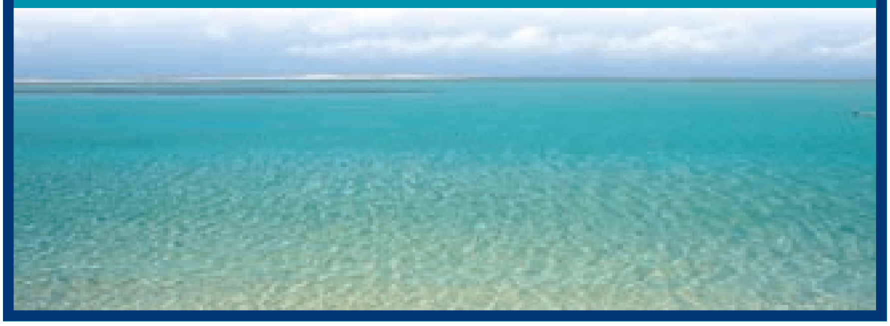
# THE ESD ASSESSMENT MANUAL FOR WILD CAPTURE FISHERIES

## *Version 1*

October 2003



Ecologically Sustainable Development

*Catching Sustainabilty*

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Government of Western Australia Department of Fisheries

CSIRO

The University Of Queensland Australia

Fish for the future

FRDC Project 2002/086

*This 'ESD Assessment Manual' is part of an on-going process to develop a framework for the reporting and assessment of ESD for fisheries within Australia. This edition is the first version, changes are expected to be made at regular intervals when further information indicates that significant improvements can be made.*

*The material may be copied for use in completing assessments and reports as long as appropriate acknowledgement of the source is given.*

*Whilst this project was originally conducted under the auspices of the SCFA, and is now a project endorsed by the Marine and Coastal Committee of the Natural Resources Management Committee (NRMC), it should not be taken as being the policy of any individual fisheries management agency.*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**www.fisheries-esd.com**

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# 1.0 INTRODUCTION

## 1.1 Background

FRDC Project 2000/145 developed the conceptual framework and guidelines to enable reports on the contribution of a fishery to Ecologically Sustainable Development (ESD) to be produced. This process involved the completion of a series of case studies covering a variety of fisheries from most jurisdictions to ensure that it is applicable in all circumstances. With the publication of the '*How to Guide'* (Fletcher et al, 2002) and the "*Technical Support Document*" (Whitworth et al., 2002), both of which are available on the Fisheries ESD website (www.fisheries-esd.com), this phase of ESD implementation has now been completed.

The development of the reporting framework was only the first step in a series of linked activities to fully implement ESD across all fisheries. It was not possible to identify, at that stage, what was appropriate performance against each criteria from which systematic assessments of reports could be undertaken by third parties. However, in the absence of a nationally agreed ESD reference document, each of the stakeholder groups that reviews any ESD report is currently forced into using their own set of 'standards'. Such a situation could lead to significantly different outcomes, depending upon which agency/group conducts the review, and potentially who within the "auditing agency" reviews the report. This has resulted in a a high level of uncertainty, which is unacceptable to many stakeholder groups (including industry, government and non-industry).

The ESD Reference Group (which includes representatives of all major stakeholders) met in November 2001 and agreed that there was a requirement to develop a set of projects to achieve the transition from ESD Reporting to ESD Assessment. One of the issues identified by most jurisdictions (and other external parties) was a strong need for assessment officers to have some guidance on what is acceptable performance with regards to performance measures, indicators and management responses for fisheries as soon as possible. Consequently, one of the primary objectives for a FRDC project (2002/086) was to produce the first edition of an Assessment manual. This manual was to include a summary of the information available from which an understanding of what was considered acceptable &/or best practice for the main species/fisheries within Australia could be initiated. Thus, the information should be used as a general guide when preparing or assessing reports, not as a prescription of what must be done.

The material presented in this manual covers most of the issues of relevance to the major "auditing"/management agencies along with environmental and broader community groups, at an appropriate level of detail. Drafts of this material have been presented to the ESD Reference group and its constituent members to ensure that the directions being taken have provided the information required. This is the first edition of what is expected to be an ongoing process with revisions and updates occurring at least annually over the next four years. At this stage, most of the information presented only relates to the ecological/ environmental issues, and mostly for commercial rather than recreational fishing. Future editions will begin to incorporate the social and economic components in more detail. It is our hope that any errors or omissions in this edition will inspire the provision of alternative or additional information that can be used in subsequent editions.

## 1.2 Outline of Material Provided

The following two sections within this edition provide different types of information to assist agencies generate and review reports on ESD. They are, however, steps in a continuum of precision - from the generic to the specific. The material presented in Section 2 is of a generic nature that should be relevant across all fisheries. The material in Section 3 uses the concepts in the first section to provide details specific to the fisheries catching particular types of species or using particular fishing methods.

Section 2 describes the generic forms of objectives, indicators, performance measures, and management responses for individual components within the generic component trees. In many respects, the information presented in this section expands upon the material presented in Appendix 2 of the '*How To Guide'* and provides more formal advice on the 'best' way to generate these segments of the reports. There are many gaps in this section which indicate where future work is required.

Section 3 presents material specific to a particular species or fishing method which, in most cases, is based on empirical data &/or direct experiences or current practices. This section extends the generic concepts presented in the first section by providing specific guidance as to what is already in use and currently regarded as acceptable (and by whom) for each of the major types of species and fishing methods. The information provided is not meant to be prescriptive about what specific management actions must be taken, as these will vary dependent upon the specific management objectives and resources available. Thus, it usually provides a commentary on specific combinations of management actions/indicators/performance measures in relation to their relative levels of robustness and risk which each can be viewed as possiblities.

Appendix 1 contains a set of reference points (both limit and target) that could be used to formulate objectives and performance measures for each of the ecological components of ESD. Many of these are, however, based on theoretical assessments.

The format of the material presented and the terminology used in this manual follows (wherever possible) that in the National ESD Reporting Framework. Thus, the issues covered are related to where they are located within the generic component tree structures. Furthermore, the main headings for discussion are within the reporting framework structure: Objectives, Indicators, Performance Measures, and Management Responses.

The list of fisheries and species covered in this edition is not final and further categories will be added in the future as more material is gathered. Furthermore, the text for some of the species or fisheries sections that are already vered may change as further material becomes available.

The use of exiting data should be the first step in any assessment because extensive literature is already available on the effects of fishing (Steele *et al.*, 2002). Completing this process has identified a number of gaps in the species/fishery specific reports which will provide direction for future resources and additional research.

Finally, the information provided is not meant to be a full review of the issues. Rather the sections provide an overview of the key points to assist in the determination of whether performance reports within an ESD assessment may have appropriately addressed the relevant issues, and whether they are using acceptable/best practice methodologies and management arrangements.  Most of this information is derived from the applications that have been submitted and in some cases, accepted by external “auditing” agencies such as the Commonwealth Dept. of Environment and Heritage and GBRMPA.

## References


Fletcher, W.,J. Chesson, J., Fisher M., Sainsbury, K.J., Hundloe, T., Smith, A.D.M. and B. Whitworth (2002) *National ESD Reporting Framework for Australian Fisheries:The* ‘How To’ *Guide for Wild Capture Fisheries*.  FRDC Project 2000/145, Canberra, Australia.  120pp

Steele, et al (2002)  Effects of Trawling and Dredging on Seafloor habitat.   National Academy Press, Washington, DC.

Whitworth, B., Chesson, J., Fletcher, W.J., Sainsbury, K.J., Fisher, M., Hundloe, T., and A.D.M. Smith, (2002) *National ESD Reporting Framework for Australian Fisheries:Technical Support Document - Ecological Components of the 2000/2001 Case Studies*.  FRDC Project 2000/145, Canberra, Australia.  98pp

# 2.0 STEPS TO DEVELOP PERFORMANCE MEASURES

For many components, the general forms of the objective, indicator, performance measure and management response will be common across fisheries. The details of which will be dependent on species, fishing method and local circumstances. This section of the manual discusses those general forms. Details specific to particular species and fishing method are discussed in Section 3.

The discussion is organised according to the generic component trees, while not all components are covered in this version of the manual. The intention is to fill in the gaps over time as experience is accumulated and results of ongoing research become available.

## 2.1 Contributions of a Fishery to Human Wellbeing

### 2.1.1 National Socio-Economic Wellbeing

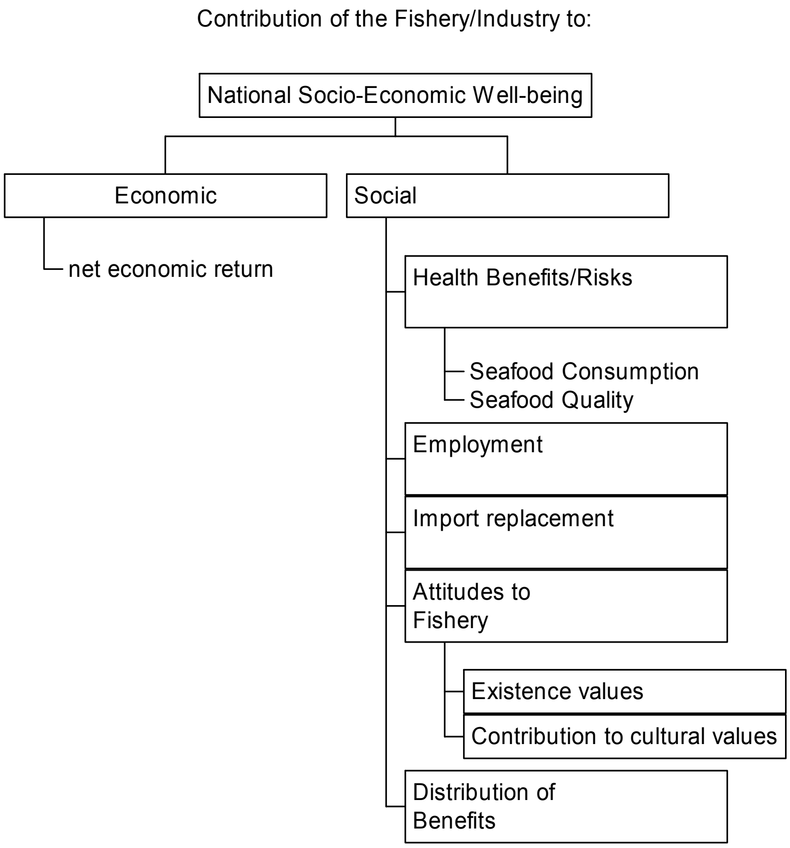


**Figure 2.1 Generic Component Tree for the contribution of the fishery to National Social and economic issues.**

**Table 2.1 Possible Objective, Indicator, Performance Measure and Data requirements for issues within the national socio-economic wellbeing components**

| Component | Objective | Indicator & performance measures | Data requirements |
|---|---|---|---|
| Effects of fishery on national economic wellbeing | Maintain or increase the contribution of the fishery to the national economy | Net economic return for the fishery.<br>(Achieving MEY) | Economic survey data gathered periodically (e.g. 5 years) |
| Import replacement | Maintain or increase the proportion of domestically-harvested fish consumed | Consumption per capita of local seafood.<br>To achieve at least an average consumption level of 6kg of locally-harvested seafood. | Consumption surveys conducted periodically (e.g 5 years) if data not available from ABS |
| Distribution of benefits | Equitable distribution of benefits to fishers | Indicator not developed | |
| Social<br>▪ Health benefits/risks seafood eaten | Improve human health/nutrition by increasing fish consumption | Consumption per capita of local seafood | Consumption surveys and/or ABS data |
| ▪ Seafood quality | Ensure seafood meets food safety requirements | Food safety reports | Food safety reports |
| ▪ Lifestyle benefits/costs | Maintain or improve lifestyle values for the fishery | Indicator not developed | |
| Cultural values<br>▪ Indigenous | Where appropriate maintain or improve cultural values associated with the fishery | Indicator not developed | |
| ▪ Non-indigenous | Maintain or improve cultural values associated with the fishery | Indicator not developed | |

## 2.1.2 Community Wellbeing

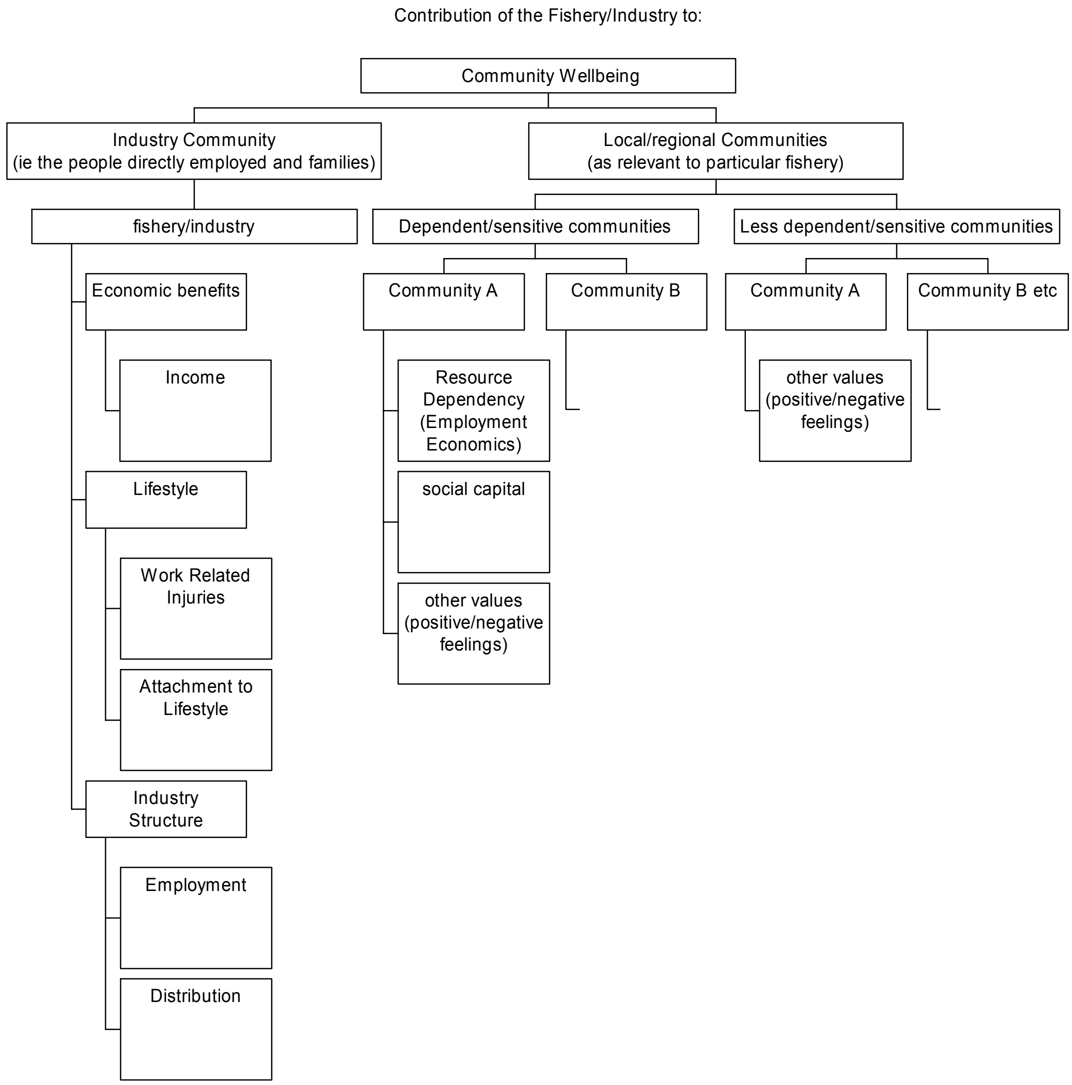


**Figure 2.2 Generic Component Tree for the contribution of the fishery to Community/ Regional Socio-Economic Wellbeing.**

**Table 2.2: Possible Objective, Indicator, Performance Measure and Data requirements for issues within the community/regional socio-economic wellbeing components**

| Component | Objective | Indicator(performance measures) | Data requirements |
|---|---|---|---|
| Effects of fishery on regional communities<br>▪ Indigenous<br>▪ Economic | Maintain or increase jobs, profits and flow-on benefits to the community | Direct and flow-on contributions to the region | Regional input-output analysis conducted periodically (e.g. 10 years) |
| ▪ Social<br>▪ Social capital | Maintain or increase the contribution the fishery makes to social capital at the local scale | Indicator not developed | Interaction of fishers, their families and people in closely-related industries (e.g. boat building) in local social fabric. One-off survey required. |
| ▪ Employment | Maintain or increase regional/local employment in the fishery and related industries | Employment in the harvesting and processing sectors, and flow-on employment in other industries | Employment numbers from ABS |
| ▪ Regional industry | Maintain or improve local/ regional attitudes to the fishery | Positive and negative feelings to the fishery | Attitudinal surveys conducted occasionally. Ad hoc media comments |
| Effects of fishery on industry participants<br>▪ Economic | Maintain or increase income to fishers | Net income | See above: economic survey data plus ABS employment data |
| ▪ Social<br>▪ Health | Reduce death and accident rate for fishers | No greater than National average for work-related injuries | Injury data from relevant government authority |
| ▪ Lifestyle benefits and costs | Maintain or improve lifestyle for fishers | Indicator not developed | |

## 2.1.3 Indigenous Community Well-being

(To be developed in a later version)

## 2.2 Contributions of a Fishery to Ecological Wellbeing

### 2.2.1 Retained Species

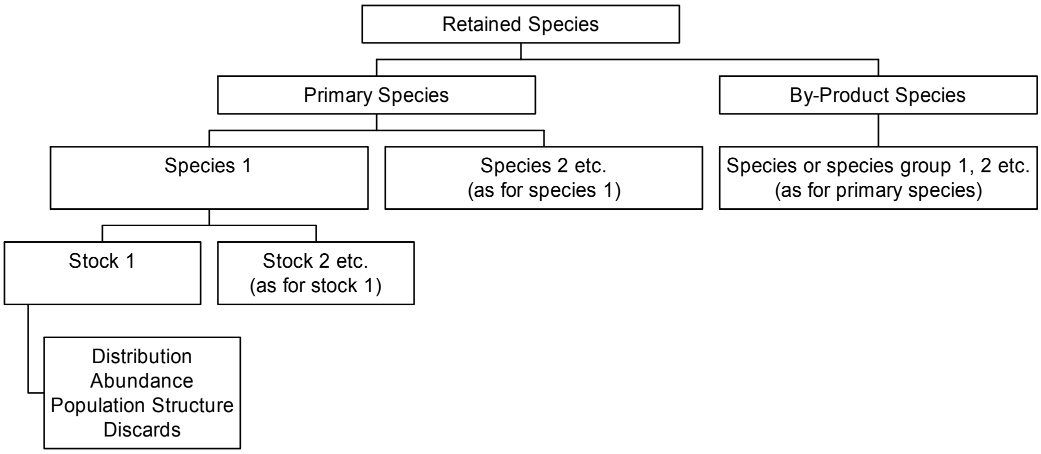


**Figure 2.1 Generic Component Tree for Retained Species.**

This component includes any species that the fishery retains at least some of the time. Each stock should be considered separately. A fishery may choose to classify species as primary species or byproduct species if it desires, but the classification does not affect generic objectives, indicators or performance measures.

#### *2.2.1.1 Abundance*

This section first describes what could be regarded as "best practice" in terms of specifying objective, indicator, performance measure and management action for the abundance of retained species. It then discusses variations that may be applicable in particular situations.

**Objective**

For retained species, the fishery has to manage two potentially competing interests: the desire to maintain stock abundance at a level that provides the best production over the long term; and the desire to minimise the ecological impact of removing individuals from the water (for example, the impact on predators that depend on the retained species for food). While both interests share a common desire to prevent abundance falling to undesirably low levels, especially those from which the stock may never recover, a well-managed fishery should aspire to something more than simply avoiding this worst-case scenario.

The objective for the abundance of a retained species can be expressed generically such that the stock abundance must satisfy one or more of the following criteria:

1. remains above a limit 'a' selected to avoid stock collapse
2. remains above a limit 'y' selected to avoid unacceptable impacts on ecologically dependent species (competitors, predators and prey)
3. remains sufficiently close to a target 'c' selected to provide maximum yield.
   If all criteria cannot be satisfied simultaneously, criteria 1 and 2 should probably take precedence over criterion 3.

The precise definition of 'remains above' and the value of the limits 'a', 'y', 'c' etc will depend on the species and the nature of the fishery. These details are addressed in Section 3.

The objective for abundance may be translated into a more operational objective that can be measured and expressed in terms of catches, fishing mortality or some other quantity. If this is done, there should be a clear argument setting out how achievement of the operational objective will guarantee achievement of the stock abundance objective.

#### Indicator

Whilst many systems use indicators that report on current or past performance, one of the better types of indicator can be expressed generically as:

> The probability that each criterion of the objective will be satisfied over a period of x years, estimated using a predictive model that incorporates uncertainty.

An indicator of this type incorporates future as well as past performance and is superior to an indicator that reflects only past performance. Even though the objective is expressed in terms of stock abundance, it is not necessary to estimate or report on stock abundance in order to generate the indicator. It recognises that fisheries impose management actions in order to obtain an acceptable performance against the objective in the future.

The model can be as simple or as complex as appropriate and does not require a 'data rich' fishery. If uncertainty is high, probability will be low for a given harvest strategy and will automatically lead to a more precautionary management response.

#### Performance measure

If the above style of indicator is used (i.e. probabilistic), the associated performance measure can be defined simply in terms of whether the indicator (probability) is above or below a specified level β. The performance measure is set to 1 (acceptable) if the indicator is greater than or equal to β and to 0 (unacceptable) if the indicator is less than β. β may be different for each criterion but would be expected to be high (at least 90%) where the consequences of not meeting the criterion were serious.

Setting the value of β provides an explicit statement of the degree of precaution being exercised. For avoiding stock collapse, a value of 50% would be regarded as a low level of precaution whereas a value of 99% would be regarded as highly precautionary.

More elaborate performance measures could be defined if a graded response is required. For example, the performance measure could be set to 0 for all values of the indicator less than β and then increase from 0 to 1 for values of the indictor between β and 100%.

#### Management response

A typically management response would be to determine the value of the indicator at regular points in time (e.g. annually) assuming various future harvest strategies and select a strategy (e.g. a total allowable catch) that gives a probability greater or equal to β. If none exists, then the fishery would be closed.

If a retained species is caught by more than one fishery, the indicator should be determined cooperatively taking into account the catches of all fisheries. If the harvest strategy is expressed in terms of a total allowable catch, the total allowable catch should be determined for the total catch of all fisheries and then allocated among the individual species. If the total allowable catch allocated to an individual fishery represents only a small proportion of the entire catch, the fishery could revert to a simple operational objective of maintaining catches within its allocated catch.

#### Example

For its southern ocean fisheries, the Australian Fisheries Management Authority (AFMA), using an approach developed by the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), requires the catch limit of Patagonian toothfish (*Dissostichus eleginoides*) to be chosen so that over a 20-year period:

- the probability of the spawning biomass dropping below 20% of its pre-exploitation median level is less than 10%; and
- the median spawning biomass remains at or above its pre-exploitation median level.

AFMA does not specify a criterion relating to desired abundance for the purposes of providing maximum yield.

In this example the limit ‘a’ is 20% of the pre-exploitation median level and the ‘y’ (the ecological limit) is 50% of the pre-exploitation median level.

For the first criterion the probability, β, must be greater than 90%. For the second criterion the probability must be greater than 50% (expressed as the median).

Note that this formulation elegantly incorporates the objective, indicator, performance measure and management response in a single statement.

#### Variations

Table 2.3 summarises the objective-indicator-performance measure-management response package just described, together with several variations. The first variation considers only current stock abundance and does not attempt to predict future abundance under the current or alternative harvesting regimes. Since it identifies overfished stocks, but not overfishing, it runs a greater risk of overshooting a lower limit of abundance and having to take more drastic action to then return stock abundance to an acceptable level. Using an estimate of abundance as the indicator, rather than the probability of satisfying specific criteria, has the advantage of being easier to communicate. However, the level of precaution is not explicit and will depend on the uncertainty associated with the estimate of abundance[1].

The second type of variation in Table 2.3 is when the objective for abundance is expressed relative to an existing or previous state that is assumed to be acceptable without having to state explicitly what the criteria for acceptability are. This is a special case of the previous variation, but the indicator is likely to be expressed in terms of abundance relative to the reference state.

The final two variations in Table 2.3 are relevant when it has been determined that the current abundance is unacceptable and the immediate objective is to move back into the acceptable range. Again, these are special cases of the earlier variations, but expressed in terms that emphasise the rebuilding objective.

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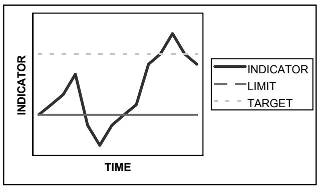
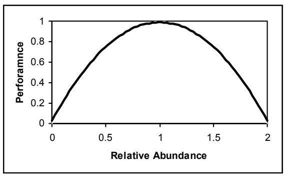
[1] This disadvantage can be overcome if the performance measure is defined appropriately. Provided the package contains the necessary ingredients, it is somewhat arbitrary which ingredients are defined in the objective, the indicator and the performance measure.

The variations in Table 2.3 are not exhaustive and different aspects can be combined in many different ways. The process of explicitly stating the objective, indicator, performance measure and management response allows the package to be scrutinised as a whole and its strengths and weaknesses evaluated.

**Table 2.3 Variations on the objective-indicator-performance measure-management response package for abundance of retained species.**

| Objective | Indicator* | Performance measure* | Management responses | Comments |
|---|---|---|---|---|
| Maintain abundance so that it satisfies specified criteria over a given period of time. Criteria can be a combination one or more limits and/or targets. | Probability that criteria will be satisfied during the time period assuming a particular course of action. Probability can be estimated using a range of techniques. Does not necessarily require 'data rich' fishery. | Probability must be greater than specified value, eg 0.9. | Select course of action, eg setting TAC/ effort levels at regular intervals, so that required probability is achieved | Combines reporting and management response into a single, integrated process. Takes into account future as well as present stock status. Deals explicitly with uncertainty. |
| Maintain abundance so that it satisfies specified criteria. Criteria can be a combination one or more limits and/or targets. | Probability that current stock abundance satisfies criteria. Probability can be estimated using a range of techniques. Does not necessarily require 'data rich' fishery. | Probability must be greater than a specified value, eg 0.9. | If performance not satisfactory, take action to remedy situation, eg reduction in TAC, closures, effort controls. Switch to a rebuilding objective below. | Considers only current stock status for purpose of measuring performance.<br>Deals explicitly with uncertainty. |
| | Estimate of stock abundance. Can be obtained from fishery-independent or fishery-dependent data using a range of techniques. | Abundance must satisfy criteria. If target is involved, could have the following form:   | If performance not satisfactory, take action to remedy situation, eg reduction in TAC, closures, effort controls. Switch to a rebuilding objective below. | Considers only current stock status for purpose of measuring performance.<br>Does not deal explicitly with uncertainty. |

| | | | | |
|---|---|---|---|---|
| Maintain abundance at current level. | Estimate of stock abundance relative to current level. Could use an indirect indicator such as catch rate in some cases. | Relative abundance must be sufficiently close to 1, ie no significant change. Could have following form:  | If significant change then take action to remedy situation. Switch to a rebuilding objective below. | Special case of previous objective. |
| Return abundance to previous level within specified time. (Rebuilding objective.) | Probability that target will be achieved within specified time assuming a particular course of action. | Probability must be greater than a specified value, eg 0.9. | If performance not satisfactory, select a course of action that achieves required probability. If none, close fishery. | Takes into account future as well as present stock status. Deals explicitly with uncertainty. |
| Return abundance to previous level (Rebuilding objective.) | Estimate of stock abundance relative to previous level | Stock abundance should be increasing over time. | If stock abundance not increasing, take further action to remedy situation, including possible closure of fishery. | Considers only current trend in stock status for purpose of measuring performance. Does not deal explicitly with uncertainty. |

*One to be selected

#### *2.2.1.2 Distribution*

To be developed.

#### *2.2.1.3 Other Components (population structure etc.)*

To be developed.

### 2.2.2 Non-retained species

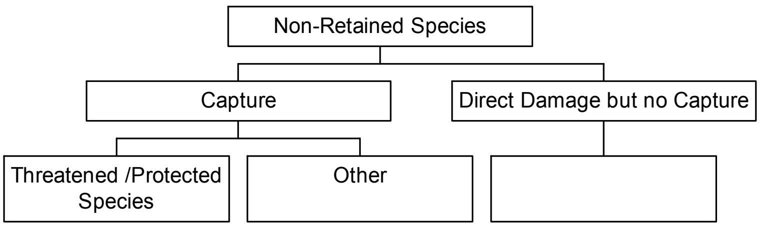



**Figure 2.2 Generic Component Tree for Non-Retained Species**

This component covers species that are killed or injured as a direct result of the fishing operation, but are not retained by the fishery. Since the fishery gains no benefit from killing or injuring individuals, the objective for non-retained species is not as complex as the objective for retained species.

Species of particular concern for whatever reason should be dealt with on an individual species or stock basis. The remaining species should be grouped or dealt with as individual stocks using a risk assessment approach as illustrated below.

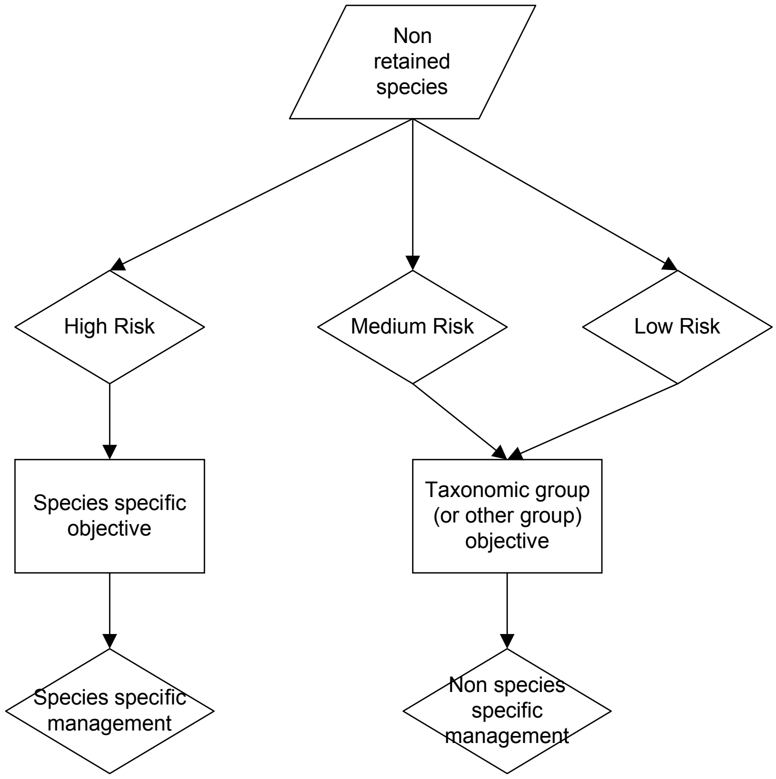



**Figure 2.3 Decision Tree to assist in determining appropriate management response for non-retained species issues.**

#### Objective

Two main approaches can be taken in specifying an objective for non-retained species. The objective can be expressed in terms of the abundance of the species or in terms of the pressure the fishery imposes on the species. The first approach is appropriate when the species is of particular concern and/or the fishery is likely to be a major determinant of its abundance. The second approach is more pragmatic when the fishery is only one of many factors affecting the abundance of the species or group of species and unlikely to be the major determinant. Each of the two approaches are summarised in Table 2.4.

