CHAPTER E ASSESSMENT OF THE DRAFT FMS

The aim of this section of the EIS is to assess the draft FMS to determine whether it will effectively reduce the intermediate to high risks to the ecosystem components of the OTF identified in Chapter B2 and ensure that the fishery continues to operate in an ecologically sustainable manner for at least the next five years. As was described in the risk analysis framework in Chapter B2, this chapter is a theoretical appraisal of the measures proposed in the draft FMS. Only by monitoring the implementation of these measures will it be possible to fully determine whether they are sufficient to reduce risks in the OTF.

The role of the FMS is to outline the long term approach to management of the fishery. Accordingly, the strategy does not include full details for the implementation of specific management changes. Ultimately, the FMS will be implemented through various supporting documents and operational plans, such as the share management plan and research and compliance strategic plans, which will establish the specific mechanisms for implementing and monitoring the changes foreshadowed by the FMS. Many of the detailed actions will require consultation with affected stakeholders so as to obtain the support that is often necessary to achieve effective implementation and compliance with the new rules.

1. Ecological Issues

1.1 Outline of the Process used to Assess the Draft Fishery Management Strategy for the Ocean Trawl Fishery

a) Introduction

In assessing the draft FMS for the OTF the two primary objectives are to determine a) whether the issues identified in the risk assessment have been addressed and b) to what extent the risks have been reduced. A secondary objective is to determine whether the proposed management responses increase the risk to any of the components in the ecosystem. Reduction in risk in the context of this EIS is defined as the decrease in the likelihood that a component of the ecosystem will become ecologically unsustainable over a five year period. Risk was determined by a combination of the fishery impact profile and the qualitative resilience of the component. From Section B2.3(b) risk had five levels – low, moderately low, intermediate, moderately high and high. Because resilience was a function of the combined biological characteristics of a component it cannot be directly changed by the proposed management strategy to reduce risk. Only the fishery impact profile can be altered by the proposed FMS because it comprises the actions of the fishery that can be changed.

Reduction in risk is difficult to determine in a qualitative risk assessment approach (as used for this EIS) because there are no quantitative measures of the magnitude or extent of the impacts. Furthermore, it is difficult to make predictions as to the outcome of various management measures as yet to be implemented. Therefore, a qualitative process of risk management was developed to assess the adequacy of the draft FMS in addressing issues and reducing risk.

b) Stages in qualitative risk management

The risk management process consisted of three stages (Table E1.1). In Stage 1 the required information to address an issue of risk is obtained. This stage can have any one or more of the

following methods – regulation review, basic studies and experimental studies. Regulation review is simply a review of the current regulations in the fishery management strategy to determine if they are appropriate or not. Basic studies are specifically designed to collect certain information for a particular purpose and as such should adhere to robust scientific sampling designs, including clearly stated hypothesis to be tested (e.g. Underwood, 1990). Research that collects basic biological information about a species and an observer survey to quantify interactions with threatened species are two examples of this type of study. Experimental studies are also specifically designed to test a proposed hypothesis about how some aspect of a component of the ecosystem works but, unlike basic studies, usually involve manipulations within the context of robust experimental design (Underwood, 1990). For example, testing the hypothesis that there is a significant difference in the growth and mortality of a species among areas could involve a tag and recapture study. Gathering this type of information is distinctly different from information obtained from monitoring (Stage 3), because it doesn't involve monitoring the outcomes of an implemented management action. The information gathering stage does not, on its own, reduce risk but it does provide essential data in refining the level of risk which best fits a component and may provide the foundation for more appropriate and effective management measures, such as the location and timing of closures.

Table E1.1 Stages in risk management for a qualitative risk analysis framework

Stage	Sub-stage	Rating	Potential influence on actual risk reduction
1. Required Information	Regulation review	1A	Negligible on its own; identifies regulations that need to be revised to reduce risk
	Basic studies	1B	Negligible reduction on its own; provides information that more precisely determines levels of risk that either upgrades or downgrades it
	Experimental studies	1C	Negligible reduction on its own; provides information about aspects of the ecology of the ecosystem or species group.
2. Implementation	Commitment to act without a control mechanism identified	2A	Minimal reduction; with no identified mechanism the adequacy of the control mechanism cannot be determined
	Commitment to act with an identifed control mechanism	2B	Substantial reduction; the adequacy of identifed control meachanism can be assessed and it provides a concrete action(s) that can be tracked when implemented
3. Monitoring	Passive	3A	In conjunction with any in stage 2, substantial reduction; provides feedback information on whether implementation of management measures are reducing risk and refining risk analysis
	Active (i.e. adaptive management)	3B	In conjunction with any in stage 2, substantial reduction; testing alternative management measures provides more precise information of what is most effective management to reduce risks; involves deliberate set up of management measures in an experimental design to test pre-defined hypotheses

Stage 2 of risk management is implementation. This stage has two types – commitment to implementation without a specific control mechanism (e.g. to reduce bycatch) and commitment to implementation with an identified control mechanism (e.g. to reduce bycatch by introducing bycatch reduction devices). A control mechanism is simply a tool of management that is the means by which a management response will be achieved (Table E1.2). Management controls are either output focused or input focused (Walters and Pearse, 1996). Output controls place limitations on how much can be taken out of a resource, such as quotas. Input controls place limitations on the effort to catch fish,

such as restrictions on number of days fished, gear specifications and closures. Usually a fishery management strategy will use a combination of management controls because of the complexities of the ecology, economic and social structure of a fishery.

Table E1.2 Different types of management controls used in fisheries management

TAC – total allowable catch; MPA marine protected area

Control	What the control does	Measures of the controls	Used in draft FMS
TAC quota [Output]	Limits the quantity of landings a fisher may have for a species in a given year.	- TAC level compared to. known spawning & maturing biomass - % of quota met/yr by fishery - % compliance to quota	No
Protected species [Output]	Prevents landings of selected species	- Zero landings of listed protected species	Yes
Trip limits [Output]	Limits quantity caught on a daily or some other basis	- Quantity permitted to be caught per trip - Proportion of catch made up of trip limited species	Yes
Effort caps [Input]	Limits the amount of fishing effort that can be applied to catch fish	- Number of days/nights fished - Number active fishers & vessels	Yes
Restrict catch to part of the population [Input]	Reduces fishing mortality on vulnerable parts of a species population, e.g. juveniles	- Size selectivity of gear - Number seasonal & area closures & proportion of population protected reasons for closures - Minimum legal lengths	Yes
Bycatch reduction devices [Input]	Allows small fish and organisms to escape being caught, reducing fishing mortality; can also be used to allow large marine animals to escape e.g. turtles	- Type of BRD used & their effectiveness - Compulsory or voluntary	Yes
Code of Conduct [Input]	Reduce mortality and/or damage to non-retained species and the envionment by specifying ways fishers should conduct themselves whilst doing their fishery operations, e.g. prohibiting use of spikes	- % of fishers adhering to Code of Conduct if voluntary - Survival of discards	Yes
Limit fishing efficiency [Input]	Limits the power of fishing vessels and fishing equipment to make them less efficient in catching fish, decreases fishing mortality and fishing pressure	- Hull units, including net units - Engine units	Yes
Refuge areas (like MPA) [Input]	Designated areas in the sea that represent a range of marine habitats and organisms that are proctected from fishing, removes fishing pressure and provides a potential suppply of recruits of organisms (larvae, juveniles or adults) for surrounding unprotected areas	- Number & position of MPA or other reserves with respect to trawl grounds - Effectivness monitored	Yes
Restoration areas - stock re-building, habitat re-building etc [Input]	Designated fishing grounds (or other uses) closed to fishing to enable habitats and the ecosystem of an area to rebuild - Protection of spawning sites of target species to secure recruitment supply	- Number & position of closed trawl grounds & other commercial fishing areas; - Recovery monitored	Yes

Depending upon the management response proposed, Stage 2 measures or controls can have a substantial influence on reducing the risk to a component (Table E1.1). Clearly, implementation with an identified mechanism will have a greater influence on reducing risk than one without a mechanism. The implementation stage can occur on the basis of relevant information (from Stage 1) or in the absence of relevant information. The latter may occur as a result of invoking the precautionary principle, which states that if there are threats of serious or irreversible environmental damage, lack of

full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (NSW *Protection of the Environment Administration Act 1991*).

