not impossible within the time frame (Probability < 2%)