Since the fishery has no interest in reducing the abundance of non-retained species (in contrast to retained species where a reduction in abundance is an unavoidable and, up to a point, desirable consequence of harvesting), the abundance objective can be expressed quite simply as maintaining the species at or above a specified level. A generic pressure objective is to avoid, minimise or reduce deaths and injuries caused by fishing. This can be further elaborated in terms of an ongoing trend (reduce, minimise) or in terms of a limit that is determined to have a biologically insignificant impact on the species or species group.

#### Indicator

If the objective is expressed in terms of abundance of the non-retained species, then the indicator is likely to be an estimate of abundance. Other possibilities discussed under retained species could be applied but may provide little additional benefit since with non-retained species the fishery is not trying to manage competing objectives to the same extent as it is with retained species. The abundance limit for a non-retained species can be set with a comfortable margin of error so that close monitoring is not as critical.

If the objective is expressed in term of managing the pressure imposed by the fishery, the indicator will typically be an estimate of deaths (e.g. catch) or injuries. This may be estimated directly from data collected during fishing operations or indirectly such as from rates of adoption of gear modifications.

#### Performance measure

For an abundance objective, the performance measure would be the same as for the appropriate entry in Table 2.3.

For a pressure objective, the performance measure could be set at 1 for an indicator value of 0 (no impact on the non-retained species) and decline to 0 as the indicator approached the specified level ‘a’. The advantage of this formulation compared to an ‘all or none’ performance measure, is that it continues to recognise superior performance below the limit ‘a’.

#### Management response

Typical management responses to reduce the impact of the fishery on non-retained species are modifications to gear and temporal and spatial closures to reduce the probability of interactions.

#### Example

In the Australian oceanic longline fisheries, the second approach is used for seabirds. The objective is expressed in terms of managing the pressure exerted by the fishery on seabirds rather than attempting to monitor and respond to the abundance of seabirds.

The objective is to reduce the seabird catch to below 0.05 birds per thousand hooks, with the ultimate aim being 0. The indicator is the catch per 1000 hooks and the performance measure could look something like the sketch below. A catch above 0.05 per 1000 hooks is given a performance measure of 0. Lower catches are assigned higher measures of performance.

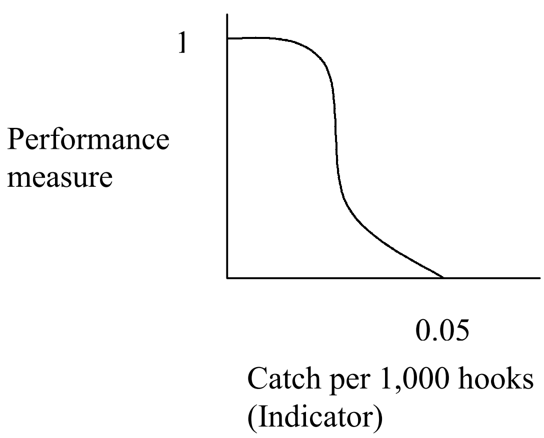
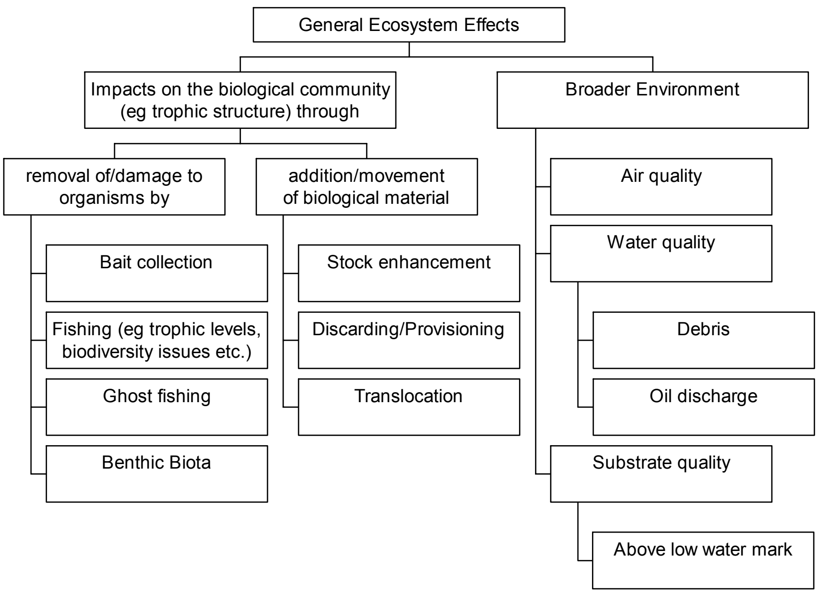


**Table 2.4 Two alternative objective-indicator-performance measure-management response packages for non-retained species.**

| Objective | Indicator* | Performance measure* | Management responses | Comments |
|---|---|---|---|---|
| Maintain species abundance at or above specified level. | Estimate of species abundance. Most likely obtained from fishery-independent data. | Performance measure set to 1 if at or above specified level, set to 0 if below specified level. | If performance not satisfactory, review possible causes (fishery or external to fishery) and take appropriate action. May implement fishery responses even though fishery is not major cause of problem in order to reduce risk to species. | Estimate of species abundance may be generated from outside fishery (eg conservation agency) |
| Avoid/minimise/reduce deaths and injuries caused by fishing | Deaths or injuries inflicted by fishery (eg, catch if returned dead). Could be estimated from data on uptake of modified gear and its effectiveness. | Performance measure set to 1 if at or below a specified level, set to 0 if above specified level.<br><br>Graded performance measure appropriate to 'minimise or reduce' objectives | If performance unacceptable: gear modifications, spatial or temporal closures. | |

## 2.2.3 General ecosystem




To be developed

# 3.0 INDIVIDUAL SPECIES AND FISHERIES REPORTS

## Introduction

The following section has been structured to assist in the consistency and effectiveness of auditing and assessment of fisheries ESD performance reports. It includes information related to the species caught and the specific fishing methods used by commercial fisheries in Australia which were covered in a generic manner in the previous section. This is done by summarising the information available on the available operational objectives, performance measures, indicators and management responses currently imposed.

There are two major components within this section; the first covers issues related to the capture and vulnerability of the target/retained species and the potential for any indirect trophic impacts resulting from their removal. The second section covers the issues related to the method of fishing and the impacts these may have on non-retained species, benthic habitats and other more general ecosystem effects of the fishery operations.

Knowing whether the species being targeted by a fishery is highly vulnerable, or if it is relatively resilient to fishing, should influence the level of information and justification that needs to be provided within the performance reports and the level of scrutiny required by the reviewer. Clearly, the more vulnerable a species is to fishing, the greater the level of precaution required for their management and the quality of information needed to justify any specific management approach. Equally, the greater the potential impact a fishing method can have on the broader ecosystem, the higher the level of information &/or the management controls needs to be. Nonetheless, just because a species has low vulnerability doesn't mean that management is not required, nor does it mean that highly vulnerable species are unable to be fished in a sustainable manner. Both need appropriate management and monitoring arrangements to be imposed.

Each of the components within these sections has a series of standard questions that can be used to assist in the assessment of any performance report. For the species-based assessments, the questions outline how you may determine the relative vulnerability and ecosystem role of the species targeted by the fishery. Similarly, the fishery-based assessments examine the likelihood and severity of impacts on the broader ecosystem from the methods of fishing used. Where possible, the conclusions made by other reviewers have been included. Specifically, the information presented in a table on the relative ecosystem effects for method types provided in Bjordal (2002) has been included.

The questions examine what performance measures and indicators are currently being used and provide suggestions to assist in determining whether the combinations being used may be appropriate for the species/fishery being examined. There are also questions that relate to the types of management actions that are being used and how these relate to the biology and behaviour of the species involved. Finally, there are questions that help to consider how likely it is that the removal of the target species will cause some additional community or trophic level impact/cascade.

Individual reports have been created that summarise the information available for a number of the common target species/groups and for each of the main fishing methods. Having specific reports for each of the common species/groups recognises that the dynamics and behaviour of species can differ greatly and that their responses and vulnerability to fishing and management actions often vary. Thus, what may be an appropriate combination of management and monitoring for one type of species group may not be suitable for another.

Each of these specific reports provide a summary of the empirical data currently available on each of the species/fisheries which has been obtained from a number of sources including research papers (including journal and non-journal publications) and relevant management plans, with additional information coming from reports/applications submitted to auditing agencies such as DEH/MSC. Where the outcomes of these assessments are known, it is indicated whether the performance limit/indicator/management response combinations have been accepted.

Having a synopsis of what is currently assessed as being acceptable for a species or fishery should minimise the effort needed to justify the use of these protocols in future reports/applications. Moreover, they should provide a greater level of certainty about whether the management approaches being taken are likely to be considered appropriate by these agencies/groups. Nonetheless, merely because a specific value or method has been used successfully in one location does not automatically make it appropriate in other circumstances, unless these can be shown to be sufficiently similar.

The information provided in these reports is not restricted to presenting only one "best practice" set of indicators/performance measures and management responses for each category. Such an approach would be of marginal value because only a small proportion of fisheries[2] will usually be in a position to implement such protocols. Instead, the reports discuss the main alternatives and identify where potential problems and benefits may arise from using each approach. They also provide suggestions as to what actions/issues may be need to be accommodated as a consequence of the effectiveness/robustness of the management actions being affected.

The approach used in this manual should assist in achieving a match between the management approaches taken, the data available and the levels of risk and uncertainty. It is not necessary to have sophisticated and expensive data to manage every issue, instead you need to have a management approach that can be justified as being appropriate given what you do and don't know[3].

Whilst the material in these reports has been written from the perspective of what a reviewer may be looking for in assessing an application/report, anyone drafting these reports should also find the material valuable by increasing their understanding of what is likely to be acceptable. Thus, it is expected that where the levels/protocols used to manage/monitor an issue are consistent with the material presented here (or more conservative levels are chosen), then this may require relatively little justification. Whereas, in situations where the levels being used are less conservative than have been accepted elsewhere, a greater level of justification may be needed to explain how these arrangements are acceptable in this situation.

The information in these sections will be updated as data become available either from new EPBC applications being submitted or from the completion of relevant research. This includes both adding new categories of species/fisheries and the revision of sections already available. It is expected that these updates will be completed on a regular basis.

## References

Bjordal, A. (2002) The use of technical measures in responsible fisheries: regulation of fishing gear. In: *A fishery manger's guidebook. Management Measures and their application.* FAO Fisheries Tech. Paper 424: 21-48.

[2] And then only a small number of species even within the most well studied fishery.

[3] It is useful to remember that collecting too much data for a situation is not consistent with ESD principles – it is a waste of resources that could be used elsewhere.

# 3.1 Individual Species Reports (Retained Species Tree)

## Scope

The issues covered in this section mostly relate to the retained species component tree (Fig 3.1) and to one of the issues from the general ecosystem component tree (Fig 3.2), which is mostly affected by the target species removal.

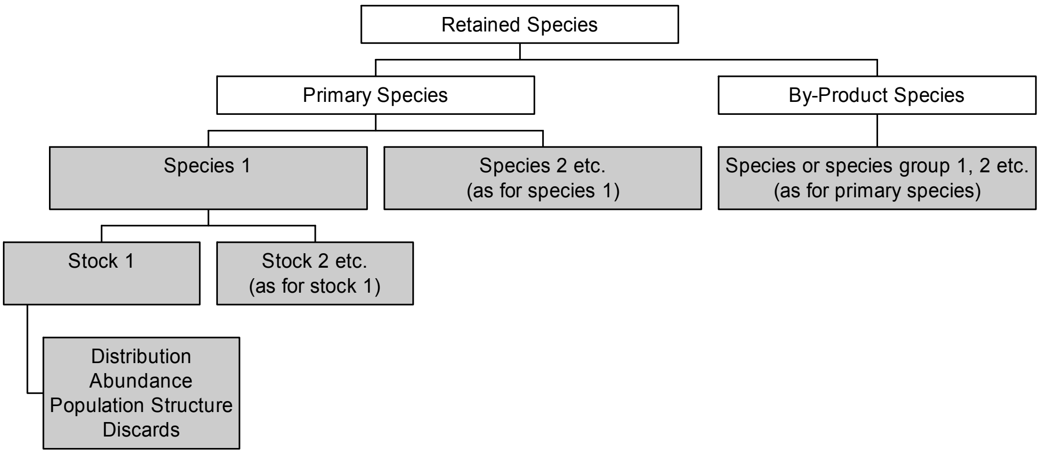



**Figure 3.1 Generic Component tree for Retained Species (Shaded boxes indicate all issues are covered in this section)**

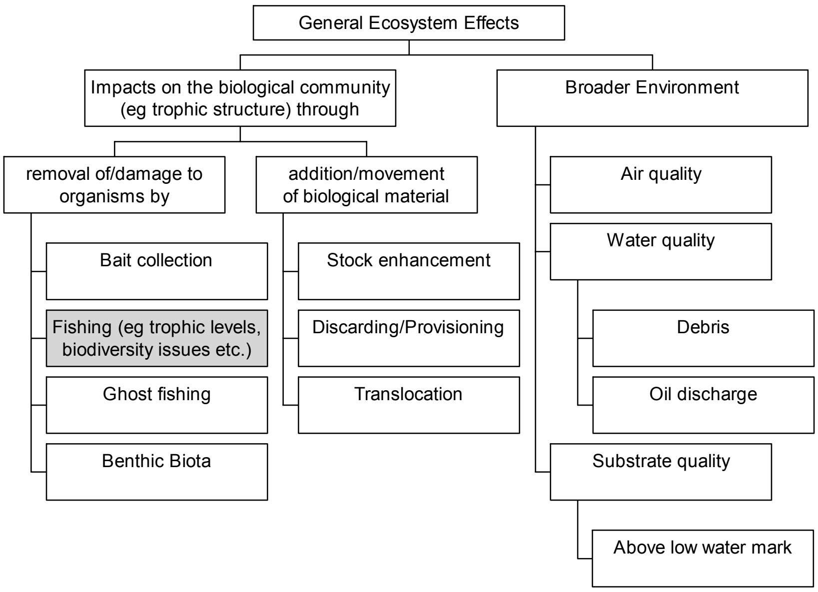



**Figure 3.2 Generic component tree for general ecosystem issues (only the highlighted box is covered in this section, the other issues are covered in the fishing method reports which are located in section 3.2).**

## Standard Questions (used to generate species reports)

## 1.0 General Characteristics (related to fishing)

### *1.1 Biology*

What habitats are they found in?

What is the growth rate, at what age does the species/group reach sexual maturity and what is the maximum age?

What is their spawning dynamics including seasonality (short – long), relative fecundity, larval behaviour/dispersal?

Do they form spawning aggregations?

Are there sex changes, sexual dimorphism, territoriality?

What size/age related migrations are there and what is the mixing amongst regions?

What are the main methods of capture and would they be susceptible to hyperstability in catch rates?

### *1.2 Relative Vulnerability to Fishing (Rate from Low – High)*

Does their biology and behaviour make them more or less vulnerable to fishing?

Has there been successful management of this species/group elsewhere?

Have there been crashes and what was the recovery period?

What are the patterns of annual recruitment – relatively consistent among years, moderately variable about a mean, or relatively long periods with little recruitment interspersed with good years every decade or so?

## 2.0 Objectives

What types of objectives are being used to manage these species/stocks? Are they related to the abundance of the spawning biomass and recruitment overfishing, exploitable biomass, economic levels of harvesting (above any biological limits), etc.?? Do these objectives relate to the current status of the stocks or do they relate to the probability of what they will be some time in the future given the current/proposed management regime?

## 3.0 Performance Measures

Given the type of objective chosen (see above), the types of performance measures and indicators to monitor performance will vary accordingly. The main categories of reference points used are either biological or economic. Within each of these categories there a number of different measures available. In any one situation, however, usually only one type will be used.

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

What is the best estimate of the % unfished levels of egg production that avoids the chances of recruitment overfishing? Describe the evidence used to determine these levels and cite any relevant scientific references. Furthermore, state who (e.g. DEH, MSC) has accepted this evidence in assessments. Where available, list any levels where crashes have been known to have occurred.

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

If there are insufficient data or agreement to determine the precise levels where the abundance should be maintained, outline (if known) the level of reduction in the biomass for this stock/ species where this has not led to obvious impacts on subsequent average recruitment levels.

#### *3.1.3 Maximum Exploitation Rate*

In situations where there are no data on the level of depletion of stocks in relation to recruitment, describe what is considered to be the maximum safe exploitation rate for this species/group and why?

## 3.2 Economic Reference Points

Are there biomass levels/mortality rates that provide the best returns for fishers -catch/value?

#### *3.2.1 MSY and MEY*

Is there evidence that the level of effort in the fishery is consistent with achieving MSY or MEY? (This assumes a yield curve/function has been developed.)

If a yield function/curve does not exist, what is the profitability of the fishery over the past 10 years? In particular, is a downward trend obvious? If profitability estimates are not available what do the catch and effort data show (where catch is measured either in weight or monetary terms, and effort in boats/pots, etc)?

## 4.0 Indicators of Abundance (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

**What is the Robustness? (Low – High)**

Describe under what circumstances catch should, or should not, be used as an indicator of abundance for this species/group.

*Issues –*

- What specific issues should be accounted for if this is to be used as the indicator? (e.g. is effort relatively stable among years and is the catch likely to change in a similar fashion as abundance varies?)

*Examples –* provide examples where it has or has not worked

### *4.2 Fishery Dependent Catch Rates*

**What is the Robustness? (Low – High)**

Describe when and how fishery dependent catch rates should, or should not, be used as an indicator of abundance for this species/group.

*Issues –*

- What specific issues should be accounted for if this is to be used as the indicator?
- Changes in fishing power/efficiency
- Changes (expansion/contraction) in fishing area
- Impacts of quotas etc on fisher behaviour/data accuracy
- Fish behaviour that may lead to hyperstability of catch rates)

*Examples –* provide examples where it has or has not worked.

### *4.3 Fishery Independent Surveys*

**What is the Robustness? (Low – High)**

Describe when and how fishery independent surveys can work or not for this species/group

*Issues –*

- What specific issues should be accounted for if this is to be used as the indicator?
- To what level do fishery independent surveys remove the biases of fishery dependent data and why?
- What impacts does survey design have on the results?
- What impacts do environmental conditions have on results?

*Examples –* provide any examples

### *4.4 Estimates of Current Abundance (model based and composite)*

**What is the Robustness? (Low – High)**

Describe what models are used to calculate the level of absolute (e.g. % unfished) or relative (e.g. compared to reference year) and how it used the various data inputs and assumptions.

*Issues –*

- What specific issues should be accounted for if this is to be used as the indicator?
- What is the validity/reliability of data inputs?
- What assumptions are used?
- What is the model structure?

*Examples –*

### *4.5 Probability of Management Meeting the "Target" in Future*

**What is the Robustness? (Low – High)**

Describe how the probability is calculated and how the level of uncertainty used was determined

*Issues –*

- How real are the probabilities, particularly how is uncertainty estimated and these calculations used?
- What assumptions are used in these circumstances – if a Bayesian approach is taken, how were the priors calculated?

- What assumptions etc. are used in the model?

*Examples –*

### *4.5 Other – (e.g. recruitment indices)*

**What is the Robustness? (Low – High)**

Describe how these indicators could work or not for this species/group

*Issues –*

- What specific issues should be accounted for if this is to be used as the indicator?
- What is the accuracy of predictions generated?
- For what length of time are data available?

*Examples –*

## 5.0 Management Responses (Relative Effectiveness/Efficiency of Management Tools for the species/group)

### *5.1 Biological (size limits)*

**Level of usefulness (Low – High)**

Describe the benefits and problems with this approach for this group

*Issues –*

- Are there any specific issues that need to be taken into consideration?
- What is the % mortality post capture?
- Are there any price differentials with size?

### *5.2 Biological (gender, reproductive stages)*

**Level of usefulness (Low – High)**

Describe the benefits and problems with this approach

*Issues –*

- Is the sex/reproductive stage discernable externally?
- What is the % mortality post capture?
- Is there a price differential for males/females?

### *5.3 Seasonal/Temporal Closures*

**Level of usefulness (Low – High)**

Describe benefits and problems with this approach

*Issues –*

- Are there precise/predictable spawning/recruitment seasons?
- Do these clash with the best time to catch the species (eg a roe fishery, best catch rates)

### *5.4 Area/Spatial Closures*

**Level of usefulness (Low – High)**

Describe benefits and problems with this approach for this group

*Issues* –

- Are there identifiable/significant nursery areas/spawning areas?
- What is the migration/movment patterns for this species, how long are they resident of any one area?

### *5.5 Effort Limitation*

**Level of usefulness (Low – High)**

Describe benefits and problems with this approach

*Issue 1* – Such systems require the level of latent effort to be minimised such that if the days fished/effort units are adjusted this has a real impact on effective effort. (i.e. Can it be demonstrated that effort is really being constrained by management?)

*Issue 2* – The total allowable level of effort usually needs adjustment at regular intervals because fishing power often increases with technological advances (ie. is the fishing power of fleet being examined at suitable intervals?).

*Issue 3* – Can the level of effort be managed and enforced? (ie. is there sufficient compliance with any limits?).

### *5.6 Output Controls*

**Level of usefulness (Low – High)**

Describe benefits and problems with this approach

*Issue 1* – Is the TACC correct? (*There can be a high risk to the stock of getting the TACC wrong if effort controls are removed.)*

*Issue 2* – If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch. *(ie. Are the variations in recruitment built into the determination of the annual quota either by having recruitment indices varying the annual TAC; or is the TAC is at the lower end of the range?)*

*Issue 3* – Compliance for quota fisheries is often harder due to the relative ease of hiding catch and the greater incentive to provide misleading information. *(ie. Is the level of compliance sufficient to ensure that the levels of illegal catches are minimal?)*

*Issue 4* – The data obtained from fishery dependent sources may not be sufficiently accurate/ appropriate for use in monitoring and fishery independent sources may be needed.

### *5.7 Monitoring Frequency and Feedback Loops*

What is the most appropriate frequency/time scale to monitor performance?

*Issues –*

How does the dynamics of the populations fit with the level of aggression of management? *(In some cases it will require real time management, other yearly in some where the dynamics are not large and the management precautionary 3-yearly reviews may be sufficient.)*

## 6.0 Ecosystem issues (Trophic Interactions)

### *6.1 Impacts on Prey and community structure*

What are the known/likely/possible impacts on any prey species from the removal of this species/group by the fishery? Is the target species a keystone species *sensu* Paine, 1966. (note - *just being a top end predator does not automatically make this a 'keystone' predator*)

### *6.2 Impact on Predators*

What are the known/likely/possible impacts on any predators from the removal of this species/group by the fishery? - Are there any predators that specialise or rely on this species?

### 3.1.1 Invertebrates

#### Summary of Invertebrates

| **Attribute** | **ROCK LOBSTER** | **ABALONE** | **CRABS (DEEP)** | **CRABS (Shallow)** | **PRAWNS** |
|---|---|---|---|---|---|
| Vulnerability to Fishing | MOD – LOW | HIGH | MOD | LOW-MOD | LOW-MOD |
| **BIOLOGICAL REFERENCE POINTS** | | | | | |
| Spawning Biomass | 10-22% $B_0$<br>Tas & WRL | Blacklip<br>40 –42% $B_{unfished}$ egg production (Tas, NSW)<br>90% of 1992 $B_{mature}$ (Vic) | 40% $B_0$ (VIC), 50% $B_0$ (WA) | ?? | 20-25% $B_0$<br>Brown Tiger Prawns (WA and NPF) |
| Lowest Level Reached | <10% (Tas)<br>15% (WRL) | | | | 15% |
| Max. Expl. Rate | 60% (WRL) | | | 70% (NT Mud Crab) | |
| **ECONOMIC REFERENCE POINTS** | | | | | |
| MSY/MEY | MSY/MEY used for WRL | 110% of $B_{msy}$ (Vic) | MSY (TAS – giant crab) | MSY (mud & spanner crabs in Qld) | MSY (used for a number of fisheries) |
| **INDICATORS OF ABUNDANCE**<br>(Robustness) | | | | | |
| Catch | LOW-MOD | LOW | LOW | LOW | LOW-MOD |
| Catch Rate | MOD | LOW-MOD | MOD | MOD | LOW-MOD |
| Independent Survey | MOD-HIGH | MOD-HIGH | MOD-HIGH | MOD-HIGH | MOD-HIGH |
| Current Stock Size (Models) | MOD-HIGH | MOD-HIGH | MOD-HIGH | MOD-HIGH | MOD-HIGH |
| Probability of meeting “target” | MOD-V HIGH | MOD - HIGH | MOD-HIGH | MOD-HIGH | MOD- V HIGH |
| Mean Size | | MOD | | MOD | |

| | | | | | |
|---|---|---|---|---|---|
| Recruit. Surveys | LOW-HIGH | MOD | MOD | | LOW-MOD |
| **MANAGEMENT RESPONSES**<br>(Effectiveness of tools) | | | | | |
| Size Limits | MOD-HIGH | MOD | MOD-HIGH | MOD-HIGH | LOW |
| Reproductive | MOD | N/A | MOD | MOD | LOW |
| Closures | LOW | LOW-MOD | LOW-MOD | LOW-MOD | MOD-HIGH |
| Effort | MOD-HIGH | LOW | LOW-MOD | MOD | MOD |
| Output | MOD-HIGH | MOD | MOD | MOD-HIGH | |
| Monitoring | | | | | |
| **ECOSYSTEM** | | | | | |
| Impacts on Prey | LOW-MOD | LOW-MOD | MOD | LOW | LOW |
| Impacts on Predators | LOW | LOW | LOW-MOD | LOW | LOW |

## Rock Lobsters (Temperate)

**(*Panulirus*, *Jasus*)**

## 1.0 General Characteristics

### *1.1 Biology*

Temperate lobsters are a moderately fast growing group, with most reaching spawning age and exploitation size by 4-5 years but with potential longevities in excess of 20 years. They are highly fecund with a long planktonic larval stage (approximately 12 months) usually with broad dispersal. Whilst individuals of many species undergo size/age related migrations there is often limited mixing amongst regions. They do not form spawning aggregations. The most common method of capture is by baited pots/traps positioned close to reefs or other structures. There is only a low risk of hyperstability in catch rates.

### *1.2 Vulnerability to Fishing – Low – Moderate*

The biology and behaviour of lobsters makes them low to moderately vulnerable to fishing. Successful long-term management has been recorded for many fisheries. The stock declines that have occurred in some lobster fisheries have followed extended periods of high exploitation. These can, however, recover in a relatively short (< 10 years) period once corrective actions are implemented. There is evidence that recruitment levels are maintained even following significant reductions in spawning biomass. Further, whilst the level of recruitment often varies annually, associated with environmental conditions, there is generally some recruitment in most years.

## 2.0 Objectives

The objectives for this group have mostly been related to maintaining the abundance of the breeding stocks, to ensure there is sufficient recruitment to replenish that taken by fishing, predation and other environmental factors. This is achieved by maintaining the spawning stock at or above a level that minimises the risk of recruitment overfishing.

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc. above which recruitment overfishing is unlikely to occur*

10-22% of unfished levels of egg production

For the Western Rock Lobster (WRL – *Panulirus cygnus*), acceptable performance requires egg production to be maintained at or above 22% of the unfished level. This level was generated from extensive analyses of spawning stock and recruitment data by Hall & Chubb (2001) using experiences of the dynamics of the stock at varying levels of $B_0$ over the past 40 years. *(This level has been accepted for the EPBC assessment and by MSC)*.

For the Tasmanian lobster fishery (TLF), the long-term goal for this fishery (ie. the target reference point) is to rebuild stocks of the southern rock lobster (*Jasus edwardsii*) to above 15% of the unfished levels (Ford, 2001- no explicit justification for choosing this level was provided). The interim performance levels state that the estimates of state-wide egg production must be no less than 95% of the previous year or an estimate of egg production in each region must be not be less than 85% of the reference year. If, however, the estimated level of egg production across all assessment areas (1-8) is less than 10% of virgin stock (ie. the limit reference point) then no further reduction is acceptable (Ford, 2001). (*This set of limits was accepted for the EPBC assessment)***.**

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

The spawning biomass of the WRL declined to approximately 15% unfished levels and was in this range for about 10 years with no real signs that this had caused adverse impacts on recruitment levels (Walters et al., 1993)

For *J. edwardsii* the Australian stock is considered to be well below 20%. The levels of the Tasmanian rock lobster stocks were estimated to have been reduced to below 10% unfished levels in some regions, whilst in Victoria, egg production is thought to vary between 6-19% and 10-20% in SA. There has been no evidence that recruitment of juveniles has been affected by these declines (Phillips & Kittaka, 2000).

#### *3.1.3 Maximum Exploitation Rate*

The WRL is considered fully exploited with an exploitation rate over the entire life after recruitment (at about age 4) of 85% and an annual exploitation of at least 60% for legal sized animals (Phillips and Brown, 1989; Chubb, et al. 2003).

### *3. 2 Economic Reference Points*

#### *3.2.1 MSY and MEY*

Hall and Brown (1995) used Schaefer techniques, production models and delay difference models to produce an estimate of MEY for the WRL. The production of MEY estimate compares well with the current long-term average catch of 10.8 million kg.

## 4.0 **Indicator Assessment** (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

**Low – Moderate**

For pot based lobster fisheries, annual catch may provide a reasonable indication of relative abundance if the levels of effort and areas of operation are relatively consistent amongst years. Such an indicator (probably used within an 'acceptable catch' range) should only be used in conjunction with a relatively precautionary management regime – ie. low risk exploitation rate. It is also used to compare with predicted values if these are available.

*Issues –*

- Can it be shown that effort does not vary greatly?
- Are the environmental conditions remaining relatively static?

*Examples of use* – Southern Zone Rock Lobster (WA) under review for an EPBC assessment

### *4.2 Fishery Dependent Catch Rates*

**Moderate**

Fishery dependent catch rate data may be acceptable as an indicator of abundance if the distribution of fishing effort and the technology used (ie. fishing power) are relatively consistent. This acceptability needs to be restricted to defined intervals with periodic determination of any changes to catchability coefficients etc. These types of indicators could then be associated with moderate levels of exploitation risk. The robustness would increase as the level of detail of the data provided increases. Thus, data that allows estimates of egg production rather than mere abundance should be more reliable.

These indices may be of less value in quota based fisheries unless there is a high level of compliance to ensure accurate information is provided due to the increased incentive to submit false returns. Moreover, quotas may affect fisher behaviour which, in turn, can impact catch rates irrespective of compliance issues. Finally, if there are large variations in price between seasons and or sizes, this could affect when and where fishers take their quota and therefore the catch rate obtained. Thus, catch rates are likely to be a less robust indicator of abundance in a quota-based fishery.

In NSW, a review of management practices will be triggered when the annual catch per unit effort is below 1998-99 levels in 2 consecutive years.