Implementation of a proposed management response via a specific control mechanism is not the end of determining whether risk has been appropriately addressed. Determining whether the action was effective in actually reducing the risk is also needed. Stage 3, therefore, involves monitoring the implemented controls. Monitoring can be either passive or active (Sainsbury *et al.*, 2000). Passive monitoring is the routine collection of information about a fishery, such as weights of landings, lengths and sex of species caught. The information is used to update resource assessments but doesn't specifically change management procedures (Sainsbury *et al*., 2000). Active monitoring, also referred to as adaptive management (Walters, 1986; Sainsbury *et al*., 2000) or responsive management, intentionally sets up management controls to test specific hypotheses about the effectiveness of alternate management strategies or action. Such active monitoring or responsive management must also adhere to rigorous experimental design (Walters, 1986; Peterman and McAllister, 1993; Underwood, 1990). Whatever form of monitoring is used it is important that there is a review of the information/data at predetermined frequencies so that the information/data is analysed and interpreted in light of the purpose of the management controls and/or strategy. Management controls that are implemented need to be assessed in some way as to their effectiveness in reducing risks. The proposed FMS is most likely to reduce the risks to a component of the ecosystem if it contains management responses that encompass all three stages of risk management.

Figure E1.1 illustrates theoretically how the different aspects and stages of risk management are linked. Information gathered about the fishery and/or species flows into formulating management actions. Implemented management actions reduce risk. Monitoring of implemented management actions assesses their effectiveness in reducing risk. This leads to improved and/or changed management actions, which are then implemented and the cycle continues. The influence on reducing risk increases with each succeeding stage.

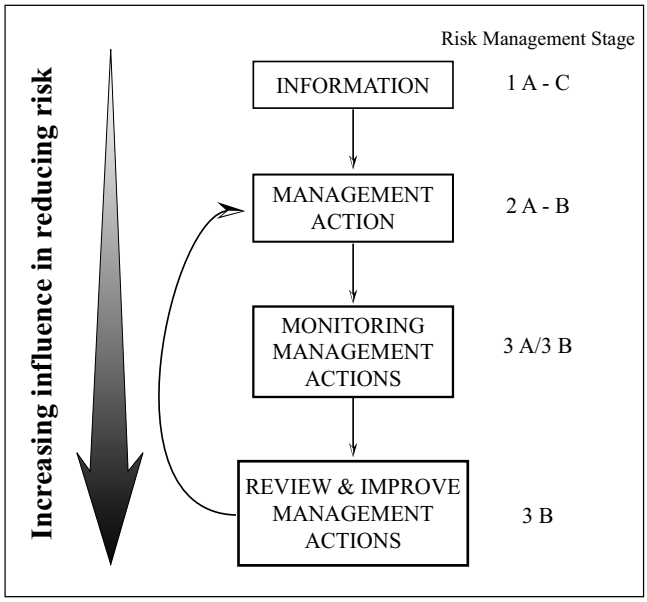

Figure E1.1 Stages and process involved in reducing risk for OTF

1.2 Primary, Key Secondary and Secondary Species

The goals, objectives and management responses (MR) dealing with issues for primary, key secondary and secondary species of the OTF are summarised for each issue in Tables E1.5-11. There

were nine major issues (see Section B2(c)) arising from the risk assessment of the primary, key secondary and secondary species. If these issues are adequately addressed in the draft FMS then theoretically the risk to primary, key secondary and secondary species of becoming unsustainable over a five year period should be reduced. An overall assessment of the risk reduction for these species is presented first. Then each issue will be discussed in detail with respect to how well it has been addressed by the draft FMS in terms of the stages in risk reduction outlined in Section E1.1.

a) Overall assessment of reduction of risk to species at high, moderately high and intermediate risk

The OTF is a diverse multispecies fishery and requires more than one type of management control to reduce the risks to individual species. The extent to which the risks overall have been reduced for the primary, key secondary and secondary species will depend on the effectiveness of the combined management controls in the draft FMS.

The strength of the draft FMS is that it uses multiple management controls on all species without relying on any one in particular. For species at highest risk (elasmobranchs) three types of controls are proposed – refuge areas, recovery programs and limited fishing effort (Table E1.3). These controls combined with the information gathering management responses result in a minor reduction in risk for elasmobranchs (Table E1.3).

Species at moderately high and intermediate risk are influenced by seven management controls and include all those used for elasmobranchs as well as juvenile prawn and spawning closures and effort controls (Table E1.4). Combined with the information gathering management responses these result in a moderate to major reduction in risk for a few species e.g. silver trevally, and minor reduction in risk for other species (Table E1.4).

Some of the controls in the proposed FMS don't go far enough in reducing risk. Many of the management controls that are at the implementation stage of risk management (see Table E1.1) don't give enough details of the specific mechanism, (although it is acknowledged that determining the specific details in some circumstances is dependent on firstly improving knowledge of the fishery and some of its effects, e.g. mapping trawl grounds, is necessary before some area closures can be determined). A lot rests therefore on the assumption that whatever the details are they will be adequate to reduce risk. However, given the complexity of the oceanic environment and high uncertainty involved in managing the OTF such assumptions limit assessment of the adequacy of the draft FMS. Therefore, the draft FMS would be strengthened if it demonstrated an understanding and commitment to applying the details of important principles needed in implementing some management controls to make them effective. For example, understanding the differences in the requirements of closures for elasmobranchs and teleosts.

Table E1.3 Summary of management controls in the draft FMS used to reduce risk for species at high risk.

	Management control proposed	Potential Risk Reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Closed areas	Moderate	2A	Depends on where & how closures are established	MR 1.1(b) 2.1(f)
	Recovery programme	uncertain	2A	Effective if an appropriate process is used for sharks to determine details of programme	MR 2.2(a)
	Minimise latent fishing effort	no change	2A	No commitment to mechanism to manage fishing effort; Investigate cost effectiveness of day/night allocations; Set overall effort level target within 10 years with interim milestones	MR 5.2(a); Harvest strategy
Information	Monitoring composition of landings	Minor	1B	Essential information for other management controls to be effective	MR 2.1.(a)
	Monitoring landings of primary & key secondary species	Minor	1B	Essential information for other management controls to be effective, e.g. effort controls	MR 2.1(c)(d)
	Research to fill information gaps	Moderate	1C	Essential information to reduce uncertainty and improve effectiveness of management controls	MR 2.1(j), 7.2(a)

Overall risk reduction for species at high risk	**MINOR**

Table E1.4 Summary of management controls in draft FMS used to reduce risk for species at moderately high and intermediate risk.

	Management control proposed	Potentail risk reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Closed areas	Moderate	2A	Depends on where & how closures are established	MR 1.1(b)
	Refuge areas & spawning closures	uncertain	2A	Details of criteria to establish refuge areas to be developed	MR 2.1(g)
	Juvenile prawn closures	Major	2B	Details provided, anecdotal evidence from fishers current closures are working	MR 2.1(f)
	Recovery programmes	Major - silver trevally, uncertain - rest	2A/B	Details only given for silver trevally	MR 2.2(a) & (b)
	Gear selectivity	Major - some species	2B	Improved gear sectivity will substantially benefit some species, but not all	2.1(e) 2.2(a)
	Minimise latent fishing effort	No change	2A	No commitment to mechanism to manage fishing effort; Investigate cost effectiveness of day/night allocations; Set overall effort level target within 10 years with interim milestones	MR 5.2(a); Harvest strategy
Information	Monitoring composition of landings	Minor	1B	Essential information for other management controls to be effective, e.g. exploitaiton status	MR 2.1.(a)
	Monitoring landings of key secondary species	Minor	1B	Essential information for other management controls to be effective, e.g. effort controls	MR 2.1(c)(d)
	Research to fill knowledge gaps	Moderate	1C	Essential information to reduce uncertainty and improve effectiveness of management controls	MR 2.1(j), 7.2(a)

Overall risk reduction for species at moderately high & intermediate risk	**MODERATE - MAJOR few species**
	MINOR - most species

Overall, the draft FMS will potentially have a minor effect in reducing the risk for those species at high risk, a moderate to major effect in reducing risk for a few species (e.g. juvenile king prawns, silver trevally) at moderately high risk and a minor effect in reducing the risk for the other species at moderately high and intermediate risk.

b) Evaluation of management responses addressing issues from the risk assessment for primary, key secondary and secondary species

i) Direct action for elasmobranchs

Elasmobranchs were at the highest level of risk of becoming ecologically unsustainable under the current management regime (Table B2.18). Their different biology, ecology, life history strategies

and movement patterns from teleost species means that several actions may be necessary to reduce the fishery impact on them in the OTF. There was only one management response specifically aimed at elasmobranchs but eight other responses were also relevant to them in the draft FMS (Table E1.5). The management responses fell into four broad sets – information, spatial restrictions, effort control and miscellaneous.

Management response 2.1(j) commits to collecting essential basic biological data of the important elasmobranch species of the OTF. Information about fecundity, size at maturity, length/age and sex structure will contribute substantially to understanding these species. This will be in addition to the usual information obtained from catch monitoring programs (Table E1.5, MR 2.1(a,c)). The basic catch composition of primary and key secondary species of elasmobranchs will provide specific information to use in some form of stock assessment. Together this information will be used to determine some of the basic biological characteristics of the elasmobranch species of the OTF, which will enable more specific management measures to be formulated and implemented. Whilst collecting this information is crucial, it will not in itself reduce the high risk to five species of elasmobranchs from the OTF. Furthermore, because the data will include spatial information it will address some aspects of the ecology of these species that would assist in setting aside refuges for them (see Section E5.2(b) for review of research plan).

The second set of management responses could potentially have the largest influence on reducing risks to elasmobranchs. These management responses propose to establish closed areas from fishing (Table E1.5). These areas seek to protect habitat, create refuges for adult populations and for reproduction from the effects of fishing mortality. These responses are an important first step in contributing to the sustainability of elasmobranch species of the OTF. Some management responses will contribute more than others in providing this protection. The proposed exclusion of all trawling from depths greater than 1100m will make little difference to the current situation because OTF does not normally trawl at these depths due to the limitations of the technology of the gear, but does prevent future expansion into these habitats. It is important to recognise that any actions to reduce risks to elasmobranchs will likely have a long response time because of the biological characteristics of those species. Consequently, uncertainty around the effectiveness of the management measures will be prolonged.

Table E1.5 Summary of management responses relating to elasmobranchs at high risk in the OTF. Responses covering common areas are grouped . See text for explanation.

Risk assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Direct action on elasmobranchs	2	2.1	*a) Monitor quantity, length and/or age and sex composition of primary & key secondary species taken by all commercial designated fishing activities in NSW*	1B
			c) Monitor annual landings of primary & key secondary species, compare against "reference" levels in Appendix D6	1B
			j) Collect additional biological information for important elasmobranch species taken by fishery, including size at maturity and fecundity/brood size data, via observer program	1B
	1	1.1	*b) Implement a series of closures to trawling to protect a range of ocean habitats & associated biodiversity, closure of all reefs and depths > 1100 metres*	2A/ B
	2	2.1	*g) Develop strategies to establish 'refuge' areas & spawning closures for species targeted by trawling*	2A
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2A
	5	5.2	*a) Manage fishing effort in the ocean trawl fishery by: (i) limiting the number of each endorsement type so as to minimise the potential activation of latent fishing effort*	2A
			(ii) maintaining the hull capacity, engine power & net length restrictions to offshore sector of the Ocean Prawn Trawl Fishery; extend these rules to other sectors of the ocean trawl fishery	2A
			(iii) establishing a maximum level of fishing effort for each sector of ocean trawl fishery within 10 years of the commencement of the share management plan	2A
			(iv) investigating the efficacy of limiting the number of days/nights each boat may work	2A
	2	2.2	*a) Major harvester of overfished species in NSW - develop and implement a recovery program for that species as detailed in the harvest strategy, & in particular: ii) determine if a recovery program required for any other species identified as 'high risk & implement necessary actions*	2A
		2.1	*b) Develop system for and conduct stock assessments for each of primary & key secondary species taken by all commercial designated fishing activities in NSW; review the assessments at least every three years thereafter*	3A

By eliminating fishery induced mortality these closed areas would contribute to reducing the fishery impact on elasmobranchs. Potentially this could allow populations to be re-structure more in accordance with natural ecological processes (Jennings, 2001). However, the refuge areas would only effectively reduce the fishery impact on this group of organisms if they were specifically designed to

do so. The life history strategies and movements of elasmobranchs are different to that of teleost species. Therefore, the diverse and specialised life styles of sharks will play an important role in applying the principles of refuge area design to this group and will have different design requirements to that of teleosts. Bonfil (1997) discussed how the general principles of designing refuge areas fit the requirements for protecting elasmobranchs. For example, for refuge areas to be effective stand-alone management tools they need to be able to support viable populations and so include a range of habitats that provide protection to all stages in a species life cycle (Bonfil, 1997). But very little is known of the life cycle, habitat associations and movement patterns of the five species of elasmobranchs at highest risk in the OTF. Therefore, it is difficult to determine where, how large and how many refuge areas there should be for this group of finfish.

In determining a strategy for establishing refuge areas for elasmobranchs consideration should be given to how this is being done for the endangered Grey Nurse Shark in NSW. Otway and Parker (2000), based their recommendations for areas to be protected from fishing on known areas of aggregation, habitat associations and the proportion of the population occurring in the area of study. Furthermore, they recommended that the initial small size of the refuges be followed up with research into the localised movements of the sharks to assess whether the areas are of a sufficient size. Their approach is one of gradual development of the refuge areas as more information is obtained through pre-planned and deliberate monitoring of the animals in the designated areas.

The draft FMS does not include details as to how the strategies for establishing closed areas and refuges will be developed. The background to management response 1.1(b) is not clear whether the proposed closure of 75% of state waters south of Barrenjoey Point will focus on current trawling and trawlable grounds or areas in general. Unless the 75% includes some trawlable and currently used grounds it will only partially aid in reducing the risk to elasmobranchs.

The draft FMS also does not include details of whether the different requirements of elasmobranchs and teleosts will be considered in designing refuges from trawling. In addition, the type of protection any reserve would provide is not discussed in the draft FMS. Otway and Parker (2000) discuss the advantages and disadvantages of three types of protection available to NSW Fisheries – sanctuary zones within Marine Parks, fishery closures and aquatic reserves. For Grey Nurse sharks aquatic reserves were deemed to provide the most protection to this elasmobranch species because they were permanent, provided protection from all forms of fishing activity (both recreational and commercial), protected habitat and were more cost effective to monitor and enforce. However, it is important to note that other closure mechanisms, such as fishing closures under section 8 of the FM Act, can provide an equivalent high level of protection. (See judgement in *Professional Fishers Association v Minister for Fisheries* at NSWLEC 15)

Because there is a lack of detailed information about the nature of the proposed refuge areas and how they are to be established, it is not possible to determine whether the risk to elasmobranchs will be reduced as a result. However, if adequate attention is given to the design requirements and level of protection needed for elasmobranchs at high risk then this would be a very effective means of reducing the fishery impact, and therefore risk, on these species. The risks to elasmobranchs otherwise will not be reduced effectively.

The third set of management responses relevant to elasmobranchs relates to fishing effort (Table E1.5, MR 5.2(a)(i-iv)). The overall intent of the draft FMS is to reduce total fishing effort (see MR 5.2(a)(iii) and associated background notes). Whilst this intention is positive, there is no clear commitment to a mechanism by which this could be achieved, and the response is focussed on

reducing total effort (comprised of currently active plus latent effort), not reducing the currently active level that the risk assessment identified as posing a threat to elasmobranchs. To effectively reduce the risk to elasmobranchs, the FMS would need to reduce the maximum number of endorsed businesses below the currently active level of approximately 252 endorsements.

Management response 5.2(a) (Table E1.5) suggests four controls by which fishing effort could be managed - limiting the number of each endorsement type, maintaining fishing capacity, establishing a maximum level of fishing effort and investigating limited day/night allocation. Limiting the number of each endorsement type seeks to minimise the potential activation of latent effort (MR 5.2(a)(i) Table E1.5), but it will not reduce the risk to elasmobranchs because it does not change active effort levels, upon which the risk assessment was based. Similarly maintaining fishing capacity at current levels (MR 5.2(a)(ii)) will bring no change to the current level of risk for elasmobranchs.

Establishing a maximum level of fishing effort (MR5.2(a)(iii)) will only be of benefit if it is a) below current active levels and b) flexible enough to respond to changes in abundances of species. To establish this maximum level of fishing effort the draft FMS (Section D4(c)(ii)) suggests that minimum shareholdings could be used, although it makes no clear commitment to using this mechanism. There are a number of ways minimum shareholdings could be applied to control fishing (as indicated in the Harvest Strategy of the draft FMS, Section D4(c)(ii)). However, its effectiveness in reducing the risk to elasmobranchs would depend on which way is chosen. Minimum shareholdings that take a long term approach to reducing effort may not be effective for long lived species such as elasmobranchs. In any case, management response 5.2(a)(iii) has placed a 10 year timeframe on establishing maximum effort levels, and this may be too long to derive any benefit for elasmobranchs at high risk because these species are already depleted, have slow growth rates and low fecundity. The interim effort milestones to be established within the 10 year period will need to be sufficiently precautionary to ensure this species group can benefit from reduced fishing effort over the long term.