*Issues –*

- changes in fishing power/efficiency,
- changes (expansion/contraction) in fishing area,

- impacts of any quotas etc on fisher behaviour/data accuracy.
- Level of compliance
- Accuracy of returns

*Examples* – WRL (one input to model), Tasmania (one input to model ), NSW (main input to model)

### *4.3 Fishery Independent Surveys*

**Moderate – High**

Assuming an appropriate design, these surveys can provide a robust indication of relative abundance/egg production of lobsters. Whilst, pot based fisheries are relatively amenable to this form of surveying there are still problems associated with short term environmentally induced changes to the lobster's catchability, which would need to be calibrated into analyses. Such independent data are likely to be needed for situations where the stock is being managed in an aggressive manner – ie. relatively high exploitation rate or where quotas are introduced.

*Issues* –

- survey design
- impacts of environmental conditions

*Examples* – WRL (one input to model), Tasmania (one input to model), NSW (developing)

### *4.4 Estimates of Current Abundance (model based and composite)*

**Mod – V High**

A combination of indicators can be used to assess performance to provide assurance that any changes will not be missed or significantly distorted due to alterations to fishing practices. This would, in most cases, be one of the most robust methods of monitoring performance and should be needed for fisheries with relatively high rates of exploitation. Furthermore, this integration usually occurs within a simulation modelling framework sometimes associated with management strategy evaluation (see below). Such models provide the advantage of incorporating additional information (e.g. size frequency) that is more informative than catch rates.

The level of robustness would vary according to the confidence about the information used within the model.

*Issues* –

- validity of data inputs/assumptions

The methods to ascribe relative weight to the indicators used must be determined to avoid difficulties if any one indicator suggests unacceptable performance

*Examples* – WRL , Tasmania, NSW, SA

**The use of composite indicators within a model framework was accepted by EA for both the WRL and Tasmanian rock lobster fisheries**

### *4.5 Probability of Management Meeting the "Target" in Future*

None in use.

### *4.6 Other – recruitment indices*

**Low – High**

A number of lobster fisheries have been using both puerulus and juvenile indices to predict future catches (eg WRL, NZ, Tas). Where possible, such data can provide highly robust indicators of what future recruitment levels will enter the fishery (1 – 4 years in advance) and alert management well before any problems surface. They may greatly increase the levels of confidence in exploitation rates that can be assigned.

*Issues –*

- the accuracy of predictions generated
- the length of time for which data are available

*Examples* – WRL, Tasmania, NZ.

## 5.0 **Management Responses** (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Moderate – High**

Lobsters are amenable to size based limits; both minimum and maximum sizes have been used successfully. Whilst the lobsters survive capture relatively well, size limits are best used in combination with escape gaps and neck size restrictions to minimise handling of unwanted sized animals. The minimum sizes chosen for some species are not always above the size of sexual maturity because of the price differentials, but exploitation must be such that sufficient numbers do survive to maintain appropriate levels of egg production (see 2.1 above).

*Issues –*

- Prices of lobsters vary with size with smaller individuals often generating relatively high prices

*Examples* – All lobster fisheries have minimum sizes, some (e.g. NSW, WRL) also have maximum sizes.

### *5.2 Biological (reproductive stages)*

**Moderate**

The reproductive stages of lobsters are easily identified and restrictions on the capture of various stages are common. Berried lobsters are banned from being landed in all fisheries. Other reproductive stages, such as setose and tar spot, are banned in some locations (WRL) to provide extra protection to the breeding stock.

### *5.3 Seasonal/Temporal Closures*

**Low – Moderate**

Seasonal closures around spawning season are used in some locations to minimise disruption to breeding and assist in maintaining sufficient egg production. Having a defined lobster season can also be used to constrain total effort.

### *5.4 Area/Spatial Closures*

**Low**

The use of area closures as a main element of management is not common for lobster fisheries due to their biological characteristics that often involve a substantial size/age dependent migratory phase (eg WRL, NSW).

### *5.5 Effort Limitation*

**Moderate – High**

This is a common form of management for lobster fisheries because the potting/trap method of capture can be controlled relatively effectively. This is achieved by limiting the number of pots allowed to be used, the numbers of fishing units, the days fished (plus closed seasons) or a combination of these designed to constrain the effective effort within a target level and therefore the exploitation rate.

*Issues –*

- Such systems require the level of latent effort to be minimised such that if the days fished/pot numbers are adjusted this has a real impact on effective effort (ie. can it be demonstrated that effort is really being constrained by management?).
- The total allowable level of effort usually needs adjustment at regular intervals because fishing power often increases with technological advances. (ie. Is the fishing power of fleet being examined at suitable intervals?)
- Can the level of effort be managed and enforced?

### *5.6 Output Controls*

**Moderate – High**

A number of lobster fisheries use TACCs and individual quotas to manage the level of exploitation. These are often used in combination with the retention of a number of input controls and have most commonly been implemented when the stock had already been overfished.

*Issues –*

- How much confidence is there that the TACC correct? There can be a higher risk to the stock of getting the TACC wrong if effort controls are largely removed.
- If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch. *(ie. are the variations in recruitment built into the determination of the annual quota either by having recruitment indices varying the annual TAC; alternatively, is the TAC at the lower end of the range?).*
- Compliance for quota fisheries is often harder due to the relative ease of hiding individuals and the greater incentive to provide misleading information. *(ie is the level of compliance sufficient to ensure that the level of illegal catches is minimal or incorporated into the assessment?)*
- The data obtained from fishery dependent sources may be compromised by altered fisher behaviour following the introduction of quotas, fishery independent sources may be needed.

### *5.7 Monitoring Frequency and Feedback Loops*

Given the dynamics of lobsters, which have a reasonable degree of variation in recruitment levels, some annual assessment would be required. However, in cases where the stocks are not close to limits and which operate on effort based systems, the level of assessment completed may not require the use and full calculation of complicated models. These may only be necessary every 2 – 5 years to reassess management arrangements.

For quota-based systems, the recalculation of the quota is likely to require annual assessments.

## 6.0 Ecosystem issues

### *6.1 Impacts on prey and community structure*

**Likely Risk Rating (LOW –MODERATE)**

Rock lobsters are generalist feeders, known to consume a diverse range of benthic plant and animal material (Lipcius & Eggleston, 2000).

There are a few examples where indirect impacts on community structure may have occurred, followed the overfishing of lobsters. These have all been related to interactions between the lobsters with sea urchins and algal communities.

In Canada, Breen & Mann (1976); Mann (1977, 1982) suggested that the "barren grounds" present off Nova Scotia were due to a lack of predation by the lobsters on the sea urchin *Strongylocentrotus droebachiensis,* caused from the overfishing of lobsters in this region. However, subsequent studies suggested that the lobsters could not have controlled the abundance of sea urchins and the increases and declines in urchins were due to variations in recruitment and disease levels respectively (Miller, 1985, Jennings & Kaiser, 1998).

In New Zealand, the abundance of *Jasus edwardsii* and the local sea urchin (*Evechinus chloroticus* – which is capable of forming barren grounds - Ayling, 1981) in a marine reserve at Goat Island near Leigh (north-eastern New Zealand) showed no clear pattern of change despite a striking increase in the number of rock lobsters within the reserve (Cole *et al*. 1990). But more recent evidence suggests that there may be some quantifiable effect (Shears & Babcock, 2002).

In South Africa, in regions where lobsters were absent or in low densities, there were dense mussel beds, sea urchins, sea cucumbers and many whelks but little macroalgae. In contrast, areas with lobsters had a dense flora of seaweeds but very few other benthic organisms (Barkai and Branch 1988, Barkai 1986, Barkai and Barkai 1985).

There is no evidence in Australia of any major community level changes following reductions in the abundance of either *Jasus* or *Panulirus.* However, none of these areas have been "overfished".

In a recent Tasmanian study (Edgar and Barrett 1999) individual abalone inside reserves were larger but less abundant than in similar habitats outside the reserve, which could be due to increased large lobsters in these areas (Barrett, in press).

*Issues –*

- Are lobsters <u>the major</u> predator of a species (or group of species) that play a significant role in the structure of a community in an area where the fishery operates (e.g. sea urchins, mussels)?

### 6.2 Impact on Predators

**Likely Risk Rating (LOW)**

Lobsters are prey to a series of larger predators including various finfish, sharks and octopus (Lipcius & Eggleston, 2000). There are no documented examples or even suggestions of significant impacts on predator species from the reduction in lobster numbers.

*Issue –*

- Is/are there predator(s) that specialise in only eating the lobsters?

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# Abalone

## 1.0 General Charactersitics

### *1.1 Biology*

Abalone are primitive gastropods that live on rocky reefs in shallow marine waters. They are herbivorous with a large muscular foot used to attach to the substrate and they feed by either scraping algae from the reefs or by capturing drift algae. Sexes are separate with no sexual dimorphism. Whilst they are broadcast spawners with pelagic eggs, dispersal of larvae is thought to be very limited for some species with the potential to form small isolated populations. For most species, sexual maturity is generally reached after 3 years and they can live well in excess of 20 years (Nash, 1992), but the age and size can vary amongst sites depending upon local conditions.

The only method of commercial capture is by hand gathering, usually assisted by scuba/ hookah diving, and they are prone to serial depletions of the sub-stocks and therefore, hyperstability in catch rates.

### *1.2 Vulnerability to Fishing Highly Vulnerable.*

Abalone are highly vulnerable to fishing activities, particularly given the often high levels of illegal fishing that occurs. Whilst successful management has been recorded in some fisheries (mostly in Australia), many abalone fisheries around the world have been over exploited and in one case (California) this has lead to virtual extinction. Recruitment levels in areas where adults are located still tend to be relatively erratic amongst years for some species (e.g. Shepherd, 1990). Moreover, some stocks do not recover quickly after depletion due to the limited dispersion of larvae (eg Prince et al., 1987) and, for some species, the apparent changes in habitat (and settlement cues) that occur when adults are no longer present. Finally, some stocks have been prone to unpredictable collapse from disease events (e.g. areas of NSW)

## 2.0 Objectives

Most of the objectives relate to ensuring that the spawning stock levels in each area are sufficient to continue recruitment at levels that will replenish what is taken by fishing, predation and other environmental factors by maintaining the spawning stock of abalone at or above a level that minimises the risk of recruitment overfishing and serial depletion.

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality/Exploitation Rate etc above which recruitment overfishing is unlikely to occur*

40% of unfished levels of egg production

The current management for the Tasmanian abalone (Black Lip) provides for a limit reference point of 40% of the unfished egg production level (DPIWE, 2001). The fishery is ‘reviewed’ at a fine resolution each year (block by block) prior to the TAC being set *(this was accepted as part of their EPBC assessment).*

Due to the uncertainties and large confidence limits around the estimates of absolute depletion, NSW and Victoria use reference limits based on relative values against a reference year. Consequently, the objectives for the NSW Black Lip Abalone fishery, based upon the assessments completed by Worthington et al (1998 etc), is a limit reference point of 85% of the 1994 levels of legal and mature biomass. Using the model outputs, the estimate of the 1994 level for mature biomass was about 55% of unfished levels which results in this limit equating to about 42% of unfished levels. The 1994 year was chosen because the abundance of abalone in that year was relatively high.

Similarly for Victoria, the performance limit for Black Lip is mature biomass (or egg numbers) must be 90% of value estimated for 1992 with 30% risk (lower limit). Stocks that retain less than this level are assumed to provide insufficient recruitment to sustain their populations. The 1992 reference year was selected as the trigger because this was the first year during which fishery independent estimates of abundance were available. Moreover, there had been no evidence of general recruitment failures in the preceding years so this biomass level is probably above the level where recruitment overfishing would have occurred (*this was accepted as part of their EPBC assessment)*.

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

The recruitment levels for abalone species in each of the Australian fisheries do not appear to have been adversely affected by stock size, except at local scales. Hence, the current stock levels and therefore, limit reference points, appear to be above the level where this is an important factor.

### *3.2 Economic Reference Points*

#### *3.2.1 MSY/ MEY*

Estimating the productivity of abalone stocks is problematic and Tasmania have not proceeded to attempt this (DPIWE, 2001).

NSW seeks to maintain or increase the legal sized biomass (< 115mm shell length) from the 1994 level as the target for their fishery (Worthington et al, 1997).

Victoria uses a maximum constant yield policy based on a target of 110% of the Bmsy value estimated with 30% risk.

## 4.0 Indicator Assessment (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

**Very Low**

As many abalone fisheries are managed using quotas, catch will usually be a relatively poor indicator of relative abundance. Furthermore, the spatial area in which the catch can be obtained needs to be relatively small for this indicator to provide information on abundance. In general, the use of catch as an indicator will only occur in situations where the quota is not obtained, by which time significant declines may have already occurred.

*Issues –*

- Have there been any changes in effort?
- Are the specific areas where the catch is being taken changing through time – serial depletion?

### *4.2 Effort*

**Low**

Given that quotas are used to limit catches, in some locations the level of effort used to take the quota is used as an indicator of abundance. In WA, an acceptable range of effort (in terms of diver days) is used to determine if the management of the stocks is operating at an acceptable level or not.

*Examples* – WA

### *4.3 Fishery Dependent Catch Rates*

**Low – Moderate**

Despite being commonly used as an index of stock abundance, catch rates (CPUE) must be used with caution for abalone fisheries. In general, the CPUE needs to be used in conjunction with a spatial assessment of any changes in the relative level of catch being taken from areas and the spatial distribution of effort within these areas. Individual areas that produce a large catch are of greater concern, along with areas where the level of catch is significantly different to previous years (DPIWE, 2001).

The major concern with using catch rates is that for larger areas, serial depletion may be occurring whilst the catch rates remain unchanged.

In NSW, a GLM analysis is used to standardised catch rates to allow for changes in the skills/experience of the fishers involved in the fishery (Worthington et al., 1998).

*Issues –*

- The degree of spatial precision of data supplied by fishers, is it a fine enough scale to detect changes such that serial depletion will not be a significant problem?
- Are there changes in the methods of operation or individuals that may affect catch rates either positively or negatively?

*Examples* – NSW Tasmania Vic WA

### *4.4 Fishery Independent Surveys*

**Moderate – High**

A range of fishery independent methods have been attempted to monitor the relative abundance of abalone because several features of the biology and ecology of abalone make the analysis of these data difficult to interpret (Worthington et al., 1998). These problems include the high levels of aggregation, the cryptic nature of juveniles, the crevice areas they inhabit and the differing search efficiencies of divers. The sampling design needs to be sufficiently robust in order to minimize these problems.

*Issues* –

- Is the number of transects/areas sampled in the program sufficient?
- Are they representative?
- Are these areas known to the fishers and will they be avoided/targeted?

*Examples* – NSW, Vic

### *4.5 Mean Size/Weight*

**Low – Moderate**

The average weight or size of abalone caught by the fishery is used as a surrogate indicator of the age of catch. If the average size of individuals increases or decreases this should correspond to more older or younger individuals, respectively, composing the catch. A decline in average weight size (in the absence of an increase in catch rate) would indicate that the exploitation rate was too high and was causing a decline in the stock abundance, or (if combined with an increase in catch rate) it can indicate a relatively large pulse of recruits entering the fishery.

*Issues* –

Whether the size changes/stability relate to moving areas, fishing stunted populations etc. Impacts of reduced densities on growth rates.

*Examples* – NSW, Tasmania, WA.

### *4.6 Estimates of Current Abundance (model based and composite)*

**Moderate – High**

Mathematical models are now commonly used to incorporate the information on size structure and catch rates (either fishery dependent &/or independent) within each spatial unit of an abalone fishery to provide a more robust assessment of their status. The main benefits of these models (size or age-based) are that they can integrate several sources of information to produce a probabilistic assessment of the stock. Size based models are the most common form because of limited ability to age most abalone populations. These models have been used to generate estimates of the current level of exploitable and spawning biomass, either compared with some reference year or to the unexploited state.

These models still generally use catch rates as the basis for the assessments and therefore, many of these issues still remain.

*Issues* –

- Validity of data inputs/assumptions,?

*Examples* – NSW, Vic, Tasmania.

### *4.7 Probability of Management Meeting the "Target" in Future*

In NSW, the triggers for review of Blacklip abalone are: a) the biomass of mature or legal sized abalone in an area in which a total allowable catch has been applied and falls below the 1994 benchmark by more than 15%; b) there is more than 50% chance of a) occurring in the next 5 years if the total allowable catch is unchanged.

In Victoria, the annual TAC for Blacklip abalone is set at a level that will allow the current mature biomass to stabilise at 110% of the biomass required to support maximum constant yield. A confidence probability of 70% is specified for this performance indicator.

# 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

## *5.1 Biological (size limits)*

**Moderate**

The management arrangements for most abalone stocks include having a size limit on the individuals that can be collected by the fishery. In general, these size limits are set to allow each abalone at least one year post-sexual maturity before they become vulnerable to the fishery.

*Issues* –

- Variable growth rates leading to stunted stocks that never reach legal size or fast growing stocks that reach legal size before they become sexually mature
- Level of compliance with this regulation (e.g. blackmarket may not comply)
- Ability to replace undersized individuals back on substrate correctly/successfully

*Examples* – All Australian stocks

## *5.2 Biological (reproductive stages)*

N/A

Spawning abalone are not normally directly discernable without a biopsy technique, which is not possible under field conditions by commercial or recreational divers.

## *5.3 Seasonal/Temporal Closures*

**Low**

This is not generally done in a formal way but some fisheries (e.g. NSW) use informal arrangements to avoid fishing in areas where spawning individuals have been seen. This is usually done because of the poor marketability of these individuals.

## *5.4 Area/Spatial Closures*

**Low – Moderate**

Given the recruitment dynamics (limited dispersal) of these species, spatial closures are not used for general management of the fishery but to assist specific regions. In particular, spatial closures are often used to rehabilitate areas that have been depleted. For example, NSW has used spatial closures in areas where the population has been severely depleted by the disease Perkinsus over the last 10 years, with informal closure from Port Stephens to Jervis Bay.

## *5.5 Effort Limitation*

**Low**

Whilst many managers of abalone fisheries initially attempted to manage stocks through the imposition of limited entry methods, most have found that simply restricting access was insufficient to stop declines in stock numbers (although this is still used to limit the total number of commercial divers for compliance reasons). This is because the efficiency of the divers to target abalone was such that it was not effective at the levels used. One example where it appears to operate relatively effectively is the Perth recreational abalone fishery where the fishery only opens for six 1.5 hour periods each year and no SCUBA is allowed but there are also output controls (e.g. bag and possession limits).

### *5.6 Output Controls*

**Moderate**

Most abalone fisheries have some total limit on catch as part of their management arrangements. For the commercial fishery, this usually relates to there being an individual quota related to an overall TACC and for recreational fisheries there are usually relatively small bag limits and possession limits. This quota is often split across various zones to control the take in these areas.

*Issues –*

- Is the TACC correct?
- If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch *(ie. Are the variations in recruitment built into the determination of the annual quota either by having recruitment indices varying the annual TAC; or is the TAC is at the lower end of the range?).*
- Compliance for quota fisheries is often hard due to the relative ease of hiding individuals and the greater incentive to provide misleading information *(i.e. is the level of compliance sufficient to ensure that the level of illegal catches are minimal or factored into the assessments?).*
- The data obtained from fishery dependent sources may not be sufficiently accurate/ appropriate for use in monitoring and fishery independent sources may be needed.

### *5.7 Monitoring Frequency and Feedback Loops*

Given that most abalone fisheries are quota based, they may need some level of monitoring on an annual basis. For some sections within a fishery, monitoring may need to be more frequent with within season reviews of catches and catch rates. For other sections, where the level of effort is low, less frequent monitoring may be required.

## 6.0 Ecosystem issues

### *6.1 Impacts on prey and community structure*

**(Likely Risk Rating LOW)**

Depending upon location and species involved, there may be some broader ecosystem issues associated with the removal of large numbers of abalone from an individual area. In most areas however, the risk to the broader ecosystem is likely to be LOW especially for the abalone species that are mainly drift algal feeders.

In some abalone fisheries (e.g. NSW), there are anecdotal reports of a negative association between abalone, urchins and barren grounds. The reduction in numbers of their natural competitor, abalone, has been associated with an increase in urchin numbers, in turn resulting in the creation of urchin barren areas (Andrew et al, 1998) but experiments to test this were not able to demonstrate any impacts within the timescale available (Worthington et al., 1999).

In some locations in the world, a reduction in abalone has been associated with an increase in algal cover, which has effectively altered the community structure of the abalone habitat. However, experimental studies on the impacts of grazers on the algal composition off the west coast of WA found that limpets and chitons had a much greater role in determining algal composition than the presence/absence of Roe's abalone (Schiebling, 1994).

In a recent Tasmanian study (Edgar and Barrett 1999), which assessed abalone abundance inside and outside of reserves, individual abalone inside the reserves were larger but less abundant than in similar habitats outside the reserve. This may be due to increased large lobsters in these areas (Barrett, in press).

*Issues –*

- Is the removal of abalone likely to cause a major change to the ecosystem/community structure?

### *6.2 Impact on Predators*

**(Likely Risk Rating LOW)**

The impact of taking abalone on the food source of abalone predators has been considered 'minor'. The total tonnage that is removed by any fishery is relatively small compared to other fisheries (usually only a few hundred tonnes). In general, there are no predators that exclusively feed on abalone, and hence, would be vulnerable to a reduction from the harvesting of abalone, but there are few studies that have investigated this directly.

*Issues –*

- Is the removal of abalone likely to cause a severe impact on one or more predators?

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## Crabs (Shallow)

**(Blue swimmer crabs, mud crabs, spanner crabs)**

## 1.0 General Characteristics

### *1.1 Biology*

**Blue swimmer crabs** – are normally found in sandy substrates in temperate to sub tropical regions but can be associated with sea grass and estuarine habitats. They mature at 8 months of age at approximately 90–100 mm and live for approximately 2-3 years. They are highly fecund with a month long planktonic larval phase with moderate dispersal rates, depending upon the local oceanography. Spawning tends to be year round in the tropics and seasonal (during summer) in temperate zones. They are sexually dimorphic, do not form spawning aggregations and females migrate out to sea to spawn. Blue swimmer crabs will display very localised territorial behaviour (e.g. will show aggression towards other crabs in the same pot). Capture method is principally potting but with some trawl based fisheries.

**Mud crabs** – Mud crabs prefer mangrove and other muddy substrates within estuaries. Growth rates vary with respect to latitude and they live for up to 3 years. Mud crabs reach sexual maturity in the tropics at about 18 months and after about 2 years in the warm temperate regions. They are sexually dimorphic and highly fecund with a month long planktonic phase. The females migrate up to 50km offshore to spawn with the larvae returning to shore via ocean currents. The species is non-aggregating (they can be cannibalistic). There is little mixing of sub-adult and adult populations between adjacent inshore habitats, however, the stocks may show a high degree of genetic mixing as a consequence of their offshore spawning and having planktonic larvae. The capture method is potting.

**Spanner crabs** – Spanner crabs prefer bare sandy areas in tropical to sub-tropical areas. They mature at approximately 2 years and live for 7 to 9 years with growth being faster in the tropics. In the tropics, they breed all year round but in cooler areas they only spawn over the late summer months. Their stock structure is unknown.

Spawning and feeding aggregations may be formed which are targeted by fishers and captured in baited tangle nets. Therefore, catch rates may show signs of hyperstability.

### *1.2 Vulnerability to Fishing*

Blue swimmer crab – **Low**

Successful long-term management has been achieved for most blue swimmer crab fisheries. There have been no recorded stock crashes, in part due to their high fecundity, fast growth rate and non-aggregating behaviour. Recruitment tends to vary depending on environmental conditions.

Mud crab – **Low**

There have been no recorded stock crashes for mud crab fisheries. The species is highly fecund, has a fast growth rate, does not aggregate and the females migrate to areas offshore outside the fishery where they are not caught. Recruitment is relatively consistent among years.

Spanner crab – **Medium**.

Spanner crabs are a more susceptible to overfishing than the other shallow crab species. They are slower growing and they have a tendency to aggregate which affects interpretation of catch rates. There has been at least one instance where there has been concern over stocks

## 2.0 Objectives

The objectives for these species usually relates to abundance or catch with the intent to ensure that there is not recruitment overfishing. In some circumstances where the exploited stocks add little to the recruitment potential due to their locations, the objectives may be more about maintaining a viable fishery.

### *3.1 Performance Measures (Limit Reference Points)*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

Not available

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

While there is no specific level, it is assumed from studies on other crab species (e.g. Zheng & Kruse, 1998) that recruitment for these species are likely to be largely environmentally driven and that good recruitment can come from relatively low stock levels.

#### *3.1.3 Maximum Exploitation Rate/Catch*

High annual exploitation rates of >70% of exploitable biomass are common for these types of species (Knuckey, 1999; Ramm 1997, Walters, cited in C-Aid, 2001).

### *3.2 Performance Measures (Target Reference Points)*

#### *3.2.1 MSY/MEY*

Yield per recruit has been calculated for spanner crabs in QLD.

## 4.0 Indicator Assessment (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

**Low – Moderate**

The annual commercial catch is used as one of the main reference points for the NT mud crab fishery. This is used given a good understanding of the dynamics of the fishers and their patterns of fishing behaviour.

Catch alone does not provide a good indication of relative population size for spanner crabs given that they are an aggregating species.

*Examples* – NT Mud Crabs *(this was accepted as part of this EPBC assessment)*

### 4.2 Fishery Dependent Catch Rates

**Low – Medium**

Catch rates can provide a useful relative measure of abundance for blue swimmer crabs because of their relatively dispersed distributions. They are less useful for spanner crabs and mud crabs. Thus, catch rates are no longer used to monitor stocks of mud crabs in NT because they are affected by the fishers habits of moving their areas of operations on a daily basis to maintain catch rates. Also the vulnerability of mud crabs is not uniform. It is affected by size, aggression levels and moult stage which also reduces the robustness of using CPUE values for determining abundance (NT).

Until the development of the Habitat Alias techniques (see below), the Qld mud crab fishery will continue to be monitored using fishery dependent total catch estimates, and regional catch rates (*currently being assessed for the EPBC assessment*)**.**

Catch rates are used in monitoring the spanner crab fishery in Qld (Brown et al, 2001), the 5 year average change in the CPUE within each of five assessment regions are used separately and pooled (excluding the region with the best response) for use within a set of decision rules. These decision rules raise or lower the quota depending upon the changes in the pooled CPUE analyses (see Brown et al, 1999 for full details). (*This was accepted as part of the EPBC Assessment*)

*Issues* –

- Accurate catch rates depend on the reliability of effort information. In the event of increasing catch efficiency, inaccurate effort information or other mitigating circumstances, catch rate data can be misleading.
- The behaviour of the fishers to serially deplete regions may lead to catch rates being maintained.

*Examples* – Qld Spanner Crabs, Blue swimmer crabs in Western Australia

### 4.3 Fishery Independent Surveys

**Low – High**

Whilst NSW has completed a number of fishery independent surveys for spanner crabs (eg Kennelly & Scandol, 1999), Dichmont (1999) found that the catchability function for spanner crabs could not be determined from depletion experiments, which makes the analysis of catch rates (even those from fishery independent surveys) somewhat problematic for this species.

NT is proposing to use a combination of habitat mapping with fishery independent density estimates to generate an overall stock assessment for their mud crab fishery.

Similary, Qld has begun a Long Term Monitoring Program (LTMP) within selected estuary systems, which surveys mud crab populations annually. These data are yet to be included in assessments (see 4.7 below).

*Issues –*

- Hyperstability of catch rates even for fishery independent surveys.

Examples – Spanner crabs in NSW, Qld.

### 4.4 Estimates of Current Abundance (model based and composite)

**Low – Moderate**

Kennelly & Scandol (1999) developed a biomass dynamics model for spanner crabs off NSW. This is not used for annual assessments of the stock.

Knuckey (1999) developed a biomass dynamics model for mud crabs in NT but these estimates suffer from problems associated with the catch rate data and the non-continuous growth pattern (Ramm, 1997). Consequently, the NT mud crab fishery uses a combination of the annual commercial catch, annual levels of effort levels and median carapace widths of the catch to monitor these stocks (This was accepted as part of the EPBC assessment).

*Issues –*

- Crabs can be difficult to age
- To enhance the applicability of length based models to crustaceans the assumption of a one-to-one relationship of length-at-age should be relaxed (Zheng et al 1995).

### 4.5 Probability of Management Meeting the "Target" in Future

None currently used.

### 4.6 Other – Size (Carapace Width)

**Low**

NT mud crab fishery uses the trend in median carapace width as a trigger point. This is monitored to assess how close the population is being fished compared to the minimum size. This is used as one of a combination of indicators

### 4.7 Habitat Alias Stock Assessment

**Moderate – High**

Because of the problems associated with the use of traditional stock assessment methods, Walters, in Ramm (1997) suggested that a 'habitat–alias method be used to estimate stock size of mud crabs.

The logic is that – Stock Size = total habitat area x number of mud crabs per unit habitat area.

These systems are yet to be fully developed and tested. The project is due for completion in 2004. It is expected that these will replace the fishery dependent catch rate assessments currently used in the NT to monitor the fishery and will be also be evaluated for application in Queensland .

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species group)

### *5.1 Biological (size limits)*

**Moderate – High**

Crabs are particularly amenable to using size-based management arrangements because they generally survive capture and release. Whilst the specific size limits for a species can vary between states and within states (e.g. blue swimmer) they need to be based on some relationship with the size at maturity. Usually size limits are set to allow one or more years of spawning prior to the individuals being vulnerable to the fishery.

*Issues* –

- The specific rate of mortality for discarded undersized animals may not be known particularly those caught in tangle nets where limbs may be lost (eg spanner crab - Brown et al. 1999).
- Large differences in size at maturity for males and females possibly needing separate limits

*Examples* – Blue swimmer, Mud Crabs, Spanner Crabs (all locations).

### *5.2 Biological (reproductive stages)*

**Moderate**

The reproductive stages of crabs are easily identified and restrictions on the capture of females are a common tool. Moreover, bans on the capture of berried crabs are almost universal. For Qld, there is a total ban on the capture of female mud and blue swimmer crabs.

*Issues* –

- Ensuring that there are sufficient males to allow mating success for all available females.

### *5.3 Seasonal/Temporal Closures*

**Low – Medium**

Crab fisheries can be amenable to seasonal closures where there is a distinct breeding season/aggregation. The blue swimmer fishery at Cockburn Sound (WA) is closed for the October and November breeding season to prevent damage to the breeding females. Similarly, there is a spawning season closure for the spanner crab fishery in Qld from 20 November 20 December annually.

### *5.4 Area/Spatial Closures*

**Low**

Area/spatial closures are not often used in crab fisheries management. There is no distinct breeding/nursery area for most species. Area closures are, however, used as a mechanism of catch sharing amongst sectors. Thus, there are only a few NT rivers that are open to commercial harvesting, the others are recreational only.

### 5.5 Effort Limitation

**Moderate**

Crab fisheries are often managed by limits to the overall number of boats licensed to fish for a particular species and/or the total number of pots/traps allowed to be used. In situations where catch rates provide good estimates of abundance, limiting effort can be effective. For species that have large variations in annual recruitment (e.g. blue swimmer crabs), using effort limitations provides for relatively stable rates of exploitation, where catches track the changes in relative abundance.