The part of the management response that seeks to investigate the efficacy of limiting the number of days/nights a vessel may fish (Table E1.5, MR 5.2(a)(iv), the fourth proposed control) could substantially decrease fishing effort on elasmobranchs. However, the management response does not explicitly commit to introducing a limitation on the number of days/nights fished, only that it will be investigated. Given there is little certainty that the other management responses controlling effort will contribute to reducing the risk to elasmobranchs, this part of the management response may be the most efficient and effective way of providing the necessary protection for elasmobranchs. Therefore, a stronger commitment in the draft FMS to limiting the number of days and nights that vessels may fish in the short term is highly recommended.

Although it is the intent of the draft FMS to reduce total fishing effort it does not give any real assurance that current (active) effort levels will not increase given the number of latent entitlements that exist in the fishery. There is also no assurance given that the potential activation of latent effort will be minimised, because it does not specify how many endorsements the fishery will be limited to nor whether the level of access available through each endorsement will change. There is also concern that limiting the effort through endorsement numbers without additional effort controls could result in an increase in effort in the short term as fishers strive to meet potentially higher management costs. Furthermore, while some potential mechanisms for effort reduction are outlined in the background note, the draft FMS does not determine with certainty what mechanism would be used to achieve the effort level subsequently decided upon. This assessment concludes that the risk to elasmobranchs will not be reduced as a consequence of the effort management controls proposed (MR 5.2(a)) being insufficient.

The fourth set of management responses applicable to elasmobranchs concern developing recovery programs and a stock assessment system (Table E1.5, MR 2.1(b), 2.2(a)). Fiddler shark, angel shark and saw shark are primary and key secondary species of whom the OTF is a major harvester. These species are at high risk and therefore would be candidates for recovery programs. There are no legislative guidelines for recovery programs. The harvest strategy of the draft FMS gives details for a recovery program for silver trevally and it is assumed that a similar appropriate process to develop a plan for the elasmobranchs at high risk. On this basis it is assumed that the recovery program developed for fiddler, angel and saw sharks would contribute to reducing their risk.

Developing and conducting a stock assessment system for primary and key secondary species will benefit fiddler, angel and saw sharks. This will not in itself reduce the risk to these species. However, it will alert the management agency to any potential problems with these stocks and may prompt mitigative action and could assist in establishing a maximum level of fishing for the management response 5.2(a)(iii).

Finally, the draft FMS does not directly address the issues that arose from the draft National Action Plan on Sharks (2002) but does so indirectly (e.g. through collection of biological information).

ii) Direct action for species at moderately high risk

Seven species of teleost finfish and two species of shellfish were at moderately high risk of becoming ecologically unsustainable. There were several management responses that addressed the risk to this group of species (Table E1.6) either directly or indirectly. Of the four species that have an overfished exploitation status (silver trevally, redfish, eastern king prawns and school prawns) three management responses deal directly with these species whilst the remaining management responses are applicable to all species in the moderately high risk category. The management responses fell into five broad sets – recovery programs, spatial restrictions, information, effort control and miscellaneous.

Table E1.6 Summary of management responses relating to species at moderately high risk in the OTF. Responses covering common areas are grouped . See text for explanation.

Broad Management Sets	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Recovery programmes	2	2.2	*a) Major harvester of species overfished in NSW develop & implement recovery program in particular:* *i) silver trevally (growth overfished)* *ii) determine if recovery program required for any species identified as 'high risk' ; implement necessary actions*	2B/2A
			b) Minor harvester of overfished species, contribute to development of any recovery programs for that species; adopt any measures required by a recovery program, in particular: *i) determine if additional measures needed to improve selectivity of fish trawl nets for redfish* *ii) implement provisions of recovery program for gemfish developed under Ocean Trap & Line Fishery Management Strategy*	2A
Spatial restrictions	1	1.1	*b) Implement a series of closures to trawling to protect a range of ocean habitats & associated biodiversity, closure of all reefs & depths > 1100 metres*	2A/ B
	2	2.1	*f) Maintain & enhance effectiveness of "juvenile king prawn" closures; in particular:* *i) modify juvenile king prawn closure off South West Rocks* *ii) make all juvenile king prawn closures year-round closures, except when Director-General, NSW Fisheries, determines* *iii) investigate need to extend juvenile prawn closures to be adjacent to mouths of all major estuaries along NSW coast*	2B
			g) Develop strategies to establish 'refuge' areas & spawning closures for species targeted by trawling	2A
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2A
Effort controls	5	5.2	*a) Manage fishing effort in the ocean trawl fishery by:* *(i) limiting the number of each endorsement type to minimise potential activation of latent fishing effort*	2A
			(ii) maintaining the hull capacity, engine power & net length restrictions to offshore sector of Ocean Prawn Trawl Fishery; *extend these rules to other sectors of the ocean trawl fishery*	2A
			(iii) establish maximum level of fishing effort for each sector of ocean trawl fishery within 10 years of commencement of share management plan	2A
			(iv) investigate efficacy of limiting the number of days/nights each boat may work	2A

Table E1.6 cont'd

Broad Management Sets	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Information	2	2.1	*a) Monitor quantity, length and/or age & sex composition of the primary & key secondary species*	1B✞
			b) Develop system for & conduct stock assessments for each primary & key secondary species; review the assessments at least every three years thereafter	3A✞
			c) Monitor annual landings of primary and key secondary species; compare against "reference" levels set out in Appendix D6	1B✞
			d) Monitor landings of all secondary species; compare against an historical range for each species or species group	1B✞
			h) Investigate cost effectiveness of using fishery independent surveys to provide information for stock assessment	1C✞
Miscellaneous	2	2.1	*e) Ensure selectivity of gear used is appropriate to biology of species targeted*	2B❖
	4	4.3	*b) Respond to information about significant changes in relative catches of the primary and key secondary species taken in each of the major sectors of the ocean trawl fishery*	2A✞

✞ - discussed under Section E1.2(b)(iii); ❖ - discussed under Section E1.2(b)(iv)

A recovery program for silver trevally will be developed (Table E1.6, MR 2.2(a)(i)). The plan will do at least two things. First, it will establish a minimum cod-end mesh size to exclude small individuals. Second, it will specify a minimum legal length of 30 cm total length for silver trevally. The aim of these measures is to increase the mean size being landed toward an optimum size. The change in mesh size is expected to decrease fishery impact on juvenile silver trevally. Sometimes the imposition of a minimum legal size can lead to increased discard mortality of smaller fish as fishers must discard any undersize fish they catch. However, if the gear selectivity is appropriate then discard mortality should be relatively small or eliminated as a result of the minimum legal length rule. It will be essential that the observer program evaluates the effectiveness of these measures for silver trevally. The instigation of a recovery program for silver trevally is a positive step in improving the management of this species and should lead to a decrease in its level of risk.

Redfish are a minor harvested species in the OTF but a quota species in the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF). Changes to cod-end mesh sizes for silver trevally are also expected to reduce the fishery impact on small individuals for redfish (MR 2.2(a)(ii)). Commitment is given to further changes in gear selectivity for this species if either state or Commonwealth research deem it is required. At present the (SESSF) does not have a recovery program for redfish. Consequently the changes made in the OTF to reduce the fishery impact on juvenile redfish will, in itself, have little effect in lowering the risk of unsustainability for this species from all fisheries.

Eastern king and school prawns are fished as adults by the OTF. Reducing the risk on these species will primarily require the protection of juveniles and their habitats. Research has found that

during periods of high discharge (i.e. high rainfall) late juvenile prawns emigrate from estuaries out to sea due to changes in salinity (Glaister, 1978; Staples *et al*., 1984; Vance *et al*., 1985). This mass movement of prawns from estuaries to sea increases the landed catch of juvenile or small prawns by the OTF operating in close vicinity of these estuaries. The harvest strategy (see Section D4(b)(vii)) and management responses (Table E1.6) propose six measures (five direct and one indirect) to address the growth overfished status of these prawn species.

Improvements to net and cod-end selectivity should reduce the capture of juvenile prawns. The adoption of minimum prawn counts as a means to establish closures when small prawns are abundant will decrease the fishery impact on these primary prawn species when they are vulnerable.

Closures will be the most effective way of protecting juveniles of these species. All current closures for juvenile eastern king prawns are situated at the mouths of rivers/estuaries. The management response 2.1(f) will modify some existing closures to make them more effective. The intention to make all juvenile king prawn closures permanent enhances the reduction in risk to this species. These closures will be in addition to the flood bycatch closures off major rivers along the coast, which will also benefit juvenile prawns. Although the closures are specifically for juvenile eastern king prawns, school prawns are believed to have a similar pattern of movement in response to high discharge (Montgomery, 1999) and therefore would also benefit from the closures.

The remaining two measures for eastern king and school prawns concern the collection of data on population dynamics and catch composition to develop better population models (see Section D4(b)(vii)). These models will assist in determining better management regimes for these species. Therefore these models should make a contribution to the long term management to reduce their risk of becoming ecologically unsustainable.

Reduction in risk for the remaining species at moderately high risk is addressed in six management responses outlined in Table E1.6. These management responses also contribute to reducing risk for species with intermediate levels of risk. The two most important management responses will be discussed here. The others will be discussed under the relevant issues that follow.

Implementation of closed areas (MR 1.1(b), 2.1(e)(f)) and establishment of refuge areas (MR 2.1(g)) would have a significant affect in reducing the fishery impact on these species provided they are appropriately designed. There are three purposes for the proposed closures – habitat protection, refuges for adult/juvenile populations and protection of spawning areas. Closures to protect habitats will benefit species at moderately high (and intermediate) risk by reducing the indirect effects of fishing on them. Protecting habitat will potentially allow ecological processes, such as food webs and species interactions, to occur with minimal impairment. It will also protect the sources of food of primary and key secondary species. These indirect benefits will contribute to the reduction of risk of all species at high, moderately high and intermediate risk.

Closures to provide refuges for adult and juvenile populations of primary and key secondary species will reduce the direct effects of fishing on these species. Protecting a proportion of their populations should at the minimum maintain the size of the current and future spawning stocks, but for species with moderately high levels of risk the higher priority should be to increase the size of spawning stocks. Therefore, these types of closures will not only address risk reduction now but also into the future. A similar reduction in risk for species with moderately high levels of risk should result from closures to protect spawning areas. Maintenance of spawning areas is essential for helping to ensure primary and key secondary species have adequate recruitment to their exploited populations.

The effectiveness of the proposed closures in reducing the risk to primary and key secondary species is dependent on the number, size and placement of the closures (Gaines *et al*., 2003; Shanks *et al*., 2003). Research has shown that patterns of recruitment into a population and larval retention have a significant bearing of the design and effectiveness of refuge areas (e.g. Carr and Reed, 1993; Allison *et al*., 1998; Walters, 2000; Warner and Cowen, 2002). Therefore, information about the timing, duration and location of spawning, larval development, larval dispersal patterns and distance, adult growth rates, movement and patterns of recruitment and habitat associations will be needed in the long term to ensure the proposed closures achieve their purposes. However, for most of the teleost and shark species at high and moderately high levels of risk such information is largely unknown. Therefore, a highly precautionary approach to the design of the closures is required. The proposal to close 75% of state waters south of Barrenjoey Point is precautionary provided the closures include trawlable and currently trawled areas.

Except for juvenile king prawns there are no details given in the management responses about the design of the proposed closures. What is proposed is a good first step. It is acknowledged that the draft FMS proposes actions that aim to increase knowledge of the fishery and some of its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of some closures can be determined. However, some closures could be established as an interim step. This would require the application of a precautionary approach to the detailed design of the closures, with a subsequent adaptive approach for further refinement. Such an approach should include closures that cover continuous areas of habitat across a range of depths, such as several strip closures that extend from the coast out to the lower continental slope. Only closures that demonstrate a high level of precaution until the necessary information required for specific designs is obtained will adequately contribute to reduction in risk to the primary and key secondary species. The effectiveness of these management responses in reducing the risk to the teleost species is uncertain but for juvenile king and school prawns the closures will be substantially effective. It will be important that any strategies in developing closures should make use of the substantial scientific literature in the area (e.g. Botsford *et al*., 2003; Gaines *et al*., 2003; Hastings and Botsford, 2003). Furthermore, establishment of closures should incorporate research with a robust monitoring component to assess their effectiveness in reducing the risk to species at moderately high and intermediate risk (e.g. McAllister and Petermen, 1992; Underwood, 1992).

Measures to control fishing effort relevant to species at moderately high risk were proposed in management response 5.2(a). The evaluation of this response given in the previous section for elasmobranchs (Section E1.2(b)(i) applies equally to species with moderately high levels of risk. It is worth reiterating that even though the species at moderately high risk are more biologically resilient than elasmobranchs, the proposed effort controls (MR 5.2(a)(i-iv)) do not make a clear commitment to a mechanism that will reduce current active effort. Therefore the assessment cannot be confident that this management response will reduce the risk to species at moderately high risk.

iii) Stock assessments for primary and key secondary species

Stock assessments will be undertaken for all primary and key secondary species across all fisheries in NSW (Table E1.7, MR 2.1(a)). In which class of stock assessment (Scandol, 2003a) each species will be assessed will depend on the availability and reliability of data. Clearly the proposed catch monitoring program (MR 2.1(b)) will be essential in providing some of this information on a long tem basis. The management response will assist in determining when levels of effort need to be reduced to lower the risk of the primary species becoming ecologically unsustainable. Therefore, this management response will contribute substantially to controlling the level of risk to primary and key

secondary species in the OTF. Because conducting stock assessments on all the primary and key secondary species will take time, it is proposed to monitor the landings of these species and compare them with set reference levels (Table E1.7). This will enable unusual trends in the data to be detected and responded to (a fuller evaluation of the trigger levels is presented in Section E5.1). This type of monitoring will contribute to managing the levels of fishery impact on these species and therefore assist in managing their levels of risk.

To address difficulties in determining relative abundances needed for stock assessments it is proposed to investigate the cost effectiveness of fishery independent surveys (Table E1.7). It is acknowledged that fishery independent surveys in the oceanic environment are very difficult and costly and may not be suitable for all species. But methods to obtain better estimates of abundance should be pursued wherever practicable. This will increase the reliability of stock assessments and hence aid in improving ecologically sustainable management of the primary and key secondary species of the OTF. Any insights from the FRDC project (FRDC 2002/059) on fishery independent surveys in NSW estuaries should be considered.

Table E1.7 Summary of management responses relating to stock assessment for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Stock assessments for primary and key secondary species	2	2.1	*a) Monitor quantity, length and/or age and sex composition of the primary & key secondary species*	3A
			b) Develop system for & conduct stock assessments for each primary & key secondary species; review the assessments at least every three years thereafter	3A
			c) Monitor annual landings of primary & key secondary species; compare against "reference" levels set out in Appendix D6	3A
			d) Monitor landings of all secondary species; compare against an historical range for each species or species group	3A
			h) Investigate cost effectiveness of using fishery independent surveys to provide information for stock assessment	1C

iv) Gear selectivity

Improvements to the selectivity of trawl gear will be made by the proposed changes to construction of the cod-ends in both prawn and fish trawl nets (Table E1.8, MR 2.1(e)). Reducing the cod-end circumference and twine thickness and increasing the hanging ratio will maximise the lateral openings of cod-end meshes during trawling. Studies have shown that reducing the circumference of the cod-end of prawn trawl nets from 200 to 100 meshes increases the lateral openings of diamond meshes, allowing more fish to escape (Armstrong *et al*., 1990; Reeves *et al*., 1992; Broadhurst and Kennelly, 1995, 1996). Larger circumferences, lower hanging ratios and thick twine result in the meshes becoming closed with the increasing weight of catch in the cod-end, thus preventing the escape of smaller fish (Broadhurst and Kennelly, 1995). The maximum circumference of prawn trawl cod-ends will be 150 meshes but increasing the hanging ratio to 1:1 should still allow smaller fish to escape. Fish trawl cod-ends will be reduced to 100 meshes round with a 1:1 hanging ratio which will also be effective in reducing catches of undersize commercial species.

The effectiveness of the changes to gear selectivity are complicated by the proposed regime for targeting school whiting set out in Appendices D3 and D5. It is proposed that for fish trawl, the current gear with poor selectivity (with 150 to 200 meshes round and a hanging ratio of less than 1:1) will be permitted to fish for whiting in certain areas until more appropriate gear can be developed (see Appendices D3 and D5).

Between Barrenjoey Point and Smoky Cape fishers can use this gear anywhere in waters less than 55m (30 fathoms) deep. These depths contain the juveniles of many of the primary and key secondary species of the OTF, including those at moderately high risk (Kailola *et al*., 1993). Consequently, the draft FMS is proposing that fish trawl gear with poor selectivity be used in waters that contain a large proportion of juveniles of the primary and key secondary species and other small

fish that are most vulnerable to being caught by this gear. Areas less than 55m deep are the very places where small fish are abundant (Bax and Williams, 2000). While an improvement to the current situation, the proposal assists little in achieving Goal 2 of the draft FMS that seeks to maintain stocks at sustainable levels. The use of the current fishing gear in these areas is only interim and a research program will be undertaken within three years to identify appropriate gear and/or areas for trawling for whiting. The possibility that the current gear will continue to be in use for a further three years reduces the effectiveness of the FMS. The draft FMS would be strengthened if it were to expedite the development of the new gear and shorten the timeframe for its implementation, preferably to a maximum of one year from the commencement of the FMS.