There is a limited entry scheme in place for NT and WA mud crab fishers and WA blue swimmer crab fishers.

*Issues –*

- Latent effort
- Effort creep

### 5.6 Output Controls

**Moderate**

Some crab fisheries use TACCs and individual quotas to manage the level of exploitation (Qld Spanner Crab Fishery). These are often used in combination with the retention of a number of input controls and most commonly implemented at points where the stock had already been overfished.

*Issues –*

- If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch. Is there a reliable stock assessment model able to predict population dynamics?
- Is the TACC correct? There can be a higher risk to the stock of getting the TACC wrong if effort controls are removed. How regularly is the TACC reviewed?
- Compliance for quota fisheries is often harder due to the relative ease of hiding individuals and the greater incentive to provide misleading information. (i.e. Is the level of compliance sufficient to ensure that the level of illegal catches are minimal?)
- The data obtained from fishery dependent sources may not be sufficiently accurate/ appropriate for use in monitoring and fishery independent sources may be needed.
- Since quota management places a premium on efficiency, is it likely to foster regional serial depletions in high catch areas?

### 5.7 Monitoring Frequency and Feedback Loops

The fisheries with quotas need to be assessed and management reviewed on an annual basis. For those with effort based controls where these are expected to work effectively, complete reviews of management many not be needed annually unless there are signs that this is warranted.

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

**(Likely Risk Rating- LOW)**

Most crabs are bottom-feeding carnivores and scavengers. Their diet chiefly consists of a variety of sessile and slow moving invertebrates, including bivalve molluscs, crustaceans, polychaete worms and brittle stars and algae. As the commercial take of crabs generally represents a relatively small portion of the biomass, which is effectively renewed annually, secondary food chain effects are likely to be minimal in these fisheries.

Whilst there is currently little information on their role in ecosystems, there are no studies that have suggested that they play a keystone role.

### *6.2 Impact on Predators*

**(Likely Risk Rating – LOW)**

Crabs are prey to turtles, sharks, rays and large fish (Kailola et al 1993). There are no known examples where predators of crabs have been affected by exploitation of crab populations.

*Issues –*

- Is there a predator that specialises in eating the crabs?

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# Crabs (Deep)

**Snow crab; Giant crab, Spiny (Champagne) crab**

## 1.0 General Characteristics

### *1.1 Biology*

Giant crabs are found in depths from 20 – 600m. The females appear to prefer the sand/mud whereas, the males tend to be caught from hard substrate. Spawning occurs annually in spring (not all females produce eggs every year). Deep sea crabs are generally thought to undergo spawning migrations to shallower water. The size of females at maturity is thought to be around 115 mm CL. They are highly fecund with a larval phase lasting around 60 days providing for limited long distance dispersal. Little is known about growth rates. Capture method is principally by potting.

Snow crabs – It has been suggested that the inherent fluctuations in Canadian snow crab may be due to cannibalism (Comeau and Conan, 1992)

### *1.2 Vulnerability to Fishing*

**Moderate**

Deep sea crabs, whilst highly fecund, have life history characteristics which make them more susceptible to overfishing. They are slow growing, with successive moults occurring up to 8 years, slow to mature and possibly recruit infrequently. Further, they are highly catchable as a result of their capacity to locate food (traps) over relatively great distances (Wenner 1990). It is possible that the Champagne crab fishery in Western Australia was overfished which has lead licenced fishers to target snow crabs. Recovery rates are likely to be slow.

## 2.0 Objectives

Most objectives relate to the maintenance of the appropriate level of abundance. In many cases, given the sizes allowed to be harvested, this may related to exploitable biomass rather than spawning biomass.

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc. above which recruitment overfishing is unlikely to occur*

Giant crabs – Percent virgin egg production at current LMLs has been estimated at approximately 40% in VIC and WA and 50% in SA. The models suggest spawning stock can be well-protected by current levels of LML, exceeding conventional crustacean % virgin egg-per-recruit reference points of 10-30% (McGarvey et al 1999).

In most cases, the actual biomass is not estimated directly but surrogate indicators of abundance and trigger points based on these are used to manage the fisheries.

For the Tasmanian Giant crab fishery, however, the trigger points relate to future stock assessments which will trigger action if the total biomass/egg production falls below 90% of the 2000 value or the estimate from any one region falls below 75% of the 2000 value.

### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

Not available.

### *3.1.3 Maximum Exploitation Rate*

Not available

### ***3.2 Economic Reference Points***

### *3.2.1 MSY/MEY*

# 4.0 **Indicator Assessment** (Levels of Robustness - when are they good and when are they bad?)

### ***4.1 Catch***

**Low??**

Catch alone may not provide a good indication of population and the data for the catch of these species has only recently been obtained. Hence there is uncertainty about the level of robustness of such data.

The Tasmanian giant crab fishery uses 90% of the 100 t TACC as one of the trigger points for this fishery but it is recognised that with only a small group of fishers, catch can vary substantially without any change in crab abundance.

The WA crab fisheries intend to use acceptable catch ranges to monitor the stocks of crabs in these regions.

*Issues –*

- Catch may fluctuate depending on external factors such as market forces and weather, rather than abundance of crabs.
- Catch of crabs as bycatch from other fisheries needs to be accounted for.

### ***4.2 Fishery Dependent Catch Rates***

**Low – Medium**

Catch rates can provide a measure of abundance. Catch and effort data for multi-species fisheries such as the spiny and giant crab fisheries in WA may be difficult to interpret. Whilst catch has been separated, effort levels have not.

Factors such as aggressive behaviour between individuals entering pots can confound this information (Miller 1979).

The Tasmanian Giant crab fishery uses 90% of the CPUE from the reference year of 2000 to trigger a review.

*Issues –*

- Accurate catch rates depend on the reliability of effort information. In the event of increasing catch efficiency, inaccurate effort information or other mitigating circumstances, catch rate data can be misleading.

- Deep sea crab fishers retrieve their pots at irregular intervals ranging from 1 to 5 days which must be accounted for in measuring effort. Some logbooks ask effort to be calculated as “24 hour pot days” which is a combined measure of the number of pots used by the fisher, and the length of time that they were deployed. This measure might provide inaccuracies as the number of crabs entering pots may decline over time as they become full.
- There has been some evidence of illegal “over-potting” in some fisheries. This could lead to an artificially high CPUE (Gardner 1998).

### *4.3 Fishery Independent Surveys*

**Medium**

Fishery independent surveys may provide useful data on stock abundance but the catchability of the crabs needs to be determined. Tag and release programs run in some fisheries.

### *4.4 Estimates of Current Abundance (model based and composite)*

**Medium**

A length-structured model is being developed for the Tasmanian giant crab fishery, that will use catch rate data, catch size structure and processor data.

*Issues* –

- Crabs cannot be aged in most cases – to enhance the applicability of length based models to crustaceans the assumption of a one-to-one relationship of length-at-age should be relaxed (Zheng et al 1995).

### *4.5 Probability of Management Meeting the “Target” in Future*

None in use at the moment, the Tasmanian model may provide this information when developed.

### *4.6 Other – recruitment indices*

No known examples where such schemes are being used for these species

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Moderate – High**

Crabs are amenable to size based limits. Size limits can vary between states with growth rates varying amongst species distributions. Also Tasmania uses a maximum size for male crabs to ensure sufficient mating capabilities remain.

Capture mortality of deep-sea crabs has been shown to be low.

*Issues* –

- A more favourable price is paid for smaller crabs in some species.
- Biological information on which size limits are based may need further analysis. It is not clear whether female fecundity increases with size.

- Minimum size limits might not afford protection for males to reach functional maturity (Gardner 1998).

### *5.2 Biological (reproductive stages)*

**Moderate**

The reproductive stages of crabs are easily identified and restrictions on the capture of females are common. Berried crabs are generally banned from being landed.

### *5.3 Seasonal/Temporal Closures*

**Low – Medium**

Crab fisheries can be amenable to seasonal closures where there is a distinct breeding season/aggregation. Closed seasons vary according to state jurisdiction and species. Thus, for the Victorian fishery there is a closed season of 1 June to 15 November each year for females and 1 September – 15 November for males.

### *5.4 Area/Spatial Closures*

**Low**

Area/spatial closures are not often used in crab fisheries management. There is no distinct breeding/nursery season or area for most species in most areas.

### *5.5 Effort Limitation*

**Moderate**

Most Deep Sea crab fisheries tend to be limited by either the overall number of boats licenced and/or pots fished even when there are TACCs in place.

### *5.6 Output Controls*

**Moderate**

A number of crab fisheries use TACCs and individual quotas to manage the level of exploitation. This includes both the Victorian and Tasmanian giant crab fisheries. Such measures are often used in combination with the retention of a number of input controls. ITQs were introduced into the Tasmanian giant crab fishery in November 1999 based on a TACC of 100t and in Victorian in November 2001 based on a TACC of 25t.

*Issues –*

- Is the TACC correct? There can be a higher risk to the stock of getting the TACC wrong if effort controls are removed.
- If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch.
- Compliance for quota fisheries is often harder due to the relative ease of hiding individuals and the greater incentive to provide misleading information. (ie. Is the level of compliance sufficient to ensure that the level of illegal catches are minimal?)
- The data obtained from fishery dependent sources may not be sufficiently accurate/appropriate for use in monitoring and fishery independent sources may be needed.

### 5.7 Monitoring Frequency and Feedback Loops

Given the relatively new status of these fisheries, yearly reviews are needed to ensure that the management systems are achieving adequate performance.

## 6.0 Ecosystem issues

### 6.1 Impacts on Prey and community structure

**(Likely Risk Rating – Low – Moderate)**

Giant crabs are known to eat starfish, finfish carrion, mammal and bird carrion, hermit crabs, molluscs, and true crabs. Evidence of cannibalism has been found and is a density dependent mechanism which can regulate recruitment. Whilst it is likely that deep sea crabs may have a significant ecological role in their deep-water habitat (Hastie 1995), the small numbers removed over a wide area and the large number of undersized crabs in the population mean that well managed stocks should not cause any significant issues.

### 6.2 Impact on Predators

**Unknown**

*Issue*s –

- Is there a predator that specialises in eating the deep-sea crabs?

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# Prawns

## 1.0 General Characteristics

### *1.1 Biology*

Prawns, whilst widely distributed, are generally found in high densities only in sandy/muddy regions within relatively sheltered areas. They are fast growing, reaching spawning age and exploitation size by 6–7 months and whilst they can live for 2-4 years most do not live that long due to high rates of natural mortality. They are highly fecund with a planktonic larval stage (approx 1-3 weeks) after which settlement occurs in inshore/estuarine nursery areas. Juvenile prawns usually inhabit seagrass beds, mangrove banks and shallow estuaries. A few species are known to undergo sex reversal (e.g. royal red) but most are dioecious. Most prawns undergo a size/maturity dependent migration at about 3-6 months to oceanic waters. The time and the extent of this varies depending on the species, but is usually in the summer months.

The main method of capture in Australia is by nighttime otter trawling. Some species (e.g. banana prawns) are known to form large schools and are caught during daylight. This habit could impact on analyses of catch rates of this species group.

### *1.2 Vulnerability to Fishing*

**Low – Moderate**

Local geography, the position of the fishery within a species range, the presence of other species in a fishery and the catchability appear to affect susceptibility to overfishing (Penn *et al.* 1997). Most stocks of prawns are able to withstand relatively high fishing mortalities and effort levels but some are more vulnerable. Successful long-term management has been recorded for many fisheries and for the few fisheries that have collapsed. Most of these have recovered quickly following reductions in fishing effort. Thus, there were no serious affects on the stocks in the long term. There are two clearly documented cases of recruitment overfishing reported for brown tiger (*P. esculentus)* stocks in WA (Penn and Caputi 1986; Penn *et al*. 1995). Whereas, for the king prawn (*P. latisulcatus*), which overlaps the distribution of the tiger prawn, because of its different biology and behaviour, it has not been ‘overfished’. Thus, multi species fisheries may present the greatest risk to less resilient prawn species.

Annual recruitment of most species varies considerably. For some species these variations have been linked to local variations in rainfall (e.g. banana prawns) or oceanographic conditions. It is probably more appropriate to have a family of SRRs corresponding to the range of likely climatic conditions rather than use just one. Other factors affecting SRRs include the high fecundity of prawns and the importance of inshore nurseries in determining recruitment strength.

## 2.0 Objectives

The objectives usually relate to abundance of remaining spawning stock. Thus, for Western Australia the objectives are for the fishery to be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability

# 3.0 Performance Measures

## *3.1 Biological Reference Points*

### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

20-25% of unfished spawning stock biomass/index

The 20% level of depletion is the approximate level below which recruitment overfishing has occurred for two brown tiger prawn fisheries in WA (Penn et al., 1995). This level of reduction was also considered the precautionary limit for white shrimp in the Gulf of Mexico (Gracia, 1996). Data from the NPF (Dichmont et al., 2002) indicate that the recruitment levels for brown tiger prawns in this region may require stock levels higher than 20% to avoid impacts. Moreover, the steepness of the SRR curves were surprisingly low indicating these stocks were less resistant to exploitation than previously thought.

More generally, using meta-analysis techniques, Ye (2000) concluded that the level of recruitment was related to spawner abundance for all penaeid fisheries and that there was a need to maintain sufficient spawning stock to yield high recruitment.

The trigger points often use catch rates as surrogates for actual abundance. Furthermore, it has been suggested that a practical management strategy for prawn stocks can only be based using the average environmental situation but with contingency plans to decrease effort when low recruitment events occur. Limit reference points are often based on minimum catch rates, particularly when used as a surrogate for minimum spawning biomass. Thus, a constant escapement policy is often suggested for prawns, where a minimum level of spawning biomass is left regardless of the initial recruitment levels.

*Examples –*

Exmouth Gulf and Shark Bay Tiger Prawns – the trigger points for these fisheries (maintaining sufficient spawning stock) are translated into operational terms by fishing being stopped each year when the catch rates of the fleets, within the defined spawning areas, have declined to levels that indicate that the minimum spawning stock has been reached. This requires "real time" management of the fleets and good consultation between the agency and the industry *(these were accepted as part of these EPBC assessments).*

The trigger points for Onslow, Nickol Bay, Broome and are all based on acceptable catch ranges.

One of the trigger points for the Queensland East coast trawl fishery includes that the annual CPUE for the principal species (which includes a number of prawn species) must remain above 70% of the average for the period 1988 – 1997.

### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

There has been no recorded impact on recruitment levels for king prawns (*P. latisulcatus*) in WA despite a decline in the spawning stock index from 30 to less than 8 (depletion to 25%). Similarly, Dichmont *et al*. (2002) found little decline in recruitment levels for *P. semisulcatus* at levels approaching 25%.

### 3.2 *Economic Reference Points*

#### 3.2.1 *MSY/MEY*

A number of prawn fisheries have calculated expected effort levels to generate the MSY in their area. The Northern Prawn fishery has, however, used MSY as the primary management objective, which was broken down into the level of spawning stock to produce maximum yields ($S_{msy}$) and the level of fishing effort ($E_{msy}$) to produce MSY. Recent assessments have shown that the current biomass levels are well below these levels and there is a need to use $E_{msy}$ as the limit reference point, not as a target as previously applied. It is proposed to reassess all reference points and indicators for this fishery *(this system is being assessed for their EPBC assessments*).

Other fisheries have used MSY as a secondary management objective. That is, for the Exmouth Gulf tiger prawn stock, when the RSR and the SSR intersect at about 40,000h effective fishing effort. This level of fishing effort has been shown historically to result in the maximum sustainable catch of just over 400t.

## 4.0 **Indicator Assessment** (Levels of Robustness - when are they good and when are they bad?)

### 4.1 *Catch*

**Low – Moderate**

Catch may provide a reasonable indication of relative abundance if the levels of effort and areas of operation are relatively consistent amongst years and the overall level of effort is not considered to be close to that where overfishing is likely. This can be documented by how much of the stock is vulnerable to the fishery (ie. less than 50%). For many species, the majority of individuals are too small for the gear to be caught in large numbers. Furthermore, many species of prawns live mostly in areas where trawling may not be allowed (inshore, in seagrass etc.). Thus, this indicator may be applicable to bycatch species that are not targeted by the fishery.

*Issues –*

- Catch may not be an index of abundance as production is affected by the level of effort on the species.
- Environmental variables can account for variations in catch.

*Examples* – Nickol Bay prawn fishery, Kimberley Prawn Fishery,

Bycatch prawn species – (*accepted as part of EPBC assessments for by product species in Exmouth Gulf and Shark Bay Prawn Fisheries*).

### 4.2 *Fishery Dependent Catch Rates*

**Low – Moderate/High (Real Time)**

These data may be acceptable if the fishing grounds and the technology used (ie. fishing power) are relatively consistent among years. Environmental variables significantly impact on prawn stocks and therefore, catch rates but this is acceptable. Uncertainty is generated by the natural variations of prawn population parameters and, in particular, the year-to-year variations in the global and seasonal SRRs and in the seasonal recruitment patterns due to environmental effects on survival of recruits.

For the WA fisheries in Exmouth Gulf and Shark Bay, the primary indicator is the catch rate by the fleet within the designated spawning zones. This is assessed on a real time basis to open and close the fishery given the sizes of prawns present and the catch rates. This minimises the chances of any over exploitation that could occur if they relied only on annual post-season assessments (*this system was accepted as part of the EPBC assessment for these two fisheries*).

There may be a need to assess fishing power on a regular basis.

The catchability of schooling species, such as banana prawns, may make commercial catch rate data of less value than for other types of species.

*Issues* –

- Changes in fishing power/efficiency, changes (expansion/contraction) in fishing area, environmental variables impact on catch rates.

*Examples* – Shark Bay – King Prawns.

### *4.3 Fishery Independent Surveys*

**Moderate – High**

Assuming an appropriate design, these can provide very robust indicators of spawning stock abundance although they may suffer from some of the same impacts as the commercial catch rates related to environmental influences on catchability. These surveys can also be used to tune the information obtained from the commercial fishery to allow adjustments to any 'real time' fishery based trigger points.

*Issues* –

- Survey design
- Impacts of environmental conditions

*Example* – The spawning abundance for tiger prawns in Exmouth Gulf is calculated by the fishery independent catch rates (kg/hr) for specific areas taken after the fishery has closed. The trigger point for closing commercial fishing based on the real time catch rates of the fleet are adjusted if the expected survey results (based on the commercial catch rates at the time it was closed) are not achieved.

### *4.4 Estimates of Current Abundance (model based and composite)*

**Moderate**

Wang and Die (1996) constructed an age-structured model for tiger prawns in the NPF. Others (e.g. Haddon, 2000) have used biomass dynamics models.

A combination of indicators can be used to assess performance to provide assurance that any changes will not be missed or significantly distorted due to alterations to fishing practices. This would in most cases be the most robust method of monitoring performance and should be used for fisheries with relatively high rates of exploitation.

For the Exmouth Gulf and Shark Bay prawn fisheries, there are independent surveys that monitor recruitment levels and spawning stock levels plus real time monitoring of the commercial fleet *(this was accepted for the EPBC assessments for these fisheries)*.

*Issues* –

- The methods to ascribe relative weight to the indicators used must be determined to avoid difficulties if any one indicator suggests unacceptable performance.

### *4.5 Probability of Management Meeting the "Target" in Future*

No fishery currently uses this system.

### *4.6 Other – recruitment indices*

**Low – High**

Given the often large variations in recruitment amongst years, having an estimate of recruitment strength from a survey completed prior to a season opening can greatly increase the ability of the management and the industry to set appropriate expectations for the season.

*Examples* – Tiger prawn, Exmouth and Shark Bay.

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Low**

Prawns are not amenable to direct size-based limits as they generally do not survive capture and normal sorting methods. They can be managed by the indirect methods of regulations affecting mesh sizes of the gear and the closure of areas until the prawns have reached a size suitable for capture.

### *5.2 Biological (reproductive stages)*

**Low**

Prawns are not amenable to restrictions based on reproductive stages except by the indirect methods of closures.

### *5.3 Seasonal/Temporal Closures*

**Moderate-High**

Seasonal closures around spawning season are used in some locations to allow prawns to reach the optimal size for capture using EPR or YPR analyses, to minimise disruption to breeding and to assist in maintaining sufficient levels of egg production. Having a defined prawn season can also be used to constrain total effort. These seasons can be either fixed, or for more sophisticated systems (often associated with higher levels of exploitation), variable opening and closing times can be used to manage the stocks more effectively taking into account year to year recruitment variations.

Additional temporal closures, related to moon cycles, are also used to increase the efficiency of the fleet due to the lowered catch rates often associated with these periods for many species.

### *5.4 Area/Spatial Closures*

**High**

The use of area closures is an important management tool for most prawn fisheries. Closures of key nursery areas and restrictions within spawning areas are used. Again, these can either be permanent (nursery areas) or temporary (spawning areas).

Example – Exmouth Gulf Tiger prawn once the threshold catch rate is reached, the main spawning grounds are closed. Key nursery areas are permanently closed to trawling.

### *5.5 Effort Limitation*

**Moderate**

Effort limitation is a common form of management for prawn fisheries. This is usually achieved by limiting the number of boats operating, power of vessels, controls on net design and other gear restrictions. It is, however, rarely used by itself but is most commonly used in conjunction with some of the above closure systems. Purely having limited entry would only work effectively if the effort levels are relatively low, unless there is some form of zoning.

*Issues –*

- Improvements in technology that may increase fishing efficiency need to be monitored and management responses implemented if necessary
- The total allowable level of effort usually needs adjustment at regular intervals because fishing power often increases with technological advances (ie. is the fishing power of fleet being examined at suitable intervals?).
- Can the level of effort be managed and enforced?
- Effort needs to be stopped if trigger limits are reached.

### *5.6 Output Controls*

**Not applicable**

Output controls, such as quotas, are not used in prawn fisheries due to the high interannual variations in recruitment.

### *5.7 Monitoring Frequency and Feedback Loops*

Prawn fisheries require regular monitoring. To be fished at aggressive levels requires real time management with areas closed off when catch rates fall to specific levels. If this is not completed, overfishing may occur if such fisheries rely solely upon annual reviews.

For those fisheries where the level of exploitation is not as high, annual reviews are probably sufficient.

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

**(Likely Risk Rating – Low)**

Most prawn species are opportunistic omnivores, feeding on small molluscs, crustaceans and polychaete worms. They are only seasonally abundant in most areas. The impact of the catch on local food chains is unlikely to be significant in view of the high natural mortality and variable biomass levels of prawns resulting from environmental factors such as rainfall and cyclones.

*This was accepted as part of the EPBC assessment for the Shark Bay and Exmouth Gulf Prawn fisheries*

### *6.2 Impact on Predators*

**(Likely Risk Rating – Low)**

Prawns have a very high natural mortality rate such that a large percentage of the yearly recruits would already be removed from the system (either from death or predation) by the end of the season regardless of fishing. As a result of the naturally high variation of prawn recruitment, the effect of removing prawns through fishing would be masked.

Furthermore, there are no known obligate prawn predators which are likely to be directly impacted upon by the removal of adult sized prawns. Most carnivorous predators are opportunistic and/or scavengers and therefore, are not considered dependent on any one species. A variety of other small crustacean, invertebrate and fish species usually live in these areas. Consequently, it is not likely that the commercial take of prawns significantly impacts on the upper trophic levels.

*This was accepted as part of the EPBC assessment for the Shark Bay and Exmouth Gulf Prawn fisheries*

## References


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## 3.1.2 Finfish

### Summary of Finfish

| | Tropical Snapper | Mid size Pelagics | Temperate Snapper | Tuna & Billfish | Sharks (Short lived) | Sharks (long lived) |
|---|---|---|---|---|---|---|
| **Characteristic** | | | | | | |
| Vulnerability to Fishing | MOD-HIGH | MOD | MOD-HIGH | LOW-HIGH | MOD | HIGH |
| **Performance Measures** | | | | | | |
| **Biological Reference Pts** | | | | | | |
| Spawning Biomass | 30% (WA) | Unknown | 30 -40% suggested | 20% | 30% | 40% |
| Lowest Level | | | | 5% Southern Bluefin | | |
| Max. Expl. Rate | | 35% for Sth Africa & Oman | | ~ 10% (Atlantic) | | |
| **Economic Reference Pts** | | | | | | |
| MSY/MEY | 40% (WA) | | 40% Shark Bay | | | |
| **INDICATORS** (robustness) | | | | | | |
| Catch | LOW-MOD | LOW-MOD | LOW | LOW | LOW - MOD | LOW |
| Catch Rate | MOD | LOW-MOD | LOW | LOW | MOD | LOW – MOD |
| Independent Survey | HIGH | N/A | MOD-HIGH | LOW-MOD | MOD | MOD |
| Age/Size Models | MOD-HIGH | MOD | HIGH | MOD | MOD - HIGH | MOD - HIGH |
| Probability of Future | MOD-HIGH | - | - | HIGH | MOD | MOD |
| Recruit. Surveys | LOW-HIGH | N/A | LOW | LOW | NA | NA |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Management Responses**<br>(Effectiveness of Tools) | | | | | | |
| Size Limits | LOW-MOD | MOD - HIGH | MOD-HIGH | MOD | LOW | LOW |
| Reproductive | MOD | N/A | LOW | N/A | N/a | N/a |
| Closures | MOD HIGH | LOW | MOD | NEG | LOW | LOW |
| Effort | MOD-HIGH | MOD | LOW-MOD | LOW-MOD | MOD | MOD |
| Output | MOD-HIGH | MOD-HIGH | MOD-HIGH | MOD-HIGH | MOD | MOD |
| **ECOSYSTEM** | | | | | | |
| Impacts on Prey | LOW- MOD | LOW | LOW | LOW - MOD | LOW | LOW - MOD |
| Impacts on Predators | LOW | LOW | LOW | LOW | LOW | LOW |

# Tropical Snappers/Jobfish

**(Lethrinids/Lutjanids)**

## 1.0 General Charactersitics

### *1.1 Biology*

Tropical snappers are found on the shelf regions in most tropical areas. Some inhabit sand areas (but often in combination with sponges soft corals etc.), some the reef areas and some are associated with vertical features. They are relatively long lived with maximum ages above 20 years to in excess of 30 years with estimates of natural mortality in the vicinity of 0.1-0.15. Their growth rate is usually relatively fast in the years before sexual maturity (which occurs somewhere between 4 – 8 years) but flattens off quickly after this time making length and age not well related. Males and females usually have different growth rates (males being bigger). Sexes are usually separate and little sex change has been recorded.

The spawning season may be short and many species form spawning aggregations which may make them vulnerable to fishing. Adults generally do not undergo large migrations and functionally separate adult stocks are often found of the same species at scales of about 500km. Juveniles and adults sometimes occupy different areas. The methods of capture include trawling, line (hand and long line) and traps. Depending upon the method and the species, hyperstability of catch rates may be an issue.

### *1.2 Vulnerability to Fishing Moderate – High*

These species may be overfished relatively easily, especially if trawling is used and or spawning aggregations are targeted. Some species may be particularly susceptible to fishing where this method involves removal of their habitat (see Section 3.2 Fish trawling). Many of the deeper water species (jobfish) have been overfished quickly in island areas where the amount of suitable habitat is small. There are often problems for many species of emperors that form spawning aggregations and require a minimum level of abundance for successful spawning.

Where suitable spawning stocks remain, recruitment fluctuations amongst years are relatively small. Whilst there are few data on the shape of the SRR, most models have used the Beverton-Holt curve with a moderate slope.

## 2.0 Objectives

The main objectives relate to maintaining the abundance of the spawning stock at or above an identified level that minimises the risk of recruitment overfishing.

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

30-40% of unfished levels of egg production (proposal only)

Given the dynamics and life history of these species, it was proposed that the limits for *Lutjanus sebae* and *Pristipomoides multidens* in the trawl and trap fisheries off northern WA would have a limit of 30% unfished spawning biomass levels and a target of at least 40% (*currently being considered as part of an EPBC assessment*).

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

No information

#### *3.1.3 Maximum Exploitation Rate*

For the Timor Reef fishery off NT, the limit points for goldband snapper (*Pristipomoides spp*) and red snapper (*L. malabaricus & L. erythropterus*) relate to keeping harvest levels less than 10-15% of the stock per year (Ramm, 1997) *(this has been accepted as part of an EPBC assessment).*

### *3.2 Economic Reference Points)*

#### *3.2.1 MSY/MEY*

The 40% unfished spawning biomass value chosen for the WA fisheries is close to the value that would produce MSY.

## 4.0 Indicator Assessment (Levels of Robustness)

### *4.1 Catch*

**Low – Moderate**

The use of catch as an indicator for these species may be possible if the level of effective effort and the areas of operation are relatively consistent through time. It should probably only be used in situations where it is clear that the stock is not close to the limits of exploitation, or it could be used as the indicator for periods in between where more sophisticated techniques are employed. Thus, it is often used as the indicator for the minor (non-target) species in what are often multi-species fisheries.

*Issues –*

- Changes to fleet dynamics, effort levels, gear and technology advances, level of aggregation of species during spawning periods or targeting.

*Examples* – NT Timor Reef fishery uses catch levels of 900t for goldband and 1300t for red snapper as the trigger points for these species (based on exploitation rates – see above). In addition, the proportion of the catch of red emperors, cods and other byproduct species is monitored as a trigger point.

WA uses acceptable catch ranges for a number of the minor species in this group for the Pilbara Trawl and Trap fisheries.

### *4.2 Fishery Dependent Catch Rates*

**Moderate**

Catch rates of these species may be useful in some fisheries and less so in others. They are likely to be most useful in trawl fisheries where the selectivity and catchability is likely to remain more consistent. Catch rates for trap and line based fisheries that target spawning aggregations will have lower robustness. Multi-species fisheries where targeting shifts amongst species due to markets may also affect catch rates.

*Issues –*

- Will aggregations affect interpretation?
- How was the effective effort determined to use in the calculation in multi-species fisheries (changes in targeting)?

### *4.3 Fishery Independent Surveys*

**Moderate – High**

Assuming that they are trawl based surveys which are conducted during periods when aggregations are not occurring these should provide reasonably robust estimates. If the surveys used line or traps these will suffer from many of the same biases as the fishery dependent data.

### *4.4 Estimates of Current Abundance (model based and composite)*

**Moderate – High**

Given the relationships between size and age, size based models should not be used for these species. Age structured models will provide an effective means for assisting with the determination of how much impact fishing has had on a stock. The main issue is the vulnerability schedules of both sexes and ages. Some species are segregated and this needs to be incorporated into the assessments.

*Examples* – Model based estimates of the spawning abundance are used to monitor the goldband snapper and red emperor stocks (used as indicator species) off WA.

### 4.5 *Probability of Management meeting the "Target" in Future*

The model projections are used in the WA Pilbara trawl fishery to assess how likely it is that the proposed levels of fishing effort ensure that stocks will be above the biological reference points in five years time.

### 4.6 *Other – recruitment indices*

Unknown – no examples of recruitment indices for these species.

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

### 5.1 *Biological (size limits)*

**Low – Moderate**

The use of size limits may only be effective in cases where the fishing method can avoid individuals less than the LML. Thus, for trawl based fisheries LMLs are usually not as effective if the juveniles live in the same location, unless the gear can be tuned to release the smaller individuals.