South of Barrenjoey Point the current gear, with its poor selectivity, will be permitted only in designated whiting grounds that are yet to be determined (Appendix D5). Restricting the use of this gear will reduce the risk to bycatch species to some extent (both commercial and non-commercial). However, assessing the effectiveness of this management measure is difficult because it depends on the number, size and placement of the whiting grounds. For example, if these areas are primarily in depths less than 55m and there are a substantial number of them, then this management measure will not contribute to reducing the risk to juvenile commercial and non-commercial bycatch species. As for the arrangements for waters between Barrenjoey Point and Smoky Cape, this proposed regime could result in permitting gear with poor selectivity to be used in areas that have abundant small fish and therefore be largely ineffective in achieving goals 1 and 2 of the draft FMS. Until the specific whiting grounds south of Barrenjoey Point are identified, a precautionary assessment approach would conclude that the reduction in risk from this proposal is very minor.

Overall, management response 1.2(e) will be effective in reducing the risk on a range of primary and key secondary species that occur in waters deeper than 55 metres and will primarily benefit teleosts and prawns. However, the arrangements for targeting whiting outlined in Appendices D3 and D5 limit the level of risk reduction that could be achieved through gear selectivity changes, and the risk would be far more effectively reduced if the arrangement proposed to be applied beyond 55 metres were extended further inshore.

Table E1.8 Summary of management responses relating to changes in gear selectivity for primary and key secondary species in the OTF.

Risk assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Poor gear selectivity	2	2.1	*e) Ensure selectivity of gear is appropriate to biology of species targeted. In particular: i) restrict prawn trawl net cod-ends to 150 meshes round (hanging ratio of 1:1), single twine maximum 4 mm diameter, mesh size 40-50 mm*	2B
			ii) restrict fish trawl net cod-ends to 100 meshes round (hanging ratio of 1:1), single twine maximum 6 mm diameter, minimum mesh size 90 mm	2B
			iii) review & modify the restrictions applying to prawn trawl & fish trawl nets on the basis of research results on the selectivity of trawl nets, including assessment of mesh size & shape	3B
			Different gear arrangements for targeting whiting in designated whiting areas – see provisions in Appendices D3 and D5	2B*
		2.2	*a) Major harvester of a species develop & implement a recovery program (detailed in the harvest strategy); in particular: i) develop and implement a recovery program for silver trevally - changes to fish trawl cod-ends*	2B

* indicates management measures are in appendices are not appropriate, see text for details

v) Discarding of commercial species

This is discussed in Section E1.3. and addresses issues 5 and 6 of the risk assessment (see Section B2.2).

vi) Inconsistent management regimes between adjacent jurisdictions

There were three specific management responses proposed to address the issue of inconsistent management regimes across jurisdictions (Table E1.9). The majority of the primary and key secondary species in the OTF are considered to be of common stock across several jurisdictions. Inconsistency in management approaches between jurisdictions poses a substantial problem to the ecological sustainability of important fish stocks. It increases the uncertainty of the effects different management regimes have on primary and key secondary species and therefore there is a greater risk of common stocks becoming unsustainable (e.g. Mitchell, 1997; Hoel, 1998). To address the overlap and inconsistent management approaches between adjacent fishery agencies on these common stocks more effective consultation with other jurisdictions (MR 4.2(c)) and monitoring management arrangements and landings in adjacent fisheries is proposed (MR 4.2(a)). Commitment to this consultation process should result in better management of the stocks of primary and key secondary species and hence decrease their risk.

Management response 6.3(b) proposes to achieve “greater complementarity” between the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) and the OTF. Appendix

D3 sets out three management measures south of Barrenjoey Point to do so – closing 75% of state waters to trawling, capping the catch of fishers based on past landings data and monitoring vessel movements using a vessel monitoring system (VMS).

Closing 75% of state waters south of Barrenjoey Point (Appendix D3(1)) might substantially reduce the area that could be trawled and therefore may reduce the risk of the effects of fishing. This part of the proposal will not make the State arrangements more complimentary with the SESSF but it may improve the management of the OTF provided appropriate enforcement structures are applied. Improved management will also depend on the placement and size of the areas closed.

Capping the total catch of individual fishing businesses south of Barrenjoey Point and adjusting the caps annually in light of the Commonwealth's TAC determinations (Appendix D3(3)) would result in greater complementarity in management arrangements than is currently the case. However, the introduction of the cap will restrain harvesting but does not necessarily ensure ecological sustainability of the fish stocks. Currently, the SESSF operates under an individual transferable quota scheme for 16 species and has few input controls. The NSW fishery operates predominantly under an input control system, apart from fishery-wide daily trip limits that apply to each of the Commonwealth's quota species in order to reduce incidences of quota evasion by dual licensed operators. To date, the State trip limits have not been regularly adjusted to account for changes in the Commonwealth TACs. The proposal in the draft FMS would result in individual catch limits being applied to each business under both jurisdictions, with those limits being closely linked. However, there are some difficulties with the proposal that would need to be overcome in order to make it effective, as outlined below.

Firstly, the cap on catches would need to be implemented at a species level in order to operate cohesively with the Commonwealth TAC regime. A single 'total catch' cap for a NSW vessel would allow the operator to take increased catches of an individual species in State waters, even if the Commonwealth TAC for that particular species is declining. Note that the setting of the Commonwealth TAC would need to take account of all relevant biological and stock assessment information, including catches taken in other jurisdictions (including NSW waters, where the caps should be at the species level).

Secondly, the proposal to set the initial level of the cap on the average of landings taken between 1999 and 2003 assumes that the catches by NSW operators in those years are sustainable. The EIS has concluded that the existing operation of the fishery is not ecologically sustainable, although this is due to a number of factors, with catch levels being only one. A review of the fishery's catch level across those years should be undertaken prior to committing to this period because if the recent catch levels are deemed to be a significant inhibiting factor for the ecologically sustainability of the primary and key secondary species, they may need to be set lower in the first instance. This review of factors affecting ecological sustainability should include discard levels of commercial species, habitat issues and ecological impacts. Furthermore, the proposed arrangements assume that the TAC levels set by the Commonwealth are set based on stock indicators alone, however the size of the Commonwealth fleet and its fishing practices also effect how the TACs are set in the SESSF. Any adjustments in the State caps should be based predominantly on stock assessment or stock status information.

Thirdly, using a capped level of catch as a management control for only this sector of the OTF (i.e. south of Barrenjoey Point) produces different management regimes within the OTF as the same management control is not proposed for fish trawlers between Barrenjoey Point and Smokey Cape.

Care would need to be taken to ensure that the different regimes between north and south of Barrenjoey Point did not create inconsistencies in the management regimes which carries the risks discussed in section 2.3 of Chapter B. Furthermore, the fishing dynamics of the SESSF are substantially different from the OTF. The size of their fleet, fishing effort, fishing practices etc are different and these differences effect how the TAC is set in the SESSF. Therefore, increases or decreases in the TAC are unlikely to be equivalent to changes in capped catches in the OTF.

Accordingly, the setting of a capped catch level for the OTF south of Barrenjoey Point has the potential to assist in risk reduction with respect to the primary and key secondary species, subject to the satisfactory resolution of the issues outlined above.

Monitoring the movement of vessels in designated whiting grounds via VMS would provide information on the frequency of trawling in the designated grounds and be a useful tool to aid compliance by NSW vessels with the new closed areas. However, the use of VMS is unlikely to provide any information on the use of the whiting net versus the general trawl net and given the complexity of the proposed arrangements (e.g. use of different gear in different areas) effective surveillance and monitoring of fishers is essential and will need to extend beyond tracking movements of vessels.

Table E1.9 Summary of management responses relating to inconsistent management regimes for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Inconsistent management regimes between adjacent jurisdictions	4	4.2	*a) Monitor management arrangements & annual landings of key ocean trawl species in fisheries outside NSW jurisdiction but impact on shared stocks*	1B
			c) Use cross-fishery & cross-jurisdictional consultation to discuss and manage issues relating to, multiple use of fishing grounds, collaborative research, fair & equitable access to stocks, complementary management arrangements & other interactions between fishing sectors	2B
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2B

vii) Data quality

The risk assessment identified the poor quality of the catch database information as a major obstacle to reducing the risk to primary, key secondary and secondary species (Section B2.3(c)). Two management responses address the issue of improving the data quality of the catch database and information for stock assessments (Table E1.10). Reviewing the adequacy of the data provided on the catch and effort returns for the different purposes in the draft FMS (MR 7.3(a)) will be essential to reduce uncertainty in management decisions. This review should be started on the commencement of the FMS so that improvements to data recording by fishers can be incorporated as soon as possible. Implementing changes to the way fishers report their catch will be essential for the on-going

monitoring of the status of the stocks. Changing from monthly to daily catch reporting should be given a higher priority in the implementation of the FMS. Improving the accuracy of fisher's species identification will also improve the quality of database, which should enhance stock assessments for some species and should be incorporated at the start of the management.

Table E1.10 Summary of management responses relating to poor data quality for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Poor data quality	7	7.3	*a) Periodically review mandatory catch & effort returns; implement changes if:* *á data are perceived poor quality or insufficient for stock or environmental assessments* *á forms are exceedingly complex for fishers to complete, emphasis on quality rather than quantity of information collected*	1A
			b) Assess accuracy of current catch recording system, & species identification in catch records, provide advice to industry to make needed changes	1A

viii) Information gaps

There were three management responses relating to the issue of information gaps in the OTF (Table E1.11). Overall the management responses acknowledge the need for research to fill information gaps in a number of critical areas for the OTF including the biology of primary and key secondary species, including elasmobranchs (MR 7.2(a)(i)). They make a commitment to promoting and supporting research relevant to the fishery. Furthermore, the management responses have picked up specific areas highlighted by the risk assessment as important information gaps, such as the biology of primary and key secondary species and identification of habitats. A detailed assessment of these research priorities and plan is given in Section E5.2. Overall there is an acknowledgment in the management response to conduct research on direct and indirect effects of fishing on primary and key secondary species which is a substantial step forward.

Table E1.11 Summary of management responses relating to information gaps for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Information Gaps	1	1.1	*d) Promote research & collaborate with research institutions to improve understanding of ecosystem functioning & how its affected by trawling*	1B
	6	6.2	*a) Develop & implement a Research Strategic Plan; using priorities for research outlined in the harvest strategy*	1B/3B
	7	7.2	*a) Promote and support targeted research projects relevant to:* *i) biology or stock assessment of the primary & key secondary species* *ii) distribution of marine habitats off NSW & potential impacts of trawling on habitats* *iii) impacts of trawling on biodiversity & environment (including mapping of fishing grounds, the effectiveness of trawl closures & 'refuge' areas, use & effectiveness of approved Bycatch Reduction Devices in reducing unwanted bycatch)*	3A/B

1.3 Bycatch – commercial and non-commercial species

For the purpose of assessing the draft FMS, bycatch will include all discarded catch including undersized commercial species and all non-commercial species. Threatened and protected species will be discussed in a separate section. The goals, objectives and management responses dealing with bycatch issues in the OTF are summarised in Tables E1.13-17.

There were seven major issues arising from the risk assessment of bycatch (both commercial and non-commercial) from Sections B2.3(c) and B2.4(d). If these issues are adequately addressed in the draft FMS, then theoretically the risk to bycatch species becoming unsustainable over a five year period should be reduced. An overall assessment of the risk reduction for bycatch is presented first, then each issue will be discussed in detail with respect to how well it has been addressed by the draft FMS in terms of the stages in risk reduction outlined in Section E1.1.

a) Overall assessment of reduction of risk to bycatch species

There were six types of management controls proposed in the draft FMS to reduce risk to bycatch species (Table E1.12). Of these, fishery closures and improved BRD will provide the greatest reduction in overall risk to bycatch. Gear selectivity are effective measures for a portion of bycatch species. The code of conduct will contribute the least to reducing risk as it will largely be voluntary and compliance will be difficult to monitor. Because so little is known about bycatch species and discarding patterns, observer programs will play a key role in determining the likely reduction risk for these species.

Table E1.12 Summary of management controls in the draft FMS used to reduce risk for all bycatch species.

	Management control proposed	Potential Risk reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Fishing closures	Major to moderate	2A, B	Some specific areas identified or being considered	MR 1.1(c) 1.2(e)
	Improved BRDs	Moderate	2B	Specific BRD already in use to be tested but currently most effective BRD not promoted	MR 1.1 (c), 1.2(b), Appendix D3
	Gear selectivity	Minor for some; may also increase discards for other commercial species	2B for some species, 2A rest	Depends on which species; will not benefit all	MR 2.1(e)
	Interim gear modifications for targeting whiting	Minor	2B	Continued use of current gear in areas with small fish not precautionary	Appendices D3 & D5
	Recovery programmes	Moderate	2B for some species, 2A rest	Details for some species	MR 2.2.(b)
	Code of conduct	Uncertain	2B	Depends on level of compliance	MR 1.2(d)
Information	Observer programmes	Minor to major	1B, 3A	Essential information for developing effective management controls	MR 1.2(a)
	Review MLL	Negligible	1A	Essential information to determine if contributing to undersized commercial bycatch	MR 2.1(a)

Overall risk reduction for bycatch	**MINOR to MODERATE**

The strength of this section of the draft FMS is the greater use of management responses that identify and use a specific control mechanism, i.e. Stage 2B in risk management. This makes it potentially more effective in reducing risk. Overall therefore, risk to bycatch species in the OTF could potentially be reduced from a minore to moderate extent.

b) Evaluation of management responses addressing issues from the risk assessment for bycatch species

i) Whole bycatch approach

With the exception of minimum legal lengths all of the management responses relating to bycatch approach it as a whole rather than splitting it into species specific management responses (Table E1.13). Such an approach will aid in reducing the risk of bycatch becoming unsustainable provided the individual responses are effective.

Table E1.13 Summary of management responses relating to holistic approach to bycatch in the OTF.

Bycatch Issue	Goal#	Objective #	Abbreviated Management Response
Whole approach to bycatch	1	1.2	*a) Design and implement an industry funded scientific observer program to document the degree of interaction with non-retained...species; collect information on use & effectiveness of Bycatch Reduction Devices*
			b) Refine & improve methods for reducing incidental catches; introduction of more effective Bycatch Reduction Devices for prawn trawl nets
			c) Investigate alternative handling practices to improve survival of incidental species returned to sea; in particular: *i) prohibit finning sharks & discarding carcasses* *ii) ban "riddling" of prawns* *iii) restrict use of "spikes" to times when other handling methods are a occupational health or safety risk*
			d) Develop a "Code of Conduct" for ocean trawl fishers
			e) Identify areas and/or times of problem incidental catch to target catch ratios and restrict trawling appropriately. In particular, implement closures to trawling around river entrances during times of high river discharge

ii) General lack of quantification

Three management responses address the issue of lack of information about bycatch in the OTF (Table E1.14). Design and implementation of observer programs onboard ocean prawn and fish trawl (MR 1.2(a)) vessels will quantify a number of important areas of bycatch. Information on the spatial and temporal variability of the abundance and diversity of both undersized commercial and non-commercial species will be essential in aiding the reduction of risk to all bycatch species. For example, it will help identify times and locations of large abundances of juvenile commercial species which will allow more effective area and/or seasonal closures to be implemented to protect them. This is reflected in management response 1.2(e). In addition, quantification of the non-commercial component of bycatch will enable a better understanding of magnitude, its spatial and temporal variability and what proportion is made up of vulnerable species such as elasmobranchs. The observer program to collect biological information on important shark species should be extended to include

species that are discarded (both undersize commercial and non-commercial) due to their high level of vulnerability to fishery impacts (MR 2.1(j)).

Collecting this information is an essential first step to reducing risk on all bycatch. As outlined in the performance monitoring section of the draft FMS, the results of these studies will be fed back to develop better management measures. One important outcome of these observer studies is that they may reveal other species or areas of risk in the fishery that were previously unknown due to lack of data (e.g. interaction with a non-commercial species with a very restricted range). The draft FMS allows for the possibility of modifying the management strategy when new information like this comes to light (see Section D5(d)).

Table E1.14 Summary of management responses relating to lack of information about bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Lack of information about bycatch	1	1.2	*a) Design and implement scientific observer program to document the degree of interaction with non-retained*	1B
			e) Identify areas &/or times of problem incidental catch to target catch ratio, e.g. flood closures	2B
	2	2.1	*j) Use observer prgramme to collect additional biological information; important elasmobranch species*	1B

iii) Effectiveness of bycatch reduction devices currently used in ocean prawn trawls

There were three management responses relating to the effectiveness of bycatch reduction devices (BRD) used on prawn trawlers (Table E1.15). The proposed observer study on prawn trawlers (MR 1.2(a)) to examine the effectiveness of BRD currently used on these trawlers and those proposed in Appendix D3 and D5 will be essential in refining their use in this sector of the OTF. The study needs to be designed so that data are collected to account for the spatial, temporal and environmental variability (such as high river discharge) in abundances and diversity of bycatch species. It would be insufficient to conduct the observer study in a limited number of places and times of year because there is an indication that BRD work differently depending on the environmental conditions (Ashby, 1999,) and also of the highly variable nature of marine assemblages.