In shallow waters of line and trap based fisheries, LMLs may be relatively useful. In deeper waters, embolism will reduce their effectiveness.

*Issues –*

- What is the discard rate of undersized individuals
- How much can they be avoided?
- What is the likely mortality rate of discarded individuals

### 5.2 *Biological (reproductive stages)*

**NA**

Unable to directly determine the spawning condition of these species without causing injury.

### 5.3 *Seasonal/Temporal Closures*

**Low**

Not normally used because of the different times of spawning seasons in what are usually multi-species fisheries.

### 5.4 *Area/Spatial Closures*

**Moderate**

Spatial closures can be useful because the adults are relatively stationary. For some species, inshore closures are used to protect juveniles.

### 5.5 *Effort Limitation*

**Moderate – High**

Limited entry fisheries, or total effort units (days fished, trap-days etc.) are a common way of managing these species. These may be used in conjunction with VMS monitoring of the fleet to ensure compliance and also in conjunction with area closures.

*Issues –*

- Changes in fleet efficiency
- Changes in targeting practices (due to markets etc.)
- Catch rates may be hyperstable

### *5.6 Output Controls*

**Moderate – High**

Not commonly used for these species possibly because they are usually multi-species and this causes problems due to discarding and high grading.

*Other Issues –*

- Ensuring the correct TAC is determined
- Compliance issues associated with reporting of catch in often remote areas

### *5.7 Monitoring Frequency and Feedback Loops*

Monitoring of these types of fisheries may require two levels of complexity. Annual checks would need to be made of the catches to ensure that there are no major changes however, extensive modelling exercises may only be necessary every 2-3 years because the dynamics are not that high given the longevity of the individuals and the lack of major year to year fluctuations in recruitment levels.

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

**(Likely to be LOW – MOD risk)**

These species are mostly carnivorous and usually target a wide variety of prey. Consequently, there is unlikely to be any measurable impacts of the reduction in these groups on lower order species. They usually have a low biomass in comparison to other species. It is very unlikely that any <u>direct</u> impacts will occur if the stocks are maintained at levels where their recruitment is unaffected (see, however, indirect impacts of trawls on community structure, if this is the method used to capture these species).

### *6.2 Impact on Predators*

**(Likely to be LOW risk)**

These species are unlikely to form a significant component of higher predators diet except as juveniles which (if the fishery has not affected recruitment) should not be impacted.

## References

Ramm, D. C. (ed 1997) Towards the sustainable use of the Northern Territory fishery resources. Review workshop lead by Prof. Carl Walters. Fishery Report No 39.

## Mid-sized Pelagics

**(Spanish Mackerel)**

# 1.0 General Characteristics

### *1.1 Biology*

Spanish Mackerel are widespread in tropical and subtropical waters. They are pelagic, rarely occupying waters deeper than 100m. Adults are commonly associated with coral reefs, rocky shoals and current lines on outer reef and offshore areas (Kailola 1993). Their stock structure in Australia appears to comprise one single genetic stock but with a mosaic of small sub-stocks. They grow fast, reach sexual maturity at around 2 years, can live up to 12-15 years and they are moderately fecund. They are spring/summer spawners and aggregate in as yet unknown breeding grounds. The length of the larval stage is not known. They do not undergo a sex change and are not territorial. Females grow faster and larger than males. In the western areas, smaller fish (ie. around 1-5 years) tend to school and are more mobile than larger fish (20kg+). In Queensland however, Spanish mackerels undertake large scale migrations as adults. The main form of capture is by trolling. As they form schools at times, this species is likely to be susceptible to hyperstability in catch rates.

### *1.2 Vulnerability to Fishing*

**Low – Moderate**

Mackerel are fast growing, early maturing, moderately fecund and reasonably long-lived. They do however, aggregate to spawn and on occasions to feed, which makes them more susceptible to overfishing. There are a few examples of explicit long term management of these stocks – mostly because dedicated fishing of this species has only been underway for the past decade. There are however, concerns in some regions about the threat from overfishing. Lack of biological information and suitable models continues to affect manageability of the stocks. In the NT, the stocks have not completely recovered since the 1980s when Taiwanese gillnetters overfished the area. Evidence suggests that there are strong and weak year classes (ie. variable recruitment) probably as a result of environmental factors.

# 2.0 Objectives

The main objectives relate to maintaining the abundance of the spawning stock at or above an identified level that minimises the risk of recruitment overfishing.

# 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

Not known

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

Not known

### 3.1.3 *Maximum Exploitation Rate*

Suggestions have been made for stocks in South Africa (Govender, 1995) and Oman (Siddeek & AL-Hosni, 1998). These suggestions based on YPR and SSB/R analyses that $F_{rep}$ and $F_{35\%,}$ were likely to be appropriate for this species.

The safe levels of fishing for Spanish mackerel in the NT are between 20-30% of the fishable biomass (O'Grady, 2002) based on the modelling work of Buckworth et al (2002). The current level of fishing in NT has been assessed as being less than 10% per annum with this 10% level (450t) used as the trigger point for the fishery (this equates to 90% of the sustainable yield) *(this was accepted as part of the EPBC assessment).*

For WA, the acceptable total catch range for all zones is 249-358t. With acceptable regional catch ranges for the Kimberley (110-165t), Pilbara (80-110t), Gascoyne (50-70t) and West Coast (9-13T) *(this is under consideration for this EPBC assessment).*

### 3.2 *Economic Reference Points)*

### 3.2.1 *MSY/MEY*

Not currently used

# 4.0 Indicator Assessment (Levels of Robustness - when are they good and when are they bad?)

### 4.1 *Catch*

**Low-Moderate**

Catch data can provide some indication of abundance for this group. Overall catch depends on how many fishers are participating which is affected by a number of external factors.

The Spanish mackerel stock in the WA fishery will be monitored using TAC and regional annual catch levels. Catch is considered to be a more reliable index of abundance than catch rate because of current difficulties in measuring the effort associated with catches of Spanish mackerel.

The NT fishery uses the catch of 450t as the trigger level with this based on the 90% of the sustainable yield.

*Issues* –

- WA – logbooks need to be amended to capture more precise information about mackerel catch.
- Fishers might be targeting other species and data on mackerel compounded and, therefore, meaningless for stock assessment purposes.
- There could be a large number of fishers fishing for small amounts that could amount to a significant catch.
- Environmental variables can account for variations in catch.

*Examples* – NT, WA mackerel fisheries

### *4.2 Fishery Dependent Catch Rates*

**Low – Moderate**

Because mackerel aggregate to spawn and sometimes feed, the catch rates might be a poor indication of abundance. This is particularly so for stocks with known breeding grounds (e.g. in the Kimberleys). Thus, the catch rates in both the WA and NT fisheries have increased once "serious" fishing for mackerel has begun.

*Issues –*

- changes in fishing power/efficiency (technology creep)
- changes (expansion/contraction) in fishing area
- environmental variables impact on catch rates

### *4.3 Fishery Independent Surveys*

**Moderate**

Not done anywhere in Australia. May be potentially useful but could also suffer from many of the same biases as the fishery dependent catch rate data.

### *4.4 Estimates of Current Abundance (model based and composite)*

**Moderate**

Attempts at age-structured models for the NT mackerel fishery have not been fully successful because of a lack of contrast in the catch rate information (Buckworth et al, 2002). Nonetheless this work has enabled the stocks to be assessed as currently healthy and perhaps increasing – the age structure is consistent with overfishing by the Taiwanese in the 1980s.

Biomass dynamics modelling has been done for the Gascoyne/west coast (combined) region of WA, as there was insufficient contrast in the catch and effort data for the other sectors. The carrying capacity for Spanish mackerel in the Gascoyne/west coast region was estimated to be 1115t (95% confidence interval = 757 – 2116t). Annual commercial catches in the region have therefore, varied between 9 and 11% of the total biomass since 1994. In 2001, the combined commercial and recreational catch was approximately 20% of the estimated biomass (915t) in the region. The biomass of mackerel in the other regions is believed to be higher, as suggested by the higher catches in combination with higher catch rates.

*Issues –*

- Estimates of mortality are currently questionable

### *4.5 Probability of Management Meeting the "Target" in Future*

None currently in use

### *4.6 Other*

None exist in Australia. Recruitment indices could be developed in near future in WA.

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Moderate – High**

Size limits apply to mackerel in all fisheries in Australia. They are surface caught and therefore, there is little concern with embolism of captured individuals. Size limits have the advantage of stopping fishers from targeting schools of juveniles.

*Issues –*

- Mortality rate of discarded undersized fish is not known.
- As strong swimming pelagics, mackerel have a tendency to injure themselves when captured.

### *5.2 Biological (reproductive stages)*

Not applicable.

### *5.3 Seasonal/Temporal Closures*

**Moderate**

Qld. applies some seasonal closures to protect breeding stocks.

*Issues –*

- Closures relating to breeding stocks could make the fishery economically unviable as breeding stocks are targeted.

### *5.4 Area/Spatial Closures*

**Low**

In the NT, management controls include limited entry to defined zones. QLD also applies zoning, including a prohibition of fishing in a zone which is considered a high risk of ciguatera, a lipid-soluble toxin, found in mackerel in that area. The high level of movement within the stock boundaries mean that closures within a section of these zones is unlikely to afford a great level of protection.

*Issues –*

- Closures relating to breeding stocks could make the fishery economically unviable as breeding stocks are targeted.

### *5.5 Effort Limitation*

**Moderate – High**

Effort in mackerel fisheries is limited by the number of licences issued, either for the overall fishery (WA) or for specific management zones (NT). Restrictions on the amount of hooks/lines used would be difficult to enforce and are considered unnecessary because when a school is encountered, fishers are limited by the amount of deck space and number of deck hands to deal with the catch.

### 5.6 Output Controls

**Moderate**

TACs and ITQs are used in some states. A higher level of enforcement is required for quota based management. There is the potential for misreporting amongst fishers who fish in more than one state or management zone (e.g. fishers who fish out of Darwin could fish in the managed NT zone and report it as caught in the unmanaged Kimberleys).

*Issues –*

- Is the TACC correct? There can be a higher risk to the stock of getting the TACC wrong if effort controls are removed.
- If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch.

### 5.7 Monitoring Frequency and Feedback Loops

Given the high level of recruitmant variations, it is likely that the there will be a need to monitor these fisheries on an annual basis.

## 6.0 Ecosystem issues

### 6.1 Impacts on Prey and community structure

**(Likely Risk Rating – LOW)**

Adult mackerel are generalist predators feeding on squid, penaeid prawns and finfish, so impacts on any one particular species may not be significant *(this was accepted as part of the EPBC assessment for the NT fishery).*

### 6.2 Impact on Predators

**(Likely Risk Rating – LOW)**

Adult mackerel are rarely preyed upon under normal circumstances except by sharks. However, when hooked whilst trolling, fish are more vulnerable and are sometimes taken by sharks before being landed.

**This was accepted by EA for the NT fishery**

## References


Buckworth, R. C. et al( 2002) Fishery Assessment report for the Northern Territory Spanish Mackerel Fishery 1999 Summary of Assessment Information. NT Fisheries, Fishery Report 52.

Govender, A. (1995) Mortality and biological reference points for the king mackerel (*Scomberomorus commerson*) fishery off Natal, South Africa (based on a per-recruit assessment). Fish. Res. 23:195-208

Kailola P.J., Williams M.J., Stewart P.C., Reichelt R.E., McNee A. and Grieve C. (1993) Australian Fisheries Resources. Bureau of Resource Sciences.

O'Grady (2002) Assessing the Ecological Sustainability of the Northern Territory Spanish Mackerel Fishery *A report prepared for Environment Australia as required for assessment under guidelines for Schedule 4 Listings under the Wildlife Protection (regulation of Exports & Imports) Act 1982*.

Siddeek, M.S.N. & A.H.S. Al-Hosni (1998) Biological reference points for managing kingfish, *Scomberomorus commerson*, in Oman waters. Naga Oct-Dec 1998: 32-38

## Temperate Snapper
**(*Pagrus*)**

## 1.0 General Characteristics

### *1.1 Biology*

Snapper have a broad range from southern Qld through the south coast of Australia up to Exmouth Gulf in WA. The biology and life history of snapper varies around the country and there are a number of separate stocks. Some inhabit inshore reef outcrops and some stocks prefer a more estuarine environment. They are relatively long lived with a maximum age of between 30–40 years, depending on the location with estimates of natural mortality varying from 0.075 (NZ) up to 0.14 in WA. They reach sexual maturity at about 40cm fork length which is reached at about 4 years of age and they can attain lengths of 100cm (>16kg).

Snapper are batch/broadcast spawners with the eggs released in discrete batches throughout the spawning period, which is referred to as serial spawning. Larvae can, depending upon oceanographic conditions, travel large distances on ocean surface currents (Qld/NSW) or remain within small embayments (Shark Bay). Snapper display spawning aggregation behaviour, they are sexually dimorphic and do not undergo a sex change. They are not territorial but may be susceptible to hyperstability in catch rates because of tendency to fish during the spawning aggregations. Capture methods include dropline, handline, longline, gillnet and fish traps.

### *1.2 Vulnerability to Fishing*

**Moderate – High**

Snapper are particularly vulnerable to overfishing due to their aggregating behaviour during the spawning season (for areas where this still occurs). The recovery period may be relatively quick if there are still some aggregations remaining but may not occur at all if these are removed entirely There is a suggestion that once aggregations are lost, they may not return. The patterns of annual recruitment for snapper varies greatly amongst the stocks from being extremely stochastic in temperate regions (e.g. Vic. SA NZ where it may vary by a factor of 20) to being relatively consistent in more sub-tropical locations (e.g. Shark Bay and West Coast WA, NSW, Qld).

## 2.0 Objectives

The main objectives relate to maintaining the abundance of the spawning stock at or above an identified level that minimises the risk of recruitment overfishing.

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

**30-40% (suggested)**

The precise nature of the stock/recruitment relationship for snapper stocks is not known. Although it has been reported that there is no relationship between recruitment and spawning stock size for this species in New Zealand (Gilbert, 1997), the levels of recruitment for finfish species similar in biology and dynamics to snapper (moderate growth rates and relatively long lived) are generally considered to be unaffected whilst the spawning stock is greater than 30% of the virgin biomass (based on the suggestions in Mace, 1994; Gabriel and Mace, 1999). Given the longevity and life history of this species, it is likely that the "safe" level of spawning biomass will be in the vicinity of 30% unfished levels. It could be larger for those stocks that have stochastic recruitment. Thus, the 40 % level has been suggested as the most appropriate for the Shark Bay Snapper stock *(this is currently being assessed as part of the EPBC application)*.

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

In NZ, the main determinant of recruitment strength is water temperature and it is thought that stock size plays a minor role (Gilbert, 1997).

#### *3.1.3 Maximum Exploitation Rate*

Unknown

### *3.2 Economic Reference Points*

#### *3.2.1 MSY/MEY*

$B_{msy}$ is used as the target for snapper fisheries in NZ. MSY was calculated for the oceanic stock of snapper off Shark Bay (600t) and this has been used as the basis for setting the TAC for the past 10 years (550t).

## 4.0 **Indicator Assessment** (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

**Low**

The overall catch of snapper may provide some indication of relative abundance in some circumstances. For fisheries managed by quota (e.g. Shark Bay) however, this will be of limited value. In effort based snapper fisheries, it may be of more use but it will still suffer from the impacts of changes to effort levels, whether or not the aggregations are targeted etc. Thus, this should only be used in situations where the rate of exploitation is not near any limit.

*Issues –*

- Catch for species with variable recruitment rates, such as snapper, will fluctuate from year to year.
- It may be difficult to tell if fluctuations are natural or due to fishing pressure.

### *4.2 Fishery Dependent Catch Rates*

**Low**

These data may be acceptable if the fishing grounds and the technology used are relatively consistent. In multi-species fisheries, the overall catch rates calculated for individual species are not a reliable measure of their abundance, due to the targeting behaviour of the fishers.

The catch rates associated with fisheries that target spawning aggregations of snapper will be less reliable because of the potential for hyperstability.

The current limit reference for pink snapper in Shark Bay is 500kg/day for the fishery in June-July. Although the catchability of the snapper varies markedly throughout the year, the catch and catch rates peaks in June-July. Therefore this period is the most appropriate estimator of local abundance. If catches fall below 500kg/day, such a decline would represent a 20% drop below the 10-year average (593kg/day) and would warrant a review and likely changes to the management arrangements unless it could be demonstrated that the drop was not due to a decline in the stocks *(currently being assessed as part of and EPBC application).*

### *4.3 Fishery Independent Surveys*

**Moderate**

Independent surveys of snapper adults using catch rates would suffer the same problems as the data from the commercial fishery. Daily Egg production surveys are also conducted for some stocks of snapper (inner Shark Bay, WA) to estimate spawning biomass although the estimates suffer from parameter estimation problems particularly related to egg mortality estimates (Jackson & Cheng 2001).

### *4.4 Estimates of Current Abundance (model based and composite)*

**Moderate – High**

The level of robustness would vary according to the confidence about the information used within the model. Such models can provide the advantage of incorporating additional information (especially age structure data) that is more informative than catch and catch rates alone.

*Issues –*

- Estimates used for parameters such as M and the SRR curve.

Examples – These techniques are used for the assessment of snapper stocks in NSW, Vic and NZ.

### *4.5 Probability of Management Meeting the "Target" in Future*

No current examples.

### *4.6 Other – recruitment indices*

**Low**

There has been some work to develop recruitment indices for snapper in NSW, Vic and WA. None have so far been successful in generating predictive relationships.

## 5.0 **Management Responses** (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Low – Moderate**

Minimum length limits (LML) apply to this species. The LML for snapper varies around the country from 30cm total length (NSW), and 35cm in Qld up to 50cm (WA). The size at maturity is normally about 40cm.

LMLs may be of limited value in some circumstances given the high mortality of snapper caught at depths of greater than 45m (St John and Moran, 2002). There is also the problem of high-grading which occurs in quota and recreational fisheries whereby larger fish caught are kept at the expense of already killed smaller fish. The optimal size for fish in some fisheries are market driven, where smaller fish often achieve a higher price per kilo. In these cases, where there is limited deck/fridge space, fishers may return fish to the water if a large catch of the preferred size is secured.

### *5.2 Biological (reproductive stages)*

**Not applicable**

Spawning condition is not easily determined for this species and hence, there are no sensible regulations that could use this in a direct way (but see below).

### *5.3 Seasonal/Temporal Closures*

**Moderate**

Given the spawning seasons are usually relatively consistent in timing among years (often within a specific location) having closures around these times may provide some protection to the spawning stock, particularly if this is the period when maximal catches occur. This may however, not be sensible for commercial fisheries where the maximal catch rates are needed to remain profitable. Such a technique may however, be appropriate for recreational fisheries where limits to the total take or limiting the number of participants is not easy to do.

### *5.4 Area/Spatial Closures*

**Low – Moderate**

The spawning aggregations of snapper are usually very well defined and consistent both within and between seasons. Consequently, it is possible that specific area closures can be used to minimise targeting of spawning aggregations again this is of most use when dealing with relatively open access fisheries. Outside of these times, the snapper move within their range and hence, would be subject to exploitation.

### *5.5 Effort Limitation*

**Low**

Mere effort limitation is not likely to be successful in achieving sustainable catch levels of snapper due to the aggregations and the large catches that can be taken at these periods. Thus, this would only work if the number of participants were kept relatively small and used in conjunction with area and temporal closures. Such a system is unlikely to be the most efficient.

### *5.6 Output Controls*

**Moderate – High**

Output controls such as TAC and ITQs are currently used to manage a number of snapper fisheries including Shark Bay in WA and various sectors of the NZ fishery. If the biomass estimates and potential yield are well known then these may be a good method. The main factor is determining what the appropriate TAC should be. There are also problems if recruitment is highly variable, which requires either a relatively low yield setting to be made or frequent changes to the TAC as stock abundance moves up and down.

Recreational bag limits apply in most jursidictions (e.g. 5 in Qld). A total take for recreational fishers, using the sale of a limited number of tags, is currently being trialled in parts of Shark Bay WA (where commercial fishing on this species is minimal) to limit their catch on a stock that was being heavily depleted.

### *5.7 Monitoring Frequency and Feedback Loops*

Given the potential variability in recruitment, some level of annual monitoring is probably required. However, full assessments may only be necessary every few years for fisheries that are harvesting stocks that have a broad spread of age classes.

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

(Likely Risk Rating – **LOW- MODERATE**)

Snapper are known to be generalist carnivores; mostly feeding on small benthic invertebrates and do not therefore, have a close association with any particular prey species. This means that the impact of a lower abundance of snapper would be distributed across many species. Snapper are usually just one of the many demersal carnivorous scalefish in a region and therefore, even with the take of snapper there will still be a large percentage of total predators available. Finally, snapper only reside in large numbers in the locations where they are captured by the fishery for only a few months of the year. It is unlikely that there would be a significant level of impact on prey species. Risk assessments of this issue have identified this as a **LOW** risk.

### *6.2 Impact on Predators*

(Likely Risk Rating – **LOW**)

Given their size and speed, snapper are unlikely to be the prey of many species except at small sizes. Therefore, if the fishery does not affect recruitment then there would be little impact on predators of snapper.

## References

Gabriel, W.L. and P.M. Mace (1999) A review of biological reference points in the context of the precautionary approach. Proc. 5th National Stock Assessment Workshop. *NMFS, NOAA Tech. Memo. F/SPO -40*. pp 34-45

Gilbert, D.J. (1997) Towards a new recruitment paradigm for fish stocks. *Can. J. Fish. Aquat. Sci*. 54, 969-977

Jackson, G & Cheng, Y.W. (2001). Parameter estimation with egg production surveys to estimate snapper, *Pagrus auratus*, biomass in Shark Bay, Western Australia. *Journal of Agricultural, Biological, and Environmental Statistics,* 6: 243-257.

Mace, P. M. (1994) Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. *Can. J. Fish. Aquat. Sci*. 52, 110-122

St John, J. & Moran, M. (2001). Post release mortality of pink snapper: a study in depth. Abstract for Australian Society of Fish Biology, Bunbury, September, 2001.

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# Temperate Slope

**(Blue Grenadier)**

## 1.0 General Characteristics

### *1.1 Biology*

These species, characterised by blue grenadier, inhabit the slope region >200 m < 800m, in temperate waters. They usually have a wide distribution within these depths covering 100-1000kms but separate stocks within this distribution have been determined.

They are reasonably long lived with maximum ages in the 20-year range.

### *1.2 Vulnerability to Fishing Low – Moderate.*

These groups have been subjected to relatively high levels of fishing pressure both off the south east coast of Australia and in NZ.

## 2.0 Objectives

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

40% of unfished levels of egg production is used as the basis of the risk assessment for blue grenadier (Punt et al. 2001). AFMA has the secondary element that the biomass must not fall below 20% (unclear if this is spawning or total).

*Examples* – South-east Fishery

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

unknown

#### *3.1.3 Maximum Exploitation Rate*

unknown

### *3.2 Economic Reference Points*

#### *3.2.1 MSY/MEY*

unknown

## 4.0 Indicator Assessment (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

**Low**

*Issues – ???*

*Examples –*

### *4.2 Fishery Dependent Catch Rates*

**Low –Moderate**

*Issues – ??*

*Examples –* ????

### *4.3 Fishery Independent Surveys*

**Moderate**

*Issues –*

*Examples –*

### *4.4 Estimates of Current Abundance (model based and composite)*

**Moderate – High**

*Issues –?*

*Examples* – ??

### *4.5 Probability of Management Meeting the "Target" in Future*

**Moderate – High**

### *4.6 Other – recruitment indices*

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Low**

These species are caught by trawls and landed dead. Hence, any LML will have only limited effect of shifting where fishing may occur.

### *5.2 Biological (reproductive stages)*

Not Applicable

### *5.3 Seasonal/Temporal Closures*

**Low**

### *5.4 Area/Spatial Closures*

**Low**

### *5.5 Effort Limitation*

**Moderate**

### *5.6 Output Controls*

**Moderate**

### *5.7 Monitoring Frequency and Feedback Loops*

Annual low level, tri-annual intensive review.

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

Likely to be LOW risk

### *6.2 Impact on Predators*

Likely to be LOW Risk

### References

Punt, A.E., Smith, A.D.M., Cui, G. (2001). Review of progress in the introduction of management strategy evaluation (MSE) approaches in Australia's South East Fishery. *Marine and Freshwater Research,* 52(4): 719-726.

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# *Tuna and Billfish*

## 1.0 General Characteristics

### *1.1 Biology*

These species live in the open ocean and have large distributions that usually encompass more than one country/ocean. Some species grow to relatively large sizes but many do not reach sexual maturity until they are >10 years of age. They continue to grow throughout life and there is a reasonable age–length relationship. They often form schools both for spawning and feeding. Individuals may each travel considerable distances. They usually are highly fecund with some of the tropical species spawning almost continuously. The larvae are pelagic and have relatively short larval life times. Fishing is undertaken using purse seines, pole and line and long line methods and catch rates may be susceptible to hyperstabilty.

### *1.2 Vulnerability to Fishing*

**Low – Moderate**

Some tuna species are amongst the most heavily fished species in the world, some (longer lived temperate species) have shown significant declines due to fishing (e.g. SBT). The main differences amongst species is the level of exploitation prior to their attaining sexual maturity. Their schooling behaviour can also make them vulnerable to fishing. Recruitment levels are relatively consistent, even for relatively depleted stocks, but strong and weak year classes are known for some species. The multi-gear, multi-nation fisheries that usually target these stocks make assessments (even determining the catch) complicated and difficult to complete successfully.

## 2.0 Objectives

The primary objective for the SBT fishery is the "rebuilding of the parental biomass".

The other objectives are to :

- Maximise the catch by weight in both the short and log term
- Achieve the rebuilding target for parental biomass by the target year
- Minimise the risk that the parental biomass falls below a predefined level
- Minimise the magnitude short term fluctuations in the fisheries

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

The values used for the steepness in the stock recruitment relationships for the southern bluefin tuna stocks are 0.9 which indicates recruitment is insensitive to changes in spawning biomass except below 20% (Punt et al 2001).

For the SBT, the operational objective is to rebuild the spawning stock back to the 1980 level by the year 2020 (AFMA, 2002).

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

The recruitment to the swordfish stock in the Atlantic has remained constant despite the parental biomass having declined substantially ~ 10% (Anon 1997).

The current spawning stock size for southern bluefin tuna may only be about 5% of unfished levels (it is 7-15% of the 1960 level) with current recruitment levels reduced to about one third of the 1960 level.

#### *3.1.3 Maximum Exploitation Rate*

Not applicable

### *3.2 Economic Reference Points*

#### *3.2.1 MSY/MEY*

## 4.0 Indicator Assessment (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

**Low**

### *4.2 Fishery Dependent Catch Rates*

**Low**

These species often form schools and/or they congregate around seamounts or oceanographic features which the fishers target. Consequently, catch rates can provide a misleading measure of abundance in these species because catch rates may not be linearly related to abundance and the historical values may be difficult to interpret (Punt et al. 2001).

*Issues* –

- How to account for schooling behaviour
- Has there been increased use of technology?
- Are satellite images used to assist searching?

### *4.3 Mean Length/Upper Length/Mean Age*

**Low- Moderate**

Using a length based trigger level, either mean length or upper length provides a more precautionary basis than catch rate for determining if stocks of tuna/billfish have fallen below a limit spawning biomass (Punt et al., 2001). Presumably, a mean age or upper age in the catch would provide a more robust estimate.

### *4.3 Fishery Independent Surveys*

**Low – Moderate**

One of the main problems for these types of methods are the wide area where these types of stocks are located, which may make effective sampling by independent means impossible. Also, many of the problems associated with catch rates affect independent surveys to a similar degree as fishery dependent data.

Examples – These types of surveys have usually been restricted to juveniles of SBT

### *4.4 Estimates of Current Abundance (model based and composite)*

**Moderate – High**

Modelling of the SBT stock is done using VPA and other catch-at-age modelling procedures (AFMA, 2002). The certainty of these models is affected by the accuracy of the age distributions used. Historical data comes from length-at-age keys Only more recent data uses ages assigned from the otoliths. This introduces a higher level of uncertainty because of the spread of ages at length. To assist with this uncertainty a number of different models are run and the summary information produced is used to determine stock status.

*Examples* – SBT.

### *4.5 Probability of Management Meeting the "Target" in Future*

For the SBT, the probability that the target levels will be reached are calculated given the proposed management arrangements.

### *4.6 Other – recruitment indices*

**Low- Moderate**

The distribution of these stocks can make collecting these data difficult. Also, there is often spatial separation between different age groups.

*Issues –*
the accuracy of predictions generated, the length of time for which data are available

*Examples –* SBT collected data on recruitment of juveniles for a number of years.

## 5.0 **Management Responses** (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Low – Moderate**

Many of these species become sexually mature at relatively old ages. These mature individuals may not be vulnerable within Australian waters.

*Examples –*

### *5.2 Biological (reproductive stages)*

**Low**

Cannot tell the spawning status directly of tuna or billfish. May be irrelevant for some species that do not mature in Australian waters.

### *5.3 Seasonal/Temporal Closures*

**Low**

Often these species are only seasonally abundant at any one place.

### *5.4 Area/Spatial Closures*

**Negligible**

These species are highly mobile and so having a closed area in any one location is unlikely to afford a significant level of protection to these stocks.

### *5.5 Effort Limitation*

**Low – Moderate**

Such systems will only work if the level of schooling behaviour that is shown by the species is not too large. Where schooling is not predominant and the effective effort of the fleet can be controlled, such methods may control the level of exploitation. These systems may be hard to enforce if the species crosses a number of jurisdictions.

*Issues –*

- Level of schooling
- Number of jurisdictions involved
- Level of latent effort
- Compliance level for the amount of fishing gear used

*Examples* – ECTBF

### *5.6 Output Controls*

**Moderate – High**

For some of these species the use of quotas is needed to constrain exploitation.

*Issues –*

- Is the quota correct?
- Does quota reflect whole stock or that within the jurisdiction?
- Level of variation in recruitment
- Compliance with quota

*Examples* – SBT

### *5.7 Monitoring Frequency and Feedback Loops*

Unknown

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

**(Likely to be LOW to MOD Risk)**

These species are opportunistic feeders, often feeding on a wide variety of baitfish and other meso-pelagic items such as cephalopods, crustaceans and salps.

*Issues –*

- Does the species tend to feed predominantly on one species?
- Is it the main predator of one species?

### *6.2 Impact on Predators*

(Likely to be LOW risk)

As predators, these species do not often form the main prey of other species.

## References

AFMA (2002) Draft Assessment Report - Southern Bluefin July 2002, AFMA Canberra, Australia.

Punt, A.E., Smith, A.D.M., Cui, G. (2001). Review of progress in the introduction of management strategy evaluation (MSE) approaches in Australia's South East Fishery. *Marine and Freshwater Research,* 52(4): 719-726.

## Sharks (Short lived)

**Gummy shark**
**Whiskery shark**
**School shark**

## 1.0 General Charactersitics

### *1.1 Biology*

Sharks inhabit a range of habitats including on or near the sea bed in rocky, coral, seaweed and kelp areas. The short-lived shark species have a range of different biological characteristics. They are generally smaller (growing up to 2m in length) than most sharks and live for up to 16 years. Reproduction is generally ovoviviparous and females produce litters of between 1 and 45 each year. There are no known nursery areas with young and adult sharks distributed widely. Capture methods are demersal gillnetting and long lining.

### *1.2 Vulnerability to Fishing – Moderate.*

Shark species are particularly vulnerable to fishing because of their life-history strategy with slow growth, late attainment of sexual maturity, low fecundity, low natural mortality and relatively direct relationship between the size of the breeding stock and recruitment. The whiskery shark is currently over-exploited with most other species fully-exploited. Similarly, the school shark stock off south eastern Australia is overfished .

## 2.0 Objectives

Most objectives relate to the maintenance of a sufficient breeding stock to ensure adequate long-term recruitment.

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

Gummy shark (Western) – estimates indicate that the total biomass is between 22.6 and 60.25% of its unexploited level with a best estimate of 42.7%.

Gummy shark (Southern) – estimates of between 45 and 78% and 72 and 89% of the virgin biomass for Bass Strait and South Australia, respectively.

WA Shark fisheries – the long term goal is to rebuild stocks to above 40% of their original biomass.

School shark (AFMA) – ensure that there is an 80% probability that in 2001 the mature biomass of school sharks are above the 1986 level.

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

No figures exist for short-lived sharks.

#### *3.1.3 Maximum Exploitation Rate*

Not known.

### ***3.2 Economic Reference Points***

#### *3.2.1 MSY and MEY*

The target biomass for the gummy and whiskery sharks (WA) is 40% of initial biomass to be achieved by 2010.

## **4.0 Indicator Assessment/Robustness** (when are they good and when are they bad)

### ***4.1 Catch***

**Low – Moderate**

Such an indicator (probably used within an 'acceptable catch' range) should only be used in conjunction with a relatively precautionary management regime – ie. low risk exploitation rate.

*Issues* –

- Can it be shown that effort does not vary greatly?
- Catch data might not be accurate due to unrecorded bycatch from other fisheries. e.g. whiskery sharks are an incidental catch of demersal otter trawlers off SA.

*Examples* – WA – by-product species

### ***4.2 Fishery Dependent Catch Rates***

**Moderate**

Catch and effort data is used to determine stock abundance in many shark fisheries.

These data may be acceptable if the fishing grounds and the technology used (i.e. fishing power) are relatively consistent. Acceptability needs to be restricted to defined intervals with periodic determinations of any changes to catchability coefficients etc. These types of indicators could then be associated with moderate levels of exploitation risk. The robustness would increase as the level of detail of the data provided increases. Thus, data that allows estimates of egg production rather that mere abundance may be more valuable.

Due to the increased incentive to submit false returns, these indices may be of less value in quota based fisheries, unless there is a high level of compliance to ensure accurate information is provided. Fisher behaviour must also not alter greatly.

*Issues* –

- Changes in fishing power/efficiency, changes (expansion/contraction) in fishing area, impacts of any quotas etc on fisher behaviour/data accuracy.

*Examples* – WA annual assessments of target species

### *4.3 Fishery Independent Surveys*

**Moderate – High**

Tagging data can be used to estimate mortality rates and their impact on the stocks.

*Issues –*

- Survey design
- Impacts of environmental conditions

### *4.4 Estimates of Current Abundance (model based and composite)*

**Moderate-High**

A combination of indicators can be used to assess performance to provide assurance that any changes will not be missed or significantly distorted due to alterations to fishing practices. This would in most cases be the most robust method of monitoring performance and should be needed for fisheries with relatively high rates of exploitation. The level of robustness when these inputs are used in a model would vary according to the confidence about the information used within the model. Such models can provide the advantage of incorporating additional information (e.g. size frequency) that is more informative than catch rates alone.

*Issues –*

- Validity of data inputs/assumptions
- The methods to ascribe relative weight to the indicators used must be determined to avoid difficulties if any one indicator suggests unacceptable performance.

### *4.5 Probability of Management Meeting the "Target" in Future*

None used

### *4.6 Other – recruitment indices*

None used

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Low**

Minimum and maximum size limits apply to these fisheries. Minimum to protect juvenile sharks and maximum to contain mercury content.

### *5.2 Biological (reproductive stages)*

**Moderate**

Not applicable.

### *5.3 Seasonal/Temporal Closures*

**Moderate**

Seasonal closures around spawning season are used in some fisheries to minimise disruption to breeding and assist in maintaining sufficient pup production.

### *5.4 Area/Spatial Closures*

**Moderate**

The use of area closures is common for shark fisheries to protect the breeding stocks of some species.

### *5.5 Effort Limitation*

**Moderate**

Effort limitation is a common form of manageing shark fisheries, usually through limited entry and gear limitations. Some fisheries also manage effort using time/gear units, which controls the number of nets and time they may be used over a year.

*Issues –*

- The total allowable level of effort usually needs adjustment at regular intervals because fishing power often increases with technological advances (ie. is the fishing power of fleet being examined at suitable intervals?).
- Can the level of effort be managed and enforced?

### *5.6 Output Controls*

**Moderate – High**

A number of fisheries use TACCs and individual quotas to manage the level of exploitation. These are often used in combination with the retention of a number of input controls.

*Issues –*

- Is the TACC correct? There can be a higher risk to the stock of getting the TACC wrong if effort controls are removed.
- If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch *(ie. are the variations in recruitment built into the determination of the annual quota either by having recruitment indices varying the annual TAC; or is the TAC is at the lower end of the range?).*
- Compliance for quota fisheries is often harder due to the relative ease of hiding individuals and the greater incentive to provide misleading information *(ie. is the level of compliance sufficient to ensure that the level of illegal catches are minimal?)*
- The data obtained from fishery dependent sources may not be sufficiently accurate/ appropriate for use in monitoring and fishery independent sources may be needed.

### *5.7 Monitoring Frequency and Feedback Loops*

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

(Likely risk rating – LOW)

Sharks feed on squid and octopus, crustaceans, bony fish and other classes of organisms. They do not target any one particular species or class so are unlikely to affect community structure.

### *6.2 Impact on Predators*

(Likely risk Rating LOW)

As adults, sharks have few predators other than bigger sharks.

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## Sharks (Long lived)

**Dusky whaler**
**School shark**
**Thickskin (sandbar) shark**
**Tiger shark**
**Hammerhead shark**

## 1.0 General Characteristics

### *1.1 Biology*

Long lived sharks inhabit a range of habitats, generally preferring offshore waters. Sharks are relatively slow growing, tending to grow rapidly until they reach sexual maturity which for long lived sharks can be up to 20 years. The maximum age is up to 50 years. These sharks tend to be vivaporous producing litters of under 20 pups, up to every third year, with larger females producing larger litters. Sharks can be schooling (eg School). Capture methods are gillnets, traps and long lines.

### *1.2 Vulnerability to Fishing*

**High**

Shark species are particularly vulnerable to fishing because of their life-history strategy with slow growth, late attainment of sexual maturity, low fecundity, low natural mortality and a relatively direct relationship between the size of the breeding stock and recruitment. The greatest risk is within multi-species fisheries where one or more species is more vulnerable to fishing. Sharks have a low capacity for recovery from overfishing.

*Example* – Overfishing has occurred in the Southern Shark Fishery.

## 2.0 Objectives

Most objectives relate to the maintenance of a sufficient breeding stock to ensure adequate long-term recruitment.

## 3.0 Performance Measures

### *3.1 Biological Reference Points)*

#### *3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

WA Shark fisheries – the long-term goal is to rebuild stocks to above 40% of their original biomass by 2040.

#### *3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

No precise figures exist for long-lived sharks but some of the deep-water dogfish in the SEF have been reduced to very low levels (Andrew et al, 1996).

#### *3.1.3 Maximum Exploitation Rate*

Not known.

### *3.2 Economic Reference Points)*

#### *3.2.1 MSY/MEY*

The target biomass for the dusky whaler shark (WA) is 40% of initial biomass to be achieved by 2040.

The sustainable yield was estimated to be about 1200t per annum for the southern shark fishery (school and gummy combined).

## 4.0 **Indicator Assessment** (Levels of robustness - when are they good and when are they bad)

### *4.1 Catch*

**Low – Moderate**

For some species, due to the age-at-capture, the catch rates are indicative of the level of recruitment of some time ago. Such an indicator (probably used within an 'acceptable catch' range) should only be used in conjunction with a relatively precautionary management regime – ie. low risk exploitation rate.

Acceptable catch ranges for the key target species are set each year.

*Issues –*

- Can it be shown that effort doesn't vary greatly?
- Catches as bycatch, and from minor fisheries may not be monitored, leading to an inaccurate overall catch rate.

### *4.2 Fishery Dependent Catch Rates*

**Moderate**

Catch and effort data is used to determine stock abundance in many shark fisheries.

*Issues –*

- Changes in fishing power/efficiency
- Changes (expansion/contraction) in fishing area

- Impacts of any quotas etc. on fisher behaviour/data accuracy
- Catches as bycatch and from minor fisheries may not be monitored, leading to an inaccurate overall catch rate. For example, a large portion of the shark catch from WA's northern bioregion is taken by vessels fishing for other target species. This factor, in addition to the multi-species nature of the tropical shark fisheries makes formal stock assessment processes particularly difficult.

*Examples* – WA.

### 4.3 Fishery Independent Surveys

**Moderate – High**

Tagging data can be used to estimate mortality rates and their impact on the stocks.

*Issues* –

- Survey design
- Impacts of environmental conditions

*Examples* – School shark.

### 4.4 Estimates of Current Abundance (model based and composite)

**Low -High**

Age and size-structured models can provide robust indicators of stock status. These have been used for the Whiskery shark in WA.

Composite

**Moderate to Very High**

A combination of catch rates and age-structured models are used in some fisheries. Models should ideally incorporate the peculiarities of shark reproduction, survival, complex movement and distribution patterns, and the selectivity characteristics of the fishing gear used (gill-nets and longlines).

*Issues* –

- The methods to ascribe relative weight to the indicators used must be determined to avoid difficulties if any one indicator suggests unacceptable performance.

### 4.5 Probability of Management Meeting the "Target" in Future

**Moderate to Very High**

### 4.6 Other – recruitment indices

The catch rate of Dusky whalers off WA is an indicator of recruitment levels because they mainly catch newly pupped individuals.

## 5.0 Management Responses (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

**Moderate**

Maximum and minimum lengths apply in some fisheries. The maximum limit is to reduce the average mercury content in the catch and to protect the spawning stock. There is sometimes a minimum length to protect young sharks.

*Examples* – Most have minimum sizes, some (e.g. VIC) also have maximum sizes.

### *5.2 Biological (reproductive stages)*

Not applicable.

### *5.3 Seasonal/Temporal Closures*

**Moderate**

Seasonal closures around spawning season are used in some fisheries to minimise disruption to breeding and assist in maintaining sufficient pup production.

### *5.4 Area/Spatial Closures*

**Low**

The use of area closures is common for some shark fisheries. Usually such closures are inshore areas, close to areas where new-born and young sharks are located. Some fisheries (north WA) close areas where there is a high concentration of adults. This is not fully effective because of the tendency for large long-lived sharks to move considerable distances, often as part of the pupping cycle.

### *5.5 Effort Limitation*

**Moderate**

This is a common form of management in shark fisheries, usually through limited entry and gear limitations. Some fisheries also manage effort using time/gear units, which controls the number of nets and time they may be used over a year.

*Issues* –

- Effort limitation does not address shark caught as bycatch from other fisheries which can account for a significant amount of catch.
- The total allowable level of effort usually needs adjustment at regular intervals because fishing power often increases with technological advances (ie. is the fishing power of fleet being examined at suitable intervals?).
- Can the level of effort be managed and enforced?

### *5.6 Output Controls*

**Moderate**

TACs are not commonly used in shark fisheries. This may however change in coming years.

*Issues –*

- Is the TACC correct? There can be a higher risk to the stock of getting the TACC wrong if effort controls are removed.
- If the stock undergoes large fluctuations in recruitment among years, this needs to be predicted accurately to either avoid overfishing or the substantial loss of possible catch *(ie. are the variations in recruitment built into the determination of the annual quota either by having recruitment indices varying the annual TAC; or is the TAC is at the lower end of the range?).*
- Compliance for quota fisheries is s often harder due to the relative ease of hiding individuals and the greater incentive to provide misleading information *(ie. is the level of compliance sufficient to ensure that the level of illegal catches are minimal?).*
- The data obtained from fishery dependent sources may not be sufficiently accurate/ appropriate for use in monitoring and fishery independent sources may be needed.

### *5.7 Monitoring Frequency and Feedback Loops*

There should be an annual review of the current status and a revision and reassessment of assumptions etc. every 3-5 years.

## 6.0 Ecosystem issues

### *6.1 Impacts on Prey and community structure*

Sharks feed on squid and octopus, crustaceans, bony fish and other classes of organisms. They do not target any one particular species or class so are unlikely to affect community structure.

### *6.2 Impact on Predators*

As adults, sharks have few or no predators.

## References

Andrew et al (1996) FRDC Final Report. NSW Fish Final Report Ser No 1.

## 3.2 INDIVIDUAL FISHERY REPORTS (NON-RETAINED SPECIES, HABITAT AND GENERAL ECOSYSTEM ASSESSMENTS)

### Scope

The issues covered in these fishing method reports include the entire non-retained species component tree (Fig 3.1) and most of the general ecosystem component trees (Fig 3.2). The only issue from the general ecosystem tree not covered is the trophic effects which were covered in the previous section on species based reports (Section 2.1).

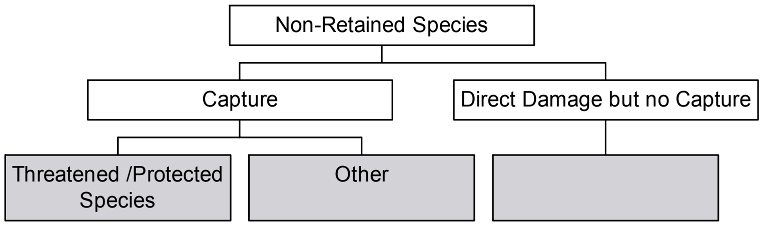


**Figure. 3.1 Generic Component Tree for Non Retained species.**

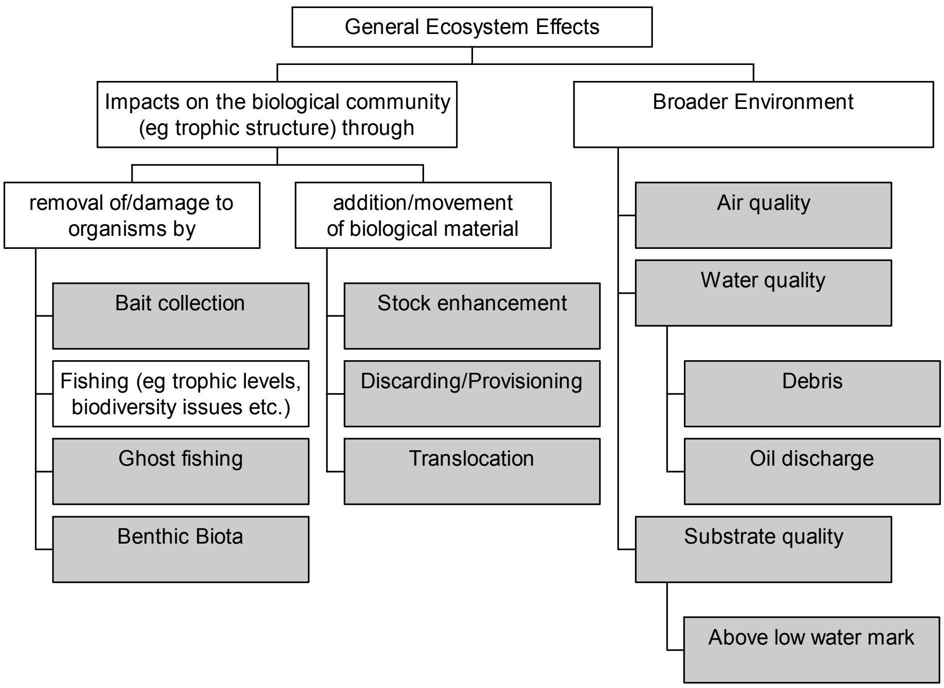


**Figure 3.2 Generic component tree for general ecosystems effects. Highlighted boxes indicate the issues covered in these fishing method reports. NB – the trophic impacts were covered in the previous section.**

## *Standard Questions (Used to create method reports)*

## 1.0 General Characteristics of the Fishing Method -

Are there comprehensive descriptions of the fishing methods used in the fishery or similar fisheries that would enable you to determine which issues may require assessment and what the likely levels of impact may be?

Are the types of fishing methods used generally associated with large or small impacts on the benthic habitat &/or broader ecosystem?

Does it appear that all the likely impacts have been identified and examined to at least some degree?

Is there anything about the way this fishery operates that makes it substantially different from other similar types of fisheries – either in a positive or negative way?

What are the main target species for this method?

## 2.0 By-catch

### *2.1 General By-catch Levels*

Do the types of fishing methods used - always/normally/rarely/never result in a high proportion of non-retained species in the catch?

Is there information to assess, in at least a qualitative manner, the level of catch of non-retained species for this fishing method in this fishery?

Are there individual species (in addition to the protected/threatened species covered below) that may require special attention – ie some particularly vulnerable species (see criteria in the species sections above)?

Is the information presented sufficiently compelling to determine from the risk assessment that direct and specific management is required or not required? These could include:

- non-retained catch less than 5% -10% of total catch;
- area of fishing activity covers less than 20% of the distribution of non-retained species caught.

For circumstances where more detailed responses are required, and/or ongoing management has been explicitly required, the following outlines the types of combinations of Performance Measures/Indicators that are often used. These are either:

- process based (the level of introduction of some management action – ie. not directly measuring impacts);

areal based (using the distribution of where fishing occurs to determine levels of impact); or

comparison based (comparing some measure from one time to another to assess performance).

The latter category can include measuring the amounts of bycatch caught per fishing operation, the level of fishing effort, the change in total amounts of bycatch caught by the fleet etc.

*Process Based*

% of vessels with Bycatch Reduction Devices (BRD)

(This is only useful if studies have already been done to indicate that these devices reduce the bycatch of each vessel to an acceptable level).

*Development of a Bycatch Action Plan*

(The plan would need to spell out what actions will be undertaken to achieve the objectives).

Thus, the main questions relate to how likely the processes implemented in these plans will be in producing the desired outcome?

*Spatially Based*

Area of fishing operation in comparison to the distribution of the non-retained species caught by the fishery.

The main question for this approach relates to how the relative areas of activity versus distribution are determined. Are there sufficient data to justify the assumptions?

*Comparison Based*

Absolute/Relative level of current/future by-catch / bycatch catch rate compared to some previous period. This could be either stated as a change in the ratio of the non-retained to retained catch, or as the total amount of non-retained catch.

Level of fishing effort compared to some previous period.

Specifying a percentage reduction in the level of by-catch caught that is required to make this acceptable.

The main questions for these types of indicators/measures relate to whether there is the ability to distinguish between a shift in the indicators caused by management of the issue or by a change in the abundance of the species.

### *2.2 Capture of Protected/Threatened Species*

These are special cases of the general by-catch section detailed in the previous section. Given their status and high level of community interest, they generally need to be assessed on an individual species basis rather than as a whole group - which is often the case for more general issues.

The initial Risk Assessment screening should include whether there is any interaction between the fishery and any species in these categories. If there is, then the risk should be based upon the real (or most probable) environmental impact to the stocks. Any moral/community-based reaction to the incidents may however, be relevant when assessing impacts on protected species. Where this is not the case, the assessment of these moral issues should be addressed within the Community attitude sections, not the environmental sections.

As a rule of thumb, if only one or two individuals are impacted per year, unless the affected stock is critically endangered, this should not be sufficient to warrant specific attention. Similarly, if a stock is endangered this should require tens to fifty per year being affected before extra management would be needed. Many protected species are not endangered and the level of catch allowable is usually based on community attitudes as to what is acceptable, not what is ecologically sustainable.

Nonetheless, when assessing protected species the appropriate management action should relate directly to the magnitude of measurable changes in estimates of absolute or (more commonly) relative abundance of these species concerned. For instance, syngnathids (pipehorses) have been harvested in the Qld East Coast Otter Trawl Fishery at least since the late 1980's and are taken in high numbers (estimated to be in the order of 14,000 in 2000/01). The most recent assessment on pipehorse catches in the ECOTF (Dunning *et al*. 2003) suggests this level of catch is moderately sustainable.

### References

Dunning, M., Bullock, C. and Haddy, J. 2003. Incidental pipefish harvest from the Queensland East Coast Trawl Fishery. Desktop study required as Condition 8 of the Declaration of an Approved Wildlife Trade Operation under the Commonwealth *Environmental Protection and Biodiversity Act 1999*, 10 July 2002. Queensland Fisheries Service. 23p.

## 3.0 General Damage/Removals

### *3.1 Ghost Fishing*

Does the fishing method continue to "fish" when the gear is lost?

If yes, how "effective" in continuing to catch (and kill) individuals is this ghost fishing likely to be? Almost as effective/moderately/minimally.

How long is this likely to occur for? Days, weeks, months, years?

What measures are in place to minimise the potential for this to be significant either in terms of the time this type of impact would continue for (e.g. using sacrificial anodes) or the effectiveness of capture (e.g. designs allow escapes to occur)?

### *3.2 Benthic Biota*

How destructive to the benthos is the method of fishing? A useful guide is the meta analysis completed by Collie *et al*. (2000). The level of impact is generally thought to increase in order (but there can be some variations around this).

- hand gathered [4]
- line[4]
- trap
- hand net
- haul net/purse seine
- prawn trawl
- beam trawl
- fish trawl
- dredge

[4] In general, hand gathered and line based fisheries will usually have little impact on the benthos except through anchoring and so should not have to undergo major scrutiny. Therefore, detailed assessments of these methods have not been provided in this edition.

The main questions that need to be asked to ascertain the level of risk to the benthos are:

- What are the substrates – mud, sand, reefs.?
- What type(s) of habitat is/are being affected (how resilient or sensitive are they?)?
- What (if any) epifauna (e.g. sponge, algae, corals) are affected?
- What are the relative recovery rates and distributions of the potentially disturbed flora/ fauna within this bioregion?
- What level of damage is likely to be caused to these habitats, at the scale relevant to the bioregion?
- What is the spatial arrangement of fishing? Is the effort localised or widespread? Is it increasing, staying the same, declining? How does this relate to the distribution of the habitat – ie. what percentage of the habitat type is affected by the fishing method?
- Do the areas affected by fishing stay the same amongst seasons or do the fishing zones move?
- What are the temporal patterns of fishing? Are the areas affected -continuously, only seasonally, probably singularly, or rarely?
- How does the magnitude and frequency of disturbance by the fishing activity compare to natural levels of disturbance within these habitats?

## 4.0 Addition/Movement

### *4.1 Discarding/Provisioning*

If non-retained species are caught by the fishery then their fate, if discarded, needs to be discussed (what is likely to eat them?) and the potential impacts this may have on the broader environment also needs to be considered. It is likely that only large levels of discarding would generate any significant impacts. The exceptions would be where the fishing operations occur in a very restricted area, or where they are occurring near some species or "feature" that could be directly impacted.

The questions are:

- What amount of discards is there?
- Over what area are the discards dispersed?
- What are the kg/km/year?
- What will eat the discards – seabirds, mammals, sharks, detritivores, scavengers?

### *4.2 Translocation*

There should be some discussion on the potential risk associated with the boats used in the fishing operations to transport exotic or other pest species from one location to another. This should be assessed against what would occur from natural oceanographic processes in the region. The only other issue would be if the fishing operations routinely moved individuals outside of their natural population range (this would most likely occur in conjunction with some aquaculture operation).

## 5.0 General Environmental Issues

### *5.1 Debris*

- Does the fishery discard waste? – e.g. bait bands, boxes etc.
- What protocols are in place to minimise this?

### *5.2 Fuel Oil*

- Are the boats likely to spill fuel or oil particularly if this is on sensitive areas?

### *5.3 Land based*

- Do the fishing operations require moving along the intertidal areas in trucks etc.? If yes, how are they minimising their impacts on these regions, are there controls imposed by local government authorities who usually control this access?
- Do the fishing operations involve camping etc.? If yes, what protocols are in place to minimise any impacts?

### References


Collie, J.S., Hall, S.J., Kaiser, J.J. and Poiner, I.R. (2000) A quantitative analysis of fishing impacts on shelf sea benthos. *J. Anim. Eco.* **69**: 785-798.


## Summary of Fishing Method Likely Risk Ratings

| Method | Overall | General Bycatch | Listed Species | Ghost Fishing | Benthic Effects | Discards/ Prov. |
|---|---|---|---|---|---|---|
| **Hand gathered** | LOW | Nil | NIL | NIL | NIL | NEGL. |
| **Line** | LOW | LOW | LOW | NIL | LOW | LOW |
| **Potting/ Trapping** | LOW | LOW | LOW-MOD | MOD-HIGH | LOW-MOD | NEGL. |
| **Haul Nets** | LOW – MOD | MOD | LOW | NEGL. | LOW - MOD | LOW |
| **Purse Seine** | LOW | LOW | LOW –HIGH | NEGL. | NEGL. | LOW |
| **Longlines** | LOW-MOD | LOW | LOW-HIGH | LOW | NEGL. | NEGL. |
| **Demersal Gillnets** | LOW | MOD | MOD | LOW - MOD | NEGL. | LOW |
| **Prawn Trawl** | MOD-HIGH | MOD –HIGH | LOW – HIGH | NIL | MOD-HIGH | MOD |
| **Fish trawl** | HIGH | MOD –HIGH | LOW –HIGH | NIL | HIGH | LOW -MOD |
| **Dredge** | HIGH | MOD | LOW-MOD | NIL | HIGH | HIGH |

# Potting/Trapping (demersal)

### 2.1 General Characteristics of the Fishing Method -

This type of fishing activity can occur from inshore regions in shallow waters out to the edge of the continental shelf depending upon the species being targeted. The design of the “pots” varies from those that use a batten design made of wooden slats to a beehive construction, constructed from cane and usually less than a metre in diameter normally having only one entrance. Traps are larger (1–2 m dimensions) and are mostly made with metal frames often with fencing mesh enclosing the frame. They may also have more than one entrance.

Many fisheries now require there to be escape gaps and neck sizes specified in regulations to minimise the capture of unwanted sizes and other non-target species. The mesh size of traps may also be subject to specific regulations. The main issues are what types of material are used to make the pot/trap, their size and internal design with respect to what they capture and what they allow to escape.

The pots/traps are usually baited (using some combination of fish and other flesh/hide) and released (set) from boats in regions thought to have the target species. These sites are often near reefs where these types of species reside or in regions thought to be along migration paths. They are identified by having long floating lines with floats attached to the end of the lines that have an identifying number/mark indicating ownership. They can be set in lines, or increasingly, due to the advent of GPS, at specific locations gained from an understanding of the target species and experience of where they are likely to get good catch rates.

Depending upon the fishery, the pots/traps may be left for a few hours, overnight or for a number of days during which time target species are attracted to the baits and enter the pots. They are usually retrieved (pulled) using winch systems and with the captured individuals removed and sorted on the deck of the boat.

Main target species:

Potting – lobsters, crabs
Trapping – demersal fish, crabs

**The likely level of direct impact for this method of fishing (if appropriate designs are used) on the habitat and aspects of the general ecosystem is LOW**[5]

### 2.2 By-catch

#### 2.2.1 General By-catch Levels

**Usually there are only LOW Levels of general bycatch/non-retained species in potting based fisheries.**

There are relatively few non-retained species caught by potting fisheries because only a select group of species actively enter pots. The main factor that will determine the amount of non-retained species caught in the pots is the size and placement of the entrance, whether there are any escape gaps and if there are internal chambers to restrict the chances of an individual escaping once it has entered. In the lobster and crab fisheries examined so far (ie.Tasmanian Lobster, WA Lobster, WA Crab) this has not been a major issue as they have each had regulations specifying what the design of the pots/traps has to be. Moreover, many of the species caught as non-retained bycatch can be returned to the water alive.

[5] This is not assessing the impact of removing the target species, see the previous section above for species based reports for discussions on these issues.

Experimental tests of fish trap designs by Ferrell (2001)[6] found that changing the mesh sizes in the bottom of traps can allow the escape of juveniles of the target species and many adult/ juvenile non-target species.

Given these minimal risks, there has not been a need to set specific performance limits and indicators for general bycatch for the potting/trapping fisheries examined to date.

#### *2.2.2 Capture of Protected/Threatened Species*

**There is usually only LOW-MODERATE risks of impacts to this group from potting based fishing**.

In the potting fisheries already examined, these have sometimes been associated with the capture of species within these categories. Seals (especially juvenile and adolescents) may be attracted to the bait in the pots and get stuck in the neck. This has required research work to minimise this possibility both in SA, and more recently in WA. The other issue that has occurred is the entanglement of whales and turtles in the rope lines. Given that these species are afforded higher levels of protection, performance reports are often needed.

***Performance Measures/Indicators***

- Absolute level of current/future by-catch compared to some previous period;
- Size of mature population of affected species.

The WA Lobster fishery monitors the interactions of the fishery with seals and turtles. Any increase in the number of logged observations, media reports or other recorded interactions with leatherback turtles for the current long term average of one per year would result in a re-assessment of the risk. This level of interaction is monitored by the Department of Fisheries observers on board commercial vessels, fishers logbooks and an annual survey of all fishers.

Given that any interactions with those species must be reported to EA as part of the EPBC Act, it seems appropriate that some assessment is made annually on their current rates of capture.

### ***2.3 General Damage/Removals***

#### *2.3.1 Ghost Fishing*

**The likely risk for ghost fishing from these methods are LOW – HIGH depending upon the design of the pot/trap.**

This should only be an issue if the design of the pots is such that individuals which enter the pot cannot leave the pot. Thus, Bjordal (2002) rated this method as potentially being ‘relatively non-favourable’ with respect to ghost fishing. Therefore, acceptable designs should not include parlour pots and should have at least one unobstructed entrance and probably have one or more escape gaps. The pots need to be made from steel or wooden bases with wooden slats or cane and tee-tree sticks on the other sides. These products decay readily which prevents any significant ghost fishing problems arising even if some individuals cannot escape. There should be some understanding of how effective they will be in allowing escapes of individuals if lost, and the length of time before they will not fish.

For demersal fish traps, there is video evidence (Moran and Jenke, 1989[6]; and others) that fish can swim in and out of standard fish traps with relative ease so long as there are no structures in the entrance specifically stopping this. Therefore, with such designs, ghost fishing should not be a problem.

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[6] Ferrell, D. NSW Fisheries FRDC Final Report.

### 2.3.2 Benthic Biota

**The likely risk to non-fragile benthic habitats from potting/trapping are LOW**

The video evidence obtained from observing fish traps (Moran & Jenke 1989)[7] found that these types of structures almost always lift off vertically when pulled, they do not scrape along the bottom. Thus, the traps were observed to move gently both when dropped and retrieved and did not appear to cause damage to soft corals and sponges present in the areas where the tests were completed.

Furthermore, unpublished video studies on a lobster fishery in WA conducted in the 1980s (R.S Brown[8], unpublished) found similar results for lobster pots. Thus, lobster pots probably never scrape across the substrate when they are pulled and therefore they pose little threat to most benthic habitats such as sand, rock and seagrass.

The main area where pots could affect habitats is if they are dropped in large numbers and frequently on fragile habitats such as branching corals (Webster et al, 2002)[9]. The area where this is allowed to be undertaken should therefore probably represent only a relatively minor percentage of this habitat.

## 2.4 Addition/Movement

### 2.4.1 Discarding/Provisioning

Because the level of by-catch of non-retained species is relatively small, this is usually not and issue for these types of fisheries. The only concern that needs some discussion is the large usage of bait that is required, - particularly what are the origins of the bait?

### 2.4.2 Translocation

There are no specific issues for these types of fisheries.

## 2.5 General Environmental Issues

### 2.5.1 Debris

For potting based fisheries, appropriate disposal of their waste will include what happens to the bait bands, bait boxes etc. that are usually used.

### 2.5.2 Fuel Oil

Unless the area of operation of the boats makes it likely to spill fuel or oil on sensitive areas this should not be an issue.

### 2.5.3 Land based

These fisheries generally do not directly impact on the land environment, as the boats have to be big enough to transport numerous pots but they may involve the use of dinghies which may be dragged over the beaches. The main impacts would be the fishing activity involved with camping on offshore islands or other isolated regions.

## References

Bjordal, A. (2002) The use of technical measures in responsible fisheries: regulation of fishing gear. In: *A fishery manger's guidebook. Management Measures and their application.* FAO Fisheries Tech. Paper 424: 21-48.

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[7] Fisheries Research Report, Fisheries Dept. WA, No 82, 29 pp.

[8] Dept. Fisheries, WA.

[9] Fisheries Research Report, Dept Fisheries, WA., No 134 120 pp.

# Demersal Gillnets

### *2.1 General Characteristics of the Fishing Method -*

**The likely level of direct impact for this method of fishing on the habitat and aspects of the general ecosystem is LOW.**

Demersal gillnets are used to catch a variety of finfish species but especially larger species such as sharks. These nets are usually long (>200m) but not very wide (about 2m high) with surface floats at each end to locate the net and weighted footrope to keep it on the bottom and a floating head rope to keep the net upright. It is common practice for intermediate surface float lines to be attached to nets to reduce the amount of net that is susceptible to two double 'bite-offs', where both the head line and ground line are severed twice between float lines. The nets usually have relatively large mesh (usually defined in the management plan) and are therefore relatively selective in the sizes of individuals they capture. The sizes used can be tuned to make the capture of either small and/or larger individuals unlikely.

Given the selectivity of the nets, high levels of bycatch are not common but interactions with protected species may occur. Whilst the nets do not make a significant contact with benthic communities (ie. they have a very small footprint), there can however, be issues associated with ghost fishing.

Main target species – sharks, demersal fish.

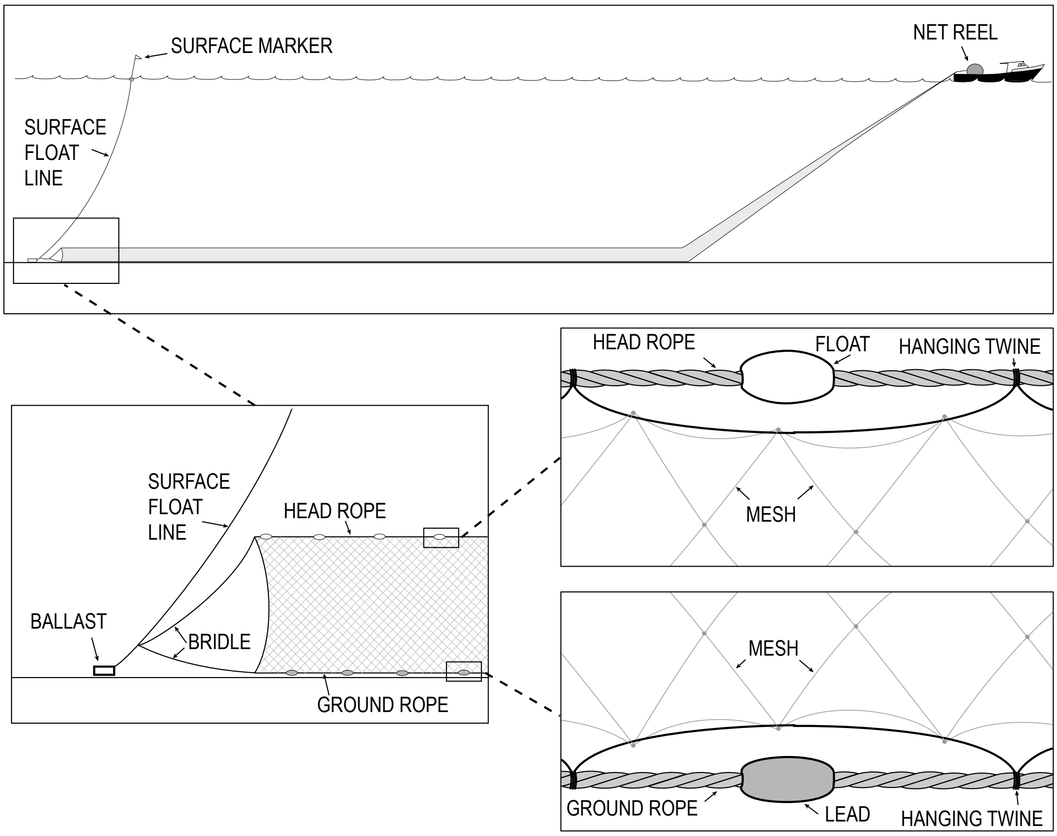


**Figure 3.3 Typical demersal gillnet configuration (From McCauley, 2003)**

### *2.2 By-catch*

#### *2.2.1 General By-catch Levels*

**This is likely to be a LOW risk issue.**

Generally, the level of non-retained species in these nets is low because they are very selective in what is retained.

#### *2.2.2 Capture of Protected/Threatened Species*

**This is likely to be a LOW –MODERATE risk Issue.**

Turtles – many of the turtles in Australia (e.g. Olive ridley, hawksbill and flatback turtles) have primarily tropical and subtropical distributions and thus, the risk of them coming into contact with dermersal gillnets, set off the lower half of Australia (operational area of most of the demersal gillnet fisheries) is low. The southernmost ranges of green and loggerhead turtles, overlap with some fisheries. No turtle captures have been observed in the JASDGDLF, WCDGDLF and fishers claim to catch, on average, one turtle every 2-3 years.

Cetaceans – In WA demersal gillnet fishers report catching an average of only one dolphin every several years.

Seals – Demersal gillnet fishers reported actively avoiding areas surrounding seal colonies as not only do they find the capture of these species highly unpleasant, but seals, sea lions and the large predatory sharks that they may attract can cause extensive damage to their nets. The majority of fishers are also well aware of the need for pinniped conservation and of the negative publicity that would be generated if their industry was perceived to be causing a significant level of pinniped mortality. The majority of demersal gillnet and demersal longline fishers either report never catching seals or sea lions or, at most, catching one every several years.

Protected sharks – Some protected shark species (e.g. white sharks, grey nurse) may be caught by this fishing method. The level of risk will depend upon the frequency of this interaction, the state in which the sharks are when captured and for the grey nurse, which population is affected (e.g. east or west coast of Australia).

### *2.3 General Damage/Removals*

#### *2.3.1 Ghost Fishing*

**The risk rating for this issue will probably be LOW – MODERATE.**

The potential consequence of ghost fishing for this method has been acknowledged, with a possible consequence rating of severe. Thus, Bjordal (2002) rates this type of fishing as having potentially non-favourable impacts with a score of 1[10]. However, with methods used in Australia (large mesh, small height and non-pelagic), the likelihood of gear loss is small and a more realistic consequence is likely to be minor.

In most of these fisheries, the only means of losing demersal gillnet is in the highly unlikely event of two double ‘bite-offs’, where both the head rope and the ground rope are severed

[10] Bjordal (2002) rates a number of issues for each of the main fishing methods as being highly favourable (10) to non favourable (1). Where relevant these scores will be provided.

twice between float lines. This event is considered extremely rare. To mitigate this already small risk, it is now standard practice for demersal gillnet fishers to attach intermediate surface float lines to their nets to reduce the amount of net that is susceptible. Demersal gillnets are therefore, far more likely to suffer single 'bite-offs', in which case they can be retrieved by simply recovering the next float line, or suffer torn meshes.

Moreover, because demersally set gillnets are weighted sufficiently to remain attached to the benthos in high-energy near-shore environments, should they ever suffer a double 'bite-off', they are unlikely to travel far. Fishers therefore consider that they have a very realistic chance of retrieving their gear and claim they would spend a significant amount of time attempting to do so as net and the associated gear is so expensive. It was also felt that should lost net be irretrievable, with out the floats to support it rather than continue fishing, they will roll up and be rendered ineffective.

#### *2.3.2 Benthic Biota*

**The potential consequence to benthic biota from demersal gillnets is probably NEGLIGIBLE.**

The 'footprint', ie. the proportion of the available benthos that this gear usually comes into physical contact with, is very small (probably less than 0.001%).

The gear is passive and, as it is recovered by lifting straight up off the bottom, it therefore, causes negligible damage as it is retrieved.

The fishing gear is set on soft substrates, usually sand.

The fishery does not target areas continuously. Fishers move locations frequently and it is therefore, unlikely for an impact to occur even at a local level.

The gear is operated in a high-energy environment, ie. habitats that are exposed to naturally high disturbance from surge, wind and wave action.

Bjordal (2002)[9] rated this method as a 7 for habitat effects which is favourable.

### *2.4 Addition/Movement*

#### *2.4.1 Discarding/Provisioning*

**The consequence of discarding/provisioning using this method of fishing will usually be NEGLIGIBLE – LOW as a result of the following factors:**

The total amount of discarded material in these fisheries is usually small and occurs over a wide area 1000s $km^2$

Approximately 70% of the non-retained bycatch is returned alive (from estimated catches, McAuley and Simpfendorfer, draft report).

Fishers move location regularly and may discard less than 1kg/$mile^2$ per year.

Sharks and other fish have not been observed following vessels to feed on discards. Birds are regularly observed feeding on discarded material but, since this sinks quickly, they are only likely to obtain a small amount. Only a few dozen birds (primarily shearwaters) are seen around vessels at any given time and this number decreases with distance offshore.

### 2.4.2 Translocation

One issue for this type of fishery related to translocation is whether there is any major likelihood of the transfer of exotic organisms in the nets if they are moved from one location to another. There is also the possibility of hull fouling organisms moved from one location to another (like all vessels).

## 2.5 General Environmental Issues

### 2.5.1 Debris

As no bait is used in gill nets there is less chance that there will be significant levels of debris.

### 2.5.2 Fuel Oil

No specific issues for these vessels.

### 2.5.3 Land based

Normal land operations apply.

## References

Bjordal, A. (2002) The use of technical measures in responsible fisheries: regulation of fishing gear. In: A fishery manger's guidebook. Management Measures and their application. FAO Fisheries Tech. Paper 424: 21-48.

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# Purse Seine Nets

## 2.1 General Characteristics of the Fishing Method -

**The likely level of direct impact for this method of fishing on the habitat and aspects of the general ecosystem is generally LOW[11]**

Purse seine fishing involves the encircling of a school of the target species (usually pelagic fish such as sardines, mackerel or tuna) by a wall of small mesh netting, usually some 200 or more metres in length and a depth of 20m or more. Once the school is encircled, a purse line that runs along the ground line of the net is pulled which closes the bottom of the net and traps the fish in the "purse". The net is then retrieved, mostly using a hydraulic power block, until the fish are concentrated into a small region of the net, "the bunt" (which is reinforced). The fish are then manually brailed onto the deck or sucked up with a fish pump. This is a very targeted form of fishing that in Australia does not capture a large amount of bycatch. However, some protected species (e.g. dolphins) may be affected in some regions.

Main target species – baitfish, tuna, mackerel.

[11] This does not consider the impact of catching the target species – see species report for this assessment.

### 2.2 `By-catch

#### 2.2.1 General By-catch Levels

**This is likely to be a LOW RISK issue.**

Due to the targeted nature of this fishing, where schools are located by sounder/sonar and only shot when there is a high expectation that the target species is available, the bycatch of unwanted species is generally low and restricted to the small numbers contained in the area of the target schools. In situations where the wrong species or sizes are caught, the net can be dropped and the fish swim away. Significant mortality of caught individuals only occurs when the fish have been concentrated in the bunt. Bjordal (2002) rated this issue as highly favourable with a score of 9.

#### 2.2.2 Capture of Protected/Threatened Species

**Whilst this is probably a LOW risk to these stocks, the issue may be LOW – HIGH risk for community concerns.**

The capture of air-breathing mammals can occur if they become encircled by the nets. If they get caught in the folds while the net is being retrieved this can lead to their death. The capture and death of dolphins have been reported off Qld in the one purse seine vessel that operated in this region in the late 1990's. This was the catalyst to stop these operations. Off the south coast, occasional captures of seals have been made although not in large numbers, as the seals are usually adept at getting out of the nets. In some circumstances, the net has to be manually lowered to allow for their escape.

### 2.3 General Damage/Removals

#### 2.3.1 Ghost Fishing

**This is a NEGLIGIBLE risk issue.**

Purse seine nets do not fish when they are lost. Their high value and large size makes it extremely unlikely that significant numbers are lost. Normally, if a purse seine net does hook up, most of the net is almost always retrieved, albeit torn. Bjordal (2002) gave this method a favourable rating with resect to ghost fishing with a score of 9.

#### 2.3.2 Benthic Biota

**This is a NEGLIGIBLE risk issue.**

Purse seine nets are not designed to touch the bottom in any conditions except where there are no rocks or major structures on which they can get hooked on. Even where they do contact the bottom, the ground rope is not heavily weighted and therefore they do not drag off a significant amount of material as they pass over the bottom during retrieval. Bjordal (2002) rated this issue for purse seining as minimal, with a score of 9.

### 2.4 Addition/Movement

#### 2.4.1 Discarding/Provisioning

Due to the highly targeted nature of this method, there is usually little bycatch in these fisheries and hence, little discarding of non-target fish. The main discard is in situations where boats “purse up” too much catch to handle on board and they have to “roll” out the excess and these individuals will mostly die (Blight et al, 1999)[12]. Codes of conduct have been implemented for such circumstances to minimise these losses.

**Depending upon the frequency of such events this issue will rate from LOW – MOD.**

#### *2.4.2 Translocation*

Not likely to be a significant issue as purse seine operations in Australia are relatively localised.

### *2.5 General Environmental Issues*

#### *2.5.1 Debris*

No specific issues

#### *2.5.2 Fuel Oil*

No specific issues

#### *2.5.3 Land based*

No specific issues

### References

Bjordal, A. (2002) The use of technical measures in responsible fisheries: regulation of fishing gear. In: *A fishery manger's guidebook. Management Measures and their application.* FAO Fisheries Tech. Paper 424: 21-48.

## Longlining

### *2.1 General Characteristics of the Fishing Method -*

From McAuley (2003)[13], longlining works by attracting fish to baited hooks. There are two types of longlining – demsersal, or bottom set; and pelagic or mid water set. They have a single, long main-line, which is usually made of thick polypropelene, from which shorter and thinner lines (snoods or ganglions) are attached at intervals, each of which has a baited hook at the end.

Demersal – The demersal long lines typically consist of long (4–15 km) of 12mm polypropelene mainline, marked at either end with surface floats (Figure 3.4). Intermittent surface floats are attached to enable retrieval of the gear in the event of the main line being severed. The line is secured to the seabed with ballasts at ether end and along the length of the mainline at intervals of approximately 200m. The mainline is suspended above the seabed between ballasts by pressure resistant floats.

[12] Department of Fisheries, WA.

[13] Dept. Fisheries, WA.

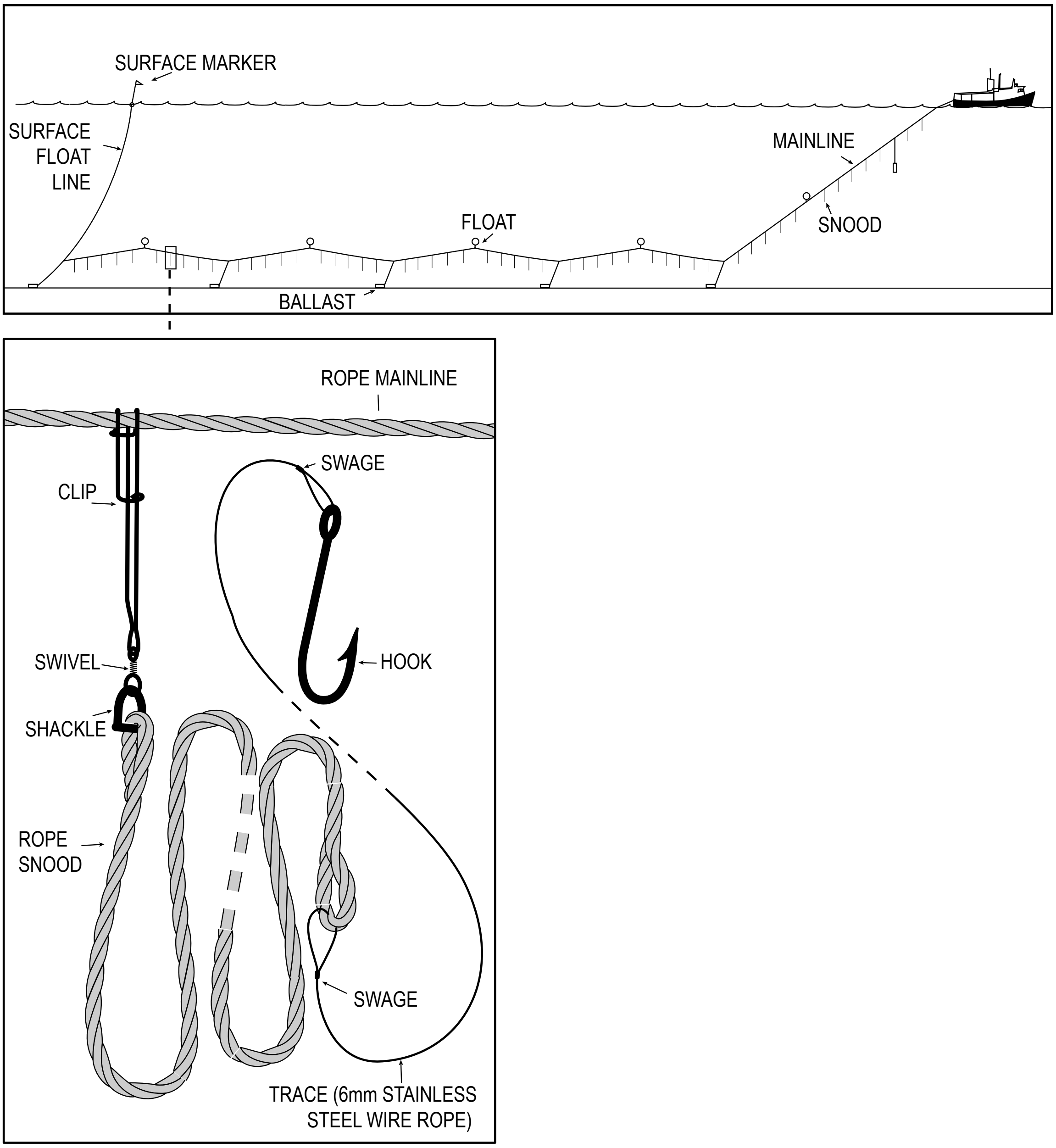


**Figure 3.4 Typical WA demersal shark longline/dropline configuration (From McAuley, 2003)**

Baited hooks are attached to the mainline via a relatively short 2-3 m snood (ganglion) with a stainless steel shark clip at approximately 10 m intervals. Snoods are comprised of 1-1.5 m of metal trace wire (typically 0.2 mm stainless steel wire rope) attached to a 1-1.5 m length of rope. Hydraulically powered drums are used to set, retrieve and store the gear.

Main target species includes sharks and demersal fish.

Pelagic Longlines – These have long monofilament mainlines which are suspended in mid-water by a series of surface floats. The baited hooks are suspended by monofilament line from the mainline at varying depths depending upon where fishing is operating and species are being targeted. The average pelagic long line is 51 km with over 1,000 hooks.

Main target species are tuna and swordfish.

### *2.2 By-catch*

#### *2.2.1 General By-catch Levels*

**The likely Risk Rating is LOW – MODERATE**

Despite the longlines using baited hooks to attract a variety of species, this gear is considered to have medium to high species and size selective properties (Bjordal, 2002). These properties can be effectively controlled by varying the species of bait used, the size of the hooks and the depth of operation. Consequently, general bycatch levels are not large. Nonetheless, there can be issues where the bycatch is sharks.

#### *2.2.2 Capture of Protected/Threatened Species*

The issues surrounding the capture of protected and threatened species differ between demersal and pelagic/midwater longlines particularly in relation to the capture of seabirds (EA, 2000). Birds may be captured when the lines are being set, when they are being hauled or when they ingest discarded material. The relative rate of seabird bycatch was rated as high for the domestic tuna (pelagic) longline fishery but only low for the demersal fisheries (EA, 2000).

Likely Risk Rating:

**Demersal – LOW – MODERATE**

**Pelagic – MODERATE -HIGH**

Performance Measures:

- Counts of seabirds caught using observer programs
- Rate of introduction of mitigation practices or devices (e.g. night setting, weighted hooks, underwater setting,

### *2.3 General Damage/Removals*

#### *2.3.1 Ghost Fishing*

**Likely Risk Rating is LOW**

These methods of fishing generally only fish whilst the hooks are baited. Therefore, there is little chance of a significant level of ghost fishing from lost or discarded long line gear. Furthermore, this gear is expensive and therefore, unlikely to be left. Given its design, it is unlikely that large sections would be lost - with the long length and numerous floats. Bjordal (2002) gave this method a highly favourable ecosystem rating of 9.

#### *2.3.2 Benthic Biota*

**Likely Risk Rating is NEGLIGIBLE**

The footprint of impact from longline gear on the benthic habitat is very small. Pelagic gear only has a few weights attaching the gear to the bottom. Demersal gear has more contact points but each of these is small. Bjordal (2002) gave this method a favourable ecosystem risk rating of 8 for this issue.

### *2.4 Addition/Movement*

#### *2.4.1 Discarding/Provisioning*

**Likely Risk Rating is LOW -MODERATE**

Given that the level of bycatch using these methods is low, the level of discarding and provisioning will also tend to be low. The main issue will be the effects on seabirds and the potential this may have to increase their chances of getting hooked on the gear when it is reset.

#### *2.4.2 Translocation*

**Likely Risk Rating LOW**

Depending upon the type of operations there is only a small chance that material would be moved in a viable state from one location to another. The most likely vector would be from fouling of the hull.

### *2.5 General Environmental Issues*

#### *2.5.1 Debris*

Nothing specific, normal issues such as the disposal of bait bands and boxes plus general rubbish.

#### *2.5.2 Fuel Oil*

Nothing specific.

#### *2.5.3 Land based*

Not normally needed for these types of operations.

## References


Bjordal, A. (2002) The use of technical measures in responsible fisheries: regulation of fishing gear. In: *A fishery manger's guidebook. Management Measures and their application.* FAO Fisheries Tech. Paper 424: 21-48

Environment Australia (2000) Threat Abatement Plan for the incidental catch (or by-catch) of seabirds during oceanic longline fishing operations. EA Biodiversity group, Canberra, Australia 61pp

# Haul/Seine Nets

### 2.1 General Characteristics of the Fishing Method -

**The likely Risk Ratings for these methods are LOW to MODERATE**

This method is similar to purse seining but operates from shore/beach, using small vessels to set the net which are often retrieved by hand. The method operates by surrounding a school of fish or a region of habitat where fish often congregate with a netting wall. The net is made of small mesh size such that the target species do not get entangled and the ends of the net are then drawn together, either onto the beach or back to a boat. The entrapped fish are then removed from the bunt, which is the reinforced section in the central section of the net.

Target Species – a variety of inshore bait fish (sardines, whitebait), and coastal species (e.g. mullet, salmon).

### 2.2 By-catch

#### 2.2.1 General By-catch Levels

**Likely Risk Rating – Moderate**

In situations where fishers are targeting specific schools of fish (e.g. salmon fishing, mullet fishing), the level of bycatch will be low. Where fishing involves beach seining of defined areas, not schools of fish, they may have poor selective properties and therefore, there can be a relatively high level of bycatch. Bjordal (2002) rates this aspect as a 2. Bycatch levels in seine nets was estimated by Gray et al (2001) for NSW estuarine fishing and also using trials of nets that had BRDS in the bunt. The ratio of catch to discards in Botany Bay was 2:1 (Gray *et al,* 2001).

From experimental work that has been done it appears that the mortality rate of fish that pass through the meshes is likely to be low (Broadhurst *et al.,* 1999).

#### 2.2.2 Capture of Protected/Threatened Species

**Likely Risk Rating – LOW**

Given the environments where these types of fishing occur (inshore and estuaries), this minimises the likelihood of contact with most of these listed species. The situations where the fishery does have interactions with these species, there is a high degree of control by fishers to let these individuals escape unharmed.

### 2.3 General Damage/Removals

#### 2.3.1 Ghost Fishing

**Likely Risk Rating – NEGLIGIBLE**

These nets are small mesh and hence, would not capture fish unless they are hauled. Moreover, given the methods of operations they are not normally lost and hence the chances of any ghost fishing is almost non existent.

#### 2.3.2 Benthic Biota

**Likely Risk Rating Low – Moderate**

The potential impacts that could occur as a result of hauling nets dragging over the benthos includes damage to sedentary organisms (including seagrass) and the alteration to sediment type and stability (NSWF, 2001). Experimental studies in Australia have shown that the effects of hauling nets on seagrass communities are unlikely to be major. Thus, whilst hauling may have caused a reduction in leaf length in *Zostera* beds of NSW, these operations were associated with increased shoot and leaf density (Otway & Macbeth, 1998). Similarly in SA, hauling over *Posidonia* beds resulted in minimal impacts due to the pressure wave which flattened the seagrass and therefore only removed dead blades and epiphytes (Cappo et al., 1998).

### 2.4 Addition/Movement

#### 2.4.1 Discarding/Provisioning

**Likely Risk Rating – LOW**

For targeted haul net fishing (e.g. salmon mullet), bycatch levels are low and therefore, there are few potential issues of provisioning. For the less targeted haul net fishing, where there are significant levels of bycatch, the method of sorting the catch can affect what levels of provisioning are likely. If the catch is sorted in water then many of the unwanted speces survive. If sorted on land then most of the bycatch will be dead. The most likely beneficiaries of this discarded catch are birds and crabs (NSWF, 2001).

#### 2.4.2 Translocation

**Likely Risk Rating – Moderate**

There is some chance that algae can be moved from one estuary/region to another from specimens that get trapped in the meshes. This may increase the chances of dispersal of exotic species. Thus, it was concluded that the "*movement of haul nets and mesh nets between fishing grounds is a significant vector for the movement of some hardy species particularly if the net is not thoroughly cleaned after each fishing operations .... and remains damp."* (NSWF, 2001).

### 2.5 General Environmental Issues

#### 2.5.1 Debris

There is unlikely to be significant debris apart from that caused by the sorting of the catch (see below).

#### 2.5.2 Fuel Oil

These operations use little fuel and oil and in some cases not even a motorised boat.

#### 2.5.3 Land based

Often the sorting of the catch caught by haul nets is completed on the beach/shore which is in view of the general public. This can result in significant concerns if this sorting is not done in a sensible fashion. The fate of discards needs to be thought of and appropriate codes of conduct developed.

## References

Bjordal, A. (2002) The use of technical measures in responsible fisheries: regulation of fishing gear. In: *A fishery manger's guidebook. Management Measures and their application.* FAO Fisheries Tech. Paper 424: 21-48.

Broadhurst, M. et al. (1999) Scale loss and survival of juvenile yellowfin bream, *Acanthopagrus australis* after simulated escape from a Nordmore-grid guiding panel and release from capture by hook and line. Bull. Mar. Sci. 64:255-268.

Cappo, M. et al., (1998) A review and synthesis of Australian fisheries habitat research. FRDC Project 95/055 AIMS Townsville, Qld.

Gray, C.A. et al. (2001) Retained and discarded catches from commercial beach-seining in Botany Bay, Australia. Fisheries Research 50:205-219.

NSWF (2001) Estuary General Environmental Impact Statement, Volume 2. NSW Fisheries, Cronulla, NSW

Otway, N & W. Macbeth (1998) Physical effects of hauling on seagreass beds. FRDC Project 95/149 & 96/286. NSW Fisheries Final Report Series No. 15. Cronulla, NSW.

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# Prawn Trawling

### *2.1 General Characteristics of the Fishing Method -*

**The possible impact of Prawn Trawling on the habitat and broader ecosystem can be MOD –HIGH and therefore requires specific management.**

Most prawn trawl fishing in Australia is conducted using demersal otter trawling (Figure 1). This can be completed with vessels that tow between two and four standard otter trawl nets.

The otter boards are attached to the extremities of each net at the opening and they slide across the sea floor. The lateral spread they provide is vital to the catching efficiency of trawl gear and determines the area swept. Generally, the headrope and ground rope is spread between 60% and 85% of their length. Attached to the footrope is the ground chain, which may be limited in size. The ground chain travels across the sea floor and disturbs the prawns and scallops so they rise from the seafloor and into the oncoming net.

The height of the fishing gear is set by the height at the point where they are connected to the otter boards. Forces produced by water flowing over the otter boards open the trawl nets laterally. Low opening nets have the headrope as a lead-ahead, which acts as a net veranda and is set in front of the footrope. This ensures that prawns disturbed by the ground chain do not pass over the headrope and thus maintains the catching efficiency of the nets.

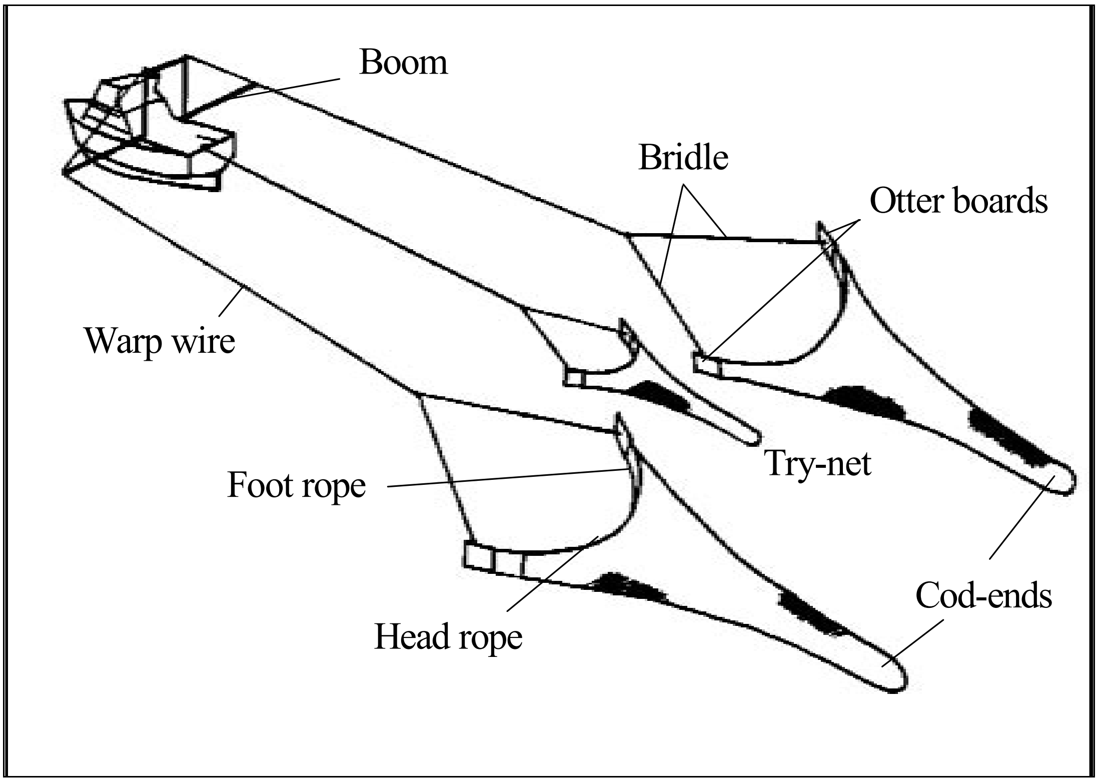


**Figure 1 The standard twin otter rig and try gear used by prawn trawlers in Australia.**

Some fleets have bycatch reduction devices (BRDs) in the form of large object excluders (i.e. grids) and finfish excluders (e.g. square mesh panels). The grids can be bottom-opening or top-opening types depending upon the occurrence of heavy rocks and sponges on the trawl grounds.

Finally, some fisheries have a 'well' or "hopper" sorting system on board. This system allows for the catch to remain in water for an extended period, thereby maximising the survival of discarded species. Dell *et al*. (2001) have evaluated the use of hoppers for reducing bycatch mortality in the Queensland East Coast Otter Trawl Fishery. These systems are relatively expensive so not all fleets have them fitted.

### References

Dell, Q., Gribble, N., Foster, S. D. and Ballam, D. 2001. Evaluation of "Hoppers" for reduction of bycatch mortality in the Queensland East Coast Prawn Trawl Fishery. Draft Final Report to FRDC on Project No. 2001/098. 59 p.

## 2.2 By-catch

### 2.2.1 General By-catch Levels

**This can be a LOW – MOD risk issue depending upon the management arrangements and relative areas of operation.**

Since prawn trawling is a non-selective form of fishing, other species which include adults of small fish species and juveniles of other larger fish, are often caught. Since these fish are generally not of commercial value, they are discarded. The ratio of discards to retained catch is often large varying from 2:1 to in excess of 10:1 (Andrew & Pepperell, 1991).

Consequently, there needs to be a reasonable assessment of the risks to the discarded species. This can be done through a formal species risk assessment process (e.g. Stobutski, 2000) if the activity occurs over a relatively wide area or from spatially based assessments if the activity is restricted in its area of operations.

### *2.2.2 Capture of Protected/Threatened Species*

**This can be a LOW – HIGH risk issue depending upon the management arrangements and relative areas of operation.**

These are special cases of the previous general bycatch section but generally need to be assessed on an individual species basis rather than a whole of group as is often the case for more general issues.

The initial Risk Assessment screening should include whether there is an interaction between the fishery and any of these species. If there is, then the risk should be based upon the real environmental impact to the stocks, not because of any moral/community-based reaction to the incidents. Any non-environmental issues should be addressed within the Community attitude sections, not the environmental sections (but most protected species are not endangered and the level of catch allowable is usually a community attitude based decision).

As a rule of thumb, if only one or two individuals are impacted per year, unless the stock is critically endangered, this should not be sufficient to warrant specific attention. Similarly, if a stock is endangered this should require tens to fifty per year being affected before extra management would be needed.

**Assessment of the Robustness of common bycatch management methods/indicators**

In most circumstances, there will need to be an explicit report justifying how the fishery is not placing any of the non-retained species in unacceptable risk categories. In terms of the objectives and performance measures and indicators that may be developed, these can be either process or outcome based. The level of robustness of the management methods varies accordingly.

**Process Based (Robustness – LOW to MOD)**

*% of vessels with BRDs,*
*Development of a BAP*

For these indicators to be robust there needs to be the experimental data available to show that the devices being implemented are effective in reducing any impacts to acceptable levels. Thus, it is probably most appropriate for the implementation of TEDs and the capture of mega fauna that can be counted easily and for which there may be a complete removal of captures once implemented. For the general bycatch of fish species, these would probably require additional information in addition to just implementing BRDs to be fully acceptable. Whilst there is significant experimental work to show the value of square mesh panels within the prawn trawl cod ends for reducing the capture of unwanted fish (e.g. Broadhurst & Kennelly 1997), the higher the reduction in bycatch and/or the lower the bycatch becomes after implementation the greater the robustness of these measures.

Example WA Shark Bay Prawn Fishery – Loggerhead Turtles *(This was accepted as part of the EPBC assessment).*

*Indicator – Proportion of fleet fishing with two BRD grids.*

*Justification* – Turtle exclusion devices are recognized as the best practice management technique for eliminating turtle capture in trawl fisheries. The proportion of the fleet fishing with BRDs will give a direct measure of the proportion of the fleet with the ability to catch turtles.

*Performance Measure* – 100% fleet fishing with two turtle exclusion devices. 90% turtles returned alive from non-BRD nets.

***Justification:*** At the commencement of the 2002 season, all vessels will be fishing with two BRD nets. Until the full introduction of BRDs (i.e. commencement of 2002 season) and in the later periods when exemptions to the use of BRDs in specified areas are granted, 90% of turtles should be returned alive. This level is set high as a precautionary measure due to the protected and threatened status of this species, but also in recognition that accidental losses still might occur.

**Spatially Based (Robustness – MOD – HIGH)**

Area of fishing operation in comparison to the distribution of non-retained species.

*Examples* – WA Shark Bay Prawn Trawl *(this has been accepted as part of the EPBC assessment for this fishery).*

Objective To ensure that there are adequate refuge areas provided within Shark Bay, for species that are caught and discarded by the SBP fishery.

*Justification:* Regardless of the level of impact on discarded fish species within the trawl grounds, if an adequate proportion[14] of the populations of these species are located outside the trawl area, then this should ensure their sustainability.

*Indicator – Distribution of bycatch species within and outside the trawl grounds.*

***Justification:*** Information on the distribution of bycatch species both within and outside the area of trawling from a research survey of the region will indicate the proportion of the region that provides a refuge to these species from trawling.

*Performance Measure* – The major species of bycatch are found in significant numbers outside of the trawled areas.

***Justification –*** Of the small fish that are caught and discarded, very few are subject to other fishing mortality; therefore the trawl fishery is the only known direct activity impacting the species. Young fish, which are generally caught by trawlers, commonly have high mortality rates and, as such, the fishing mortality may have little additive impact on this rate. Secondly, as the species are generally only taken by trawling, maintaining a trawl impact of less than 40% on the stock distribution can be expected to keep all of the individual stocks above the precautionary reference point of 40% of virgin biomass for most finfish species

**Comparison Based (Robustness – LOW – HIGH)**

Absolute level of current/future by-catch compared to some previous period
Level of fishing effort compared to some previous period
Percentage reduction in the level of by-catch required

[14] this adequate proportion should use the same principles as determining adequate depletion of target stocks (ie > 40% should be adequate for any species).

*Example* – East Coast Trawl (Qld)

The current Qld East Coast Trawl plan has an objective to reduce bycatch from the 2000 levels by 40% by 2005. There was, however, no specific justification given for this level and it was likely to be measured as a combination of a reduction in total fishing effort (swept area) and from the introduction of BRD grids and mesh panels. *(This has been accepted by GBRMPA).*

### 2.3 General Damage/Removals

#### 2.3.1 Ghost Fishing

**This is a LOW risk Issue**

Not an issue for prawn trawling because this gear is only capable of fishing when being towed.

#### 2.3.2 Benthic Biota

**This is potentially a MOD – HIGH risk issue depending upon the management regime.**

**General**

A recent assessment of the effects of trawling and dredging on seafloor habitat (Steele *et al*,. 2002), provides a useful summary of these issues. The direct responses of benthic communities to trawling and dredging are consistent with ecological predictions on disturbance theories. Stable communities of long lived low mobility species are more vulnerable to acute and chronic effects than short lived species in changeable environments. Thus, the extent of the initial effects and the rate of recovery depend upon the stability of the habitat – the more biogenic (mud) habitats experience the greatest changes and slowest recoveries. Coarse sediments in areas of high natural disturbance show fewer initial effects and because they are colonised by opportunistic species, also recover faster. Similarly, a meta-analysis of fishing impacts by Collie *et al*. (2000) found that otter trawling had the least impact of all forms of trawling.

Two basic approaches can be taken to address these issues. One is where trawling is allowed to occur over a relatively high percentage (>50%) of the trawlable[15] habitats in a bioregion unless there is evidence to restrict it. This method requires the assessment (and ongoing monitoring) of the level of impact that trawling is causing to the communities in the bioregion (infauna, epifauna, benthic or pelagic bycatch) and was the approach taken in the GBRMPA experiment. Such a strategy requires a high level of information on the biodiversity of the trawled regions and experimental assessments of the relative impact of trawling on each of these communities. The statistical analysis of this information often suffers from low power given the high levels of sampling variability against a background of high natural variability and differential susceptibility and temporal responses (recovery dynamics) of the species involved. It can also suffer from the inherent difficulty of trying to “prove a negative”. Moreover, determining what is an “unacceptable level of impact” is not well defined even if data are available.

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[15] The boundaries of the fishery should not be used as the baseline because these will almost certainly include non-trawlable habitats.

Using this approach as the basis of management would require comprehensive information on the patterns of trawling along with detailed experiments and sampling of all elements of the communities in the region to be monitored at regular intervals to ascertain if changes were occurring requiring additional management to be instigated (e.g. the changes to the Queensland Prawn Trawl Fishery – reduce trawling to < 60% of the trawlable area). Consequently, the costs would be substantial. Moreover, the outcomes of such programs are often inconclusive for management purposes and may require several years of sampling to provide adequate trends in the data before any specific management could be considered.

The alternative approach is to clearly acknowledge that trawling may have a level of impact on the abundance of species and therefore, limit the area where trawling can occur to an acceptable percentage of the trawlable habitat Such limits on trawling ensure that sufficient refuge areas are available within the bioregion for the species and communities potentially affected by trawling not to be put at risk by these fishing activities. Ongoing management only requires that the areas trawled are maintained within the defined boundaries - this is now a simple task to monitor using VMS. The main assumption that needs to be tested for this spatially-based approach is that the species caught by the trawls are also present in areas where trawling is not allowed. These surveys need to sample in the trawlable regions that either have been open to fishing and those have been (and will continue to be) closed to trawl fishing to assess whether the basic species composition (not abundance) in each of these areas is sufficiently similar to support the assumption and hence this management approach.

#### Sand/Mud Habitats

When trawling, ground chains and otter boards make contact with the sea bottom, disrupting organisms within the habitat. Evidence from video footage of trawled areas of suggests that trawling over sand has the effect of flattening this otherwise rippled and three-dimensional substrate. This may also indirectly affect the species that inhabit this area by changing the nature of their habitat. The degree to which this affects the area depends upon the background levels of disturbance to sediments caused by currents, swells, waves etc.

Kaiser and Spencer (1996) found no detectable difference between trawled and untrawled areas (beam trawl) within mobile sediment regions. Van Dolah *et al*. (1991) studied changes in infaunal communities over 5 months for areas closed to shrimp trawling. They concluded that the seasonal reductions in abundance and number of species sampled had a much greater effect than fishing. Finally, Jennings and Kaiser (1998) suggested that light shrimp trawls (i.e. otter trawls) do not cause significant disturbance to communities in shallow water with poorly sorted sediments.

In Australia, Gibbs *et al*. (1980) found only minimal impacts on the benthic communities resulting from prawn trawling in Botany Bay. In southwest Western Australia, Laurenson *et al*. (1993) compared trawled and untrawled areas using trawl samples and underwater video. Their study concluded that the dominant fauna of each area showed marked similarities, although each group had a different group of less abundant species. The difference was attributed to the fact that the untrawled area was small and encroached in all directions by seagrass. Underwater video observation of both areas before and after the completion of the depletion experiment failed to detect any visual impact on the substrate or habitat.

Performance Measures/Indicators/Management

WA – Shark Bay Prawn Trawl Fishery, Exmouth Gulf Prawn Trawl Fishery – The area of mud/sand habitat available for trawling needs to be kept to no greater than 40% of the total mud/sand habitat within the region *(these have been accepted as part of the EPBC assessments for these fisheries).*

#### Sponge/Soft Coral

Experimental work in the GBR has shown that prawn trawling can remove soft corals and sponges if the intensity of effort is sufficient (Poiner *et al*, 1998). The rate of removal of the epibenthos was in the order of 10% per trawl but impact from one pass of the net could not be statistically detected. Repeat trawling in the same area can result in a substantial loss of these organisms. Recent modelling work (Pitcher *et al*., 2000), that includes assumptions on the recovery rates and resilience of these sessile organisms, suggests that in areas of intense trawling there will be a significant depletion of the faunal types that are easy to remove or slow to recover. Therefore, these impacts need to be directly managed by restricting the total effort or the areas open to trawling.

Performance Measures/Indicators/Management

The area of fishing within the Qld East Coast Trawl Fishery must not exceed 60% of the total area and the impacts of trawling on benthos will be reduced by 25% from 1999 to 2005 *(This has been agreed to by GBRMPA).*

For the WA Shark Bay Prawn Trawl fishery – No more than 20% of the remaining coral and sponge habitat in Shark Bay to be contained within the legally trawlable area *(This has been accepted as part of the EPBC assessment).*

#### Seagrass

Prawn trawling can remove seagrass, particularly inshore species and therefore, this impact needs to be managed. Seagrass is often the nursery areas for many prawn species and therefore, there is a direct incentive not to affect these habitats.

Performance Measures/Management

In both the WA and Qld Prawn Trawl Fisheries – Shallow water areas of seagrass are generally closed to trawling. Anecdotal evidence suggests that some deepwater seagrass species may be more resilient to trawl impacts at moderate levels of effort over the longer term.

## *2.4 Addition/Movement*

### *2.4.1 Discarding/Provisioning*

**This is a LOW – HIGH risk issue**

Bycatch from prawn trawling often results in a large amount of fish and, to a lesser extent invertebrates, being discarded and therefore made available to others organisms that would normally not have access to such a food source or in such abundance. This has the potential to affect the feeding behaviour of some species, particularly predators, and alter the distribution of other species throughout the water column and at the surface. For example, dead fish that sink to the seafloor become available to benthic scavengers such as crabs. These fish would only normally be available, in that level of abundance, to pelagic predators.

Studies on the fate of discards through the trophic structure have been undertaken in a number of prawn or similar fisheries. For example:

- Britton and Morton (1994) reviewed the discard provisioning issue and found that discarding had a "positive" impact on bird population numbers as they can follow the North Sea fleet and consume 50% of the discards. Other benthic fauna can only get what actually falls down on to the seabed and only in the area where they reside (Ramsey et al., 1997). Hence, this study concluded that discarding would not have a major impact on immobile benthic species.

- In the Great Barrier Reef Trawl Fishery, a study showed that the majority of the discards were fish and about 40% floated. Most were taken in the daytime by birds, dolphins and sharks (Poiner et al., 1999). Poiner *et al* (1999). concluded that because discards were dispersed over the seabed and most scavengers forage over a restricted area, discards probably did not cause a measurable impact to the seabed.

- In Moreton Bay, Queensland, Wassenburg & Hill (1987) found that crabs were a dominant scavenger of bycatch from the local prawn trawl fishery, with 30% of their diet coming from this source (note over 65% of the bycatch material from this fishery sinks). This study also found that trawl discards have become the principal food source for three species of seabirds (Wassenberg and Hill, 1990). It is also thought that larger populations of the blue swimmer crab (*Portunus pelagicus)* occur in Moreton Bay than would normally exist because of the food provided by trawler discards (Wassenberg and Hill, 1987).

Objectives/ Performance Limits/ Indicators

Objective for WA prawn fisheries – To minimise the level of discards, which in turn will minimise possible changes in trophic structure from provisioning (accepted by EA).

Justification: The objective to manage the amount of discards was chosen over an objective relating to reducing the impact on the complex trophic interactions because the identified consequences were not considered major at current levels of discarding. Given this, it is considered that the most appropriate management objective would be to minimise the opportunity for this to occur, by reducing the amount of discards (through reducing the amount of bycatch in the first instance).

*Indicator*

**Amount of discards per season**

The amount of discards per fishing season will be monitored as a measure of the performance against the objective.

**Ratio of discards to target catch**

Changes in the current range of bycatch to catch ratios (or ratios once full implementation of bycatch reduction devices is complete) may indicate either changes in the behaviour of fishermen in targeting prawns; abundance of bycatch species and/or prawns; or lack of quality control / compliance with respect to the functioning of effective bycatch reduction devices.

*Performance Measures*

Reduction in the amount of discards from the introduction of bycatch reduction device levels. Reduction in the ratio of discards to target catch from levels obtained pre-introduction of bycatch reduction devices.

Reduction in the discarded bycatch rate and the target species catch rate derived from a known bycatch reduction device efficiency and estimated effort reduction (e.g. difference between area swept pre- and post- introduction of BRDs).

**Justification**

In the absence of empirical data on the impact of discard provisioning on the ecosystem, it is necessary that a precautionary approach be adopted. The very minimum type of performance measure would be one where the level of discards does not increase beyond existing levels but ideally that the quantity of discards and/or the ratio of discards to target catch declines and discard survivorship increases.

#### *2.4.2 Translocation*

Prawn trawlers often travel large distances to reach fishing grounds and this may facilitate the transport of hull fouling organisms or sediment associated animal and plant propagules in fishing gear from one region to another. Trawlers can often move substantial distances from where they fish from where they conduct refits.

### *2.5 General Environmental Issues*

#### *2.5.1 Debris*

No specific issues for this type of fishery.

#### *2.5.2 Fuel Oil*

The boats are generally too large to conduct significant fuelling or maintenance at sea. This is usually completed in recognised port facilities (except in emergencies).

#### *2.5.3 Land based*

These fisheries generally do not involve land based movements or camping.

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## Fish Trawling

**(demersal)**

### *2.1 General Characteristics of the Fishing Method -*

**The <u>possible</u> impact of Fish Trawling on the habitat and broader ecosystem can be MOD- HIGH and therefore requires specific management**

Fish trawling in Australia is mainly conducted using otter trawl gear which is similar in basic design to that used in prawn trawling. The major difference with fish trawling is that normally only one net is towed, the size of which is usually larger than an individual prawn net. These nets have long wire sweeps that herd the fish into the net and the mouth of the net often has a series of bobbins on the foot rope that keep the net off the bottom and minimises fouling on small rocks etc. This method of fishing will result in varying levels of bycatch of unwanted species and the doors, sweeps and bobbins will make contact with the substrate and therefore, have the potential to affect benthic dwelling organisms. Depending upon the region, the trawls may interact with various protected species such as dolphins and seals. Some fisheries use BRDs in their nets to reduce the bycatch levels and depending upon the size of the bobbins, these can reduce or increase the potential levels of interaction.

The other main methods of fish trawling used in Australia are mid water/semi pelagic trawling in which the nets are not designed to make contact with the bottom. This is used for fishing for deep-water species that are found near pinnacles and will be the subject of a separate report.

### *2.2 By-catch*

#### *2.2.1 General By-catch Levels*

**This can be a LOW – HIGH risk issue depending upon the management arrangements and relative areas of operation.**

The multi-species nature of these fisheries means that net designs have to be a compromise to take all marketable species which may be a combination of large and small species. Depending upon the net configuration and the area of operation, demersal fish trawling can result in the capture of significant levels of unwanted fish and invertebrates. This usually comprises small individuals of the target species plus all individuals of unmarketable species. Because the mesh size is usually larger and the locations fished are usually deeper, fish trawling generally collects less bycatch than prawn trawling. The average ratios of retained to discarded species are usually less than 1:2; whereas the average for prawn trawling is 1:7 (Andrews and Pepperell, 1991).

There is a need to ensure that the design of the net is optimised and where practical BRDs are used (e.g. square mesh panels are employed) to reduce the level of bycatch of smaller individuals. This can also be assisted by determining the spatial distribution of species and avoiding areas with depth ranges where these predominate in the catches. For larger bycatch species, mesh size cannot influence the catch of these species. There are initiatives in some fisheries to look for alternative to minimise the levels of discarding.

In shelf waters <150 m, the operations are unlikely to affect fish and invertebrate species greatly and the Risk ratings will probably be LOW (the main impact will be on the target species). In deeper waters such as the slope regions where there are a larger number of longer lived species (dogfish etc.), fish trawling may by a HIGH risk to these species.

#### 2.2.2 Capture of Protected/Threatened Species

**This can be a LOW – HIGH risk issue depending upon the management arrangements and relative areas of operation.**

Fish trawls can interact with protected and threatened species. Thus off the south east coast, trawlers may interact with seals, whereas in the north interactions with dolphins have been recorded. The nature and levels of these interactions needs to be assessed in relation to the population size of the affected species.

### 2.3 General Damage/Removals

#### 2.3.1 Ghost Fishing

**This is a NEGLIGIBLE risk issue**

Fish trawls do not fish when lost, and the level of netting is insignificant (see below for issues on benthic impacts).

#### 2.3.2 Benthic Biota

**This is a MOD – HIGH risk issue.**

The direct effect of fishing on the seabed varies according to the gears used and the habitats fished – the relative impact is determined by the magnitude of natural disturbance (Jennings & Kaiser, 1998). The relative impact will increase with depth of operation and the stability of the substratum.

The impacts of fish trawling on the benthic communities may sometimes be of greater intensity compared to prawn trawling because the areas where some fish trawling operations occur may have greater structural complexity in the initial phases. There are a number of studies that have demonstrated impacts of fish trawling on these communities (e.g. Sainsbury, 1988 – but note that this was pair trawling not otter trawling).

### 2.4 Addition/Movement

#### 2.4.1 Discarding/Provisioning

**The likely impact from discarding from fish trawl is LOW – MOD.**

The discards from fish trawling are less likely to be a problem compared with prawn trawling because of the reduced amount of discards, the deeper waters in which they operate in and the reduced densities of boats operating in any one area. This most often reduces the potential impacts on the ecosystem unless there are specific circumstances that favour the interaction with susceptible species (e.g. provisioning of floating discards by some seabirds: see Zeller *et. al* 2003).

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#### *2.4.2 Translocation*

**This still only rates a LOW risk**

Fish trawlers often travel large distances to reach fishing grounds and this may facilitate the transport of hull fouling organisms from one region to another. Trawlers can often move substantial distances from where they fish from where they conduct refits.

### *2.5 General Environmental Issues*

#### *2.5.1 Debris*

No specific issues for this type of fishing operations. Product processing is limited to packing of whole frozen product at sea in the Qld Stout whiting fishery and there appears to be no significant discarding of fish offal or packing materials into the marine environment.

#### *2.5.2 Fuel Oil*

The boats are generally too large to conduct significant fuelling or maintenance at sea. This is usually completed in recognised port facilities (except in emergencies)

#### *2.5.3 Land based*

These fisheries generally do not involve land based movements or camping.

# APPENDIX 1: GENERIC PERFORMANCE LIMITS AND TARGETS

Suggested generic 'best practice' reference points for assessment against the main ecological components of the objectives of a sustainable fishery

| Component | Target reference point | Limit reference point | Comments |
|---|---|---|---|
| Target species<br><br>(see below for modifications of these reference points to when applied to significant prey species) | Fraction of fishing mortality or spawning biomass that gives Maximum Sustainable Yield, modified according to information reliability.<br><br>Fraction of MSY fishing mortality or biomass levels if well estimated; otherwise fishing mortality giving 40% reduction in equilibrium spawners per recruit or fishing mortality equals 75% natural mortality.<br><br>If only catch history available then catch target is 75% of the average annual catch during period reasonably argued to be sustainable.<br><br>CAY (sensu  Francis 1993) with less than 10% probability of violating limit reference point. | Fishing mortality or spawning biomass that gives Maximum Sustainable Yield, modified according to information reliability: MSY fishing mortality or biomass levels if well estimated; otherwise fishing mortality giving 35% reduction in equilibrium spawners per recruit or fishing mortality equals natural mortality. If only catch history available then catch limit is the average annual catch during period reasonably assumed to be sustainable. | See Mace (2001) and NMFS (1998) for use of MSY points as limit points. Tiered linkage of targets and limits to information availability based on Witherell (1999) and Witherall at al. (2000).<br><br>A reducing catch limit is implied for species without assessment (i.e.. catch history only).<br><br>Explicit decision rules needed to ensure targets achieved and limits not exceeded. |
| By-catch (retained, discarded, or killed but not landed) | As for target species | As for target species | |
| Endangered or protected species | Fishing mortality as close to zero as possible. | Precautionary limit on mortality that does not significantly impair recovery. Eg Potential Biological Removal (PBR) | See Wade (1998) for description of PBR. |

| | | | |
|---|---|---|---|
| Food chain structure, productivity and flows | Fishing mortality or biomass targets for significant prey species altered from the levels appropriate for target species (see above) to give 80% chance that spawner biomass is no less than mid-way between the unfished level and the MSY level: modifications for information reliability altered accordingly from the levels appropriate for target species.<br><br>Viable and representative biodiversity undisturbed in protected areas (no specific target but viability and representativeness justified on case by case basis).<br><br>'Foodweb in Balance' (FIB) index not systematically decreasing through time. | Fishing mortality or biomass limits for significant prey species altered from the levels appropriate for target species (see above) to give 50% chance that spawner biomass mid-way between the unfished level and the MSY level: modifications for information reliability altered accordingly. | Based on CCAMLR approach (eg Constable et al. (2000).<br><br>See Pauly et al. (2000) for FIB index. |
| Biodiversity at ecosystem, species and genetic levels | No species threatened or endangered.<br><br>No loss of stocks.<br><br>No reduction in number of discrete spawning areas.<br><br>No local extinctions within the managed ecosystem.<br><br>Fishing practices with minimal selective differential and minimal reduction in effective number of spawners (Ne)<br><br>Viable and representative biodiversity undisturbed in protected areas, and protected areas encompass breeding sites (no specific target but viability and representativeness justified on case by case basis). | No species extinct either globally or throughout the managed ecosystem.<br><br>No populations below genetically viable level.<br><br>No significant habitat type reduced to less than half unfished level.<br><br>Genetically effective number of spawners (Ne) in populations not reduced below half unfished number. | Reference points above for target and bycatch species should result in larger populations and therefore Ne than many other reference points. Estimation of genetically viable population level and effective number of spawners (Ne) in Burgman et al. (1993). Estimation and effects of fishing practices on selective differential in Law (2000) and on Ne in Kenchington (1999).<br><br>Half reduction in habitats and Ne a limit by analogy with target species population size. |

| | | | |
|---|---|---|---|
| Reversibility of impacts | Changes potentially reversible in less than a human generation time (<20y).<br><br>Recovery of overfished stocks within 10y (or a fish generation time if much longer or shorter). | No irreversible change. Changes potentially reversible in at most a human generation time (20y).<br><br>Recovery of overfished stocks in 10y (or a fish generation time if much longer or shorter). | To meet objectives of inter-generational equity.<br><br>Recovery of overfished stock from NMFS (1998). |
| Effects of non-fishery uses on the marine environment | Sustainability targets for components above individually met for combined effects of all users. | Sustainability limits for components above individually met for combined effects of all users. | Management of combined effects of all users achieved through integrated management of appropriately defined local ecosystems (eg Large Marine Ecosystems, Sherman and Dunda, 1999). |

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# APPENDIX 2: BLANK INDIVIDUAL SPECIES REPORT

## 1.0 General Charactersitics

### *1.1 Biology -*

### *1.2 Vulnerability to Fishing Level.*

## 2.0 Objectives

## 3.0 Performance Measures

### *3.1 Biological Reference Points*

*3.1.1 Levels of Spawning Biomass/Fishing Mortality etc above which recruitment overfishing is unlikely to occur*

??% of unfished levels of egg production

*Examples –*

*3.1.2 Lowest Level where biomass has been taken and no long-term adverse effects on recruitment have been found*

*3.1.3 Maximum Exploitation Rate*

### *3. 2 Economic Reference Points*

*3.2.1 MSY/MEY*

## 4.0 Indicator Assessment (Levels of Robustness - when are they good and when are they bad?)

### *4.1 Catch*

{ROBUSTNESS}

*Issues – ???*

*Examples –* ???

### *4.2 Fishery Dependent Catch Rates*

{ROBUSTNESS LEVEL}

*Issues – ??*

Examples – ????

### *4.3 Fishery Independent Surveys*

{ROBUSTNESS LEVEL}

*Issues –*

*Examples –*

### *4.4 Estimates of Current Abundance (model based and composite)*

{ROBUSTNESS LEVEL}

*Issues –?*

*Examples* – ??

### *4.5 Probability of Management Meeting the "Target" in Future*

ROBUSTNESS LEVEL}

*Issues –?*

*Examples* – ??

### *4.6 Other – recruitment indices*

{ROBUSTNESS LEVEL}

*Issues – the accuracy of predictions generated, the length of time for which data are available*

*Examples* – ?

## 5.0 **Management Measures** (Relative Effectiveness/Efficiency of these tools for the species/group)

### *5.1 Biological (size limits)*

{ROBUSTNESS LEVEL}

*Issues – ??*

*Examples* – ??

### *5.2 Biological (reproductive stages)*

{ROBUSTNESS LEVEL}

### *5.3 Seasonal/Temporal Closures*

{ROBUSTNESS LEVEL}

### *5.4 Area/Spatial Closures*

{ROBUSTNESS LEVEL}

### *5.5 Effort Limitation*

{ROBUSTNESS LEVEL}

*Issues –*

### *5.6 Output Controls*

{ROBUSTNESS LEVEL}

### *5.7 Monitoring Frequency*

{Acceptable frequency}

*Issues* –

## 6.0 **Ecosystem issues** (Trophic Level Impacts)

### *6.1 Impacts on Prey and community structure*

*Issue* –

### *6.2 Impact on Predators*

*Issue* –

# APPENDIX 3: BLANK INDIVIDUAL FISHERY TEMPLATE (HABITAT AND ECOSYSTEM)

### *2.1 General Characteristics of the Fishing Method -*

### *2.2 By-catch*

#### *2.2.1 General By-catch Levels*

*Performance Measures*

#### *2.2.2 Capture of Protected/Threatened Species*

### *2.3 General Damage/Removals*

#### *2.3.1 Ghost Fishing*

#### *2.3.2 Benthic Biota*

### *2.4 Addition/Movement*

#### *2.4.1 Discarding/Provisioning*

#### *2.4.2 Translocation*

### *2.5 General Environmental Issues*

#### *2.5.1 Debris*

#### *2.5.2 Fuel Oil*

#### *2.5.3 Land based*