Management responses 1.1(c) and 1.2(b) provide for the modification of BRD permitted to be used in the fleet based on data retrieved through the onboard observer program and a minor modification to the existing square mesh panel. Those BRD found to be more effective at reducing bycatch without significant loss of primary and key secondary species will be promoted to fishers as the best options to use. This will have a substantial influence on reducing risk on bycatch because the specific mechanism proposed (effective BRD) will be underpinned by rigorous research.

Under the proposed arrangements for targeting whiting with prawn trawl nets, a modified square mesh panel BRD will still be permitted (Appendices D3 and D5). It is acknowledged in the draft FMS that this BRD is less effective in reducing bycatch (MR 1.2(b)) than the composite square-mesh panel BRD (Broadhurst and Kennelly, 1997) and the modifications proposed would have a negligible effect on the risk to bycatch. Broadhurst *et al*. (2002) found that the important factor in

enabling more bycatch to escape via the square mesh panel BRD is its position in the cod-end. For the most effective reduction in bycatch the panel should be placed at least 1.2 m anterior to the last row of meshes in the cod-end which maintains an acceptable catch of prawns while still allowing large numbers of small fish to escape. Panels positioned at 1.6 m from the end of the cod-end reduced overall bycatch by 20.3% compared with panels located at 1.2 m which reduced overall bycatch by 32.8% (Broadhurst *et al*. (2002)). When calculated up, this would represent a large difference in the total tonnage discarded between these two configurations across the entire prawn trawl fleet over the course of a year. Appendices D3 and D5 include rules relating to the position of the square mesh panel in the cod-end (ie. to ensure it is anterior of and in the top of the cod-end and within certain limits from the end of the cod-end), but enables the panels to be positioned beyond 1.2 m from the end of the cod-end. Consequently, the proposed rules for positioning the square mesh panel are less effective than they should be based on the available scientific research (and, as noted above, far less effective than use of the composite square mesh panel).

The arrangements specified in the Appendices D3 and D5 reflect the current arrangements regarding the way in which the panel must be sewed into the net (ie. the bating arrangements) and ensure the meshes in the panel remain square and open during trawling, thereby aiding bycatch reduction.

Appendices D3 and D5 allow the use of a BRD that is known to be less effective in reducing bycatch than other scientifically tested designs (see Broadhurst and Kennelly, 1997, Broadhurst *et al*., 2002). This seems contrary to the intent of the management response to "refine and improve methods for reducing incidental catches, including the introduction of more effective Bycatch Reduction Devices". Broadhurst *et al*. (2002) clearly state that "the composite square-mesh panel is currently the most appropriate behavioural-type BRD" for the OTF. Yet nowhere in the draft FMS is this particular BRD promoted as the best one to use for the OTF. Whilst it does make clear that other approved BRD can be used, it does not advocate the more effective composite square-mesh panel BRD, which does not promote the intent of Objective 1.2 and Goal 1. Moreover, it brings into question the value of undertaking future research into more effective BRD (MR 1.2(b)) when in the past the results of such research (e.g. Broadhurst *et al*., 2002) have not been implemented to improve management measures. Therefore, the proposed requirements of the BRD in Appendices D3 and D5 need substantial revision before they can be regarded as meaningfully reducing the risk to bycatch species.

Table E1.15 Summary of management responses relating to effectiveness of BRD in reducing bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Effectiveness of BRD used in prawn trawls	1	1.1	*c) Implement additional Bycatch Reduction Device requirements for prawn trawl nets south of Smoky Cape*	2B/3B
		1.2	*a) Design and implement scientific observer program to…..collect information on the use and effectiveness of Bycatch Reduction Devices*	3A
			b) Refine & improve methods for reducing incidental catches, including the introduction of more effective Bycatch Reduction Devices for prawn trawl nets; modified square mesh panel BRD	2B
	2	2.1	*e) Appendix D3(6), D5(1)(4) dimension of modified square mesh panel BRD when targeting whiting*	2B*

* indicates management measure is not precautionary

iv) Discarding of undersized commercial species

Discarding of undersized commercial species is addressed in eight management responses (Table E1.16). The importance of improved BRD (MR 1.1(c), 1.2(b)) (except when targeting whiting) was discussed in the previous section and will obviously have benefits for reducing impacts on undersized commercial bycatch caught in prawn trawl nets. The introduction of an effective observer program, also discussed previously will improve our understanding of the extent, magnitude and temporal and spatial variability of undersized commercial bycatch (MR 1.2(a)). Reviewing the regulations on minimum legal lengths (MLL) (MR 2.1(i)) for many primary and key secondary commercial species will help identify whether they are suitable. It is proposed to introduce a MLL for silver trevally because it is growth overfished. However, MLL can be the cause of excessive discarding of undersized commercial species, therefore increasing discarded bycatch (Cook, 2001). In reviewing MLL for primary and key secondary species attention should be given to the effect these regulations might potentially have on this component of bycatch in the OTF, and this is foreshadowed in MR 2.2(a).

A more effective mechanism for reduction of risk on under-sized commercial bycatch species is improved gear selectivity of both prawn and fish trawl nets (MR 2.1(e)). This will be especially effective in fish trawl gear because, unlike prawn trawlers, they cannot use the conventional BRD due to the wide range of species taken as landed catch by fish trawlers. But as noted earlier whilst current gear is permitted to be used in expansive areas for targeting school whiting (see Appendices D3 and D5) this will do little to contribute to reducing risk to under-sized commercial and non-commercial bycatch species in these areas. Improved gear selectivity for fish trawlers on its own will not be sufficient to reduce risk to undersized commercial species because some species will have different body shapes and modes of swimming and changed mesh size will have no impact. For example, unmarketable John and Mirror dories will likely still be caught because of their elongated dorsal spines and flattened dorsal-ventral shape. Elasmobranchs also have a body shape that makes them

prone to being trawled. Therefore other mechanisms are required in addition to changes in gear selectivity for fish trawlers to reduce undersized commercial species. This will primarily be achieved through the use of appropriately designed closures that are proposed in the draft FMS (MR 1.1(b)).

There are three types of closures in particular that will aid in reducing discard mortality of undersized commercial species – flood closures, closing 75% of state waters south of Barrenjoey Point and continued bans on fish trawling north of Smoky Cape (MR 1.2(e), 2.1(f), 1.1(c)(e)). During high river discharge as a result of flooding, a number of studies (Glaister, 1978) have shown that there is an increase in abundance of juvenile prawns and many estuarine finfish species at river mouths, thereby increasing the catch of unmarketable commercial species and potentially increasing discarding. Closures near the mouths of rivers during these floods will reduce catches of the undersized commercial component of bycatch. On-going monitoring (Stage 3A of risk management) to determine the effectiveness of these flood closures in reducing the risk to this component of the bycatch (MR 1.2(e)) will be essential.

Contributions to recovery programs for species of which OTF is a minor harvester (MR 2.2(b)) have the potential to address the capture of unmarketable individuals of redfish and gemfish. Until details of these recovery programs are known it cannot be determined how effective they will be in reducing the risk to this component of bycatch.

If limitations on fishing effort in the form of allocated days/nights fished are introduced (MR 5.2(a)(iv)) there could be an indirect affect on the discarding of unmarketable commercial bycatch. Reducing fishing effort overall, provided this includes current active effort, should have corresponding effects of reducing bycatch. But this will only be valid if there are no changes in how the fishing fleet proportionately targets each part of the fishery complex (Stratoudakis *et al*., 1998; Sampson, 1994). Limiting the time available to fish can give incentive to fishers to increase efficiency and thus catchability (Sampson, 1994). This could result in an increase in discarding of unmarketable commercial bycatch because fishers have a greater ability to catch larger abundances of the target species with a larger range of sizes. Consequently, a greater proportion of the discards could be unmarketable commercial species (Sampson, 1994). Improved gear selectivity (MR 2.1(e)) should contribute to minimising this type of problem. Limited time available to fish may also lead to high-grade discarding where in order to maximise their revenue fishers only keep the most valuable fish including those of a larger size and discard the rest (Gillis *et al*., 1995; Cook, 2001). This could lead to an increase in the fishery's impact on primary and key secondary species. Therefore, whatever mechanism is proposed to reduce effort (e.g. allocation of limited nights and days) it will be essential that it is followed-up with an appropriately designed monitoring program to determine whether it has led to an increase in discarding of undersized commercial species.

The introduction of a Code of Conduct (MR 1.2d(i),(ii)) is likely to have a minor influence in reducing risk on discarding of unmarketable commercial species since compliance to the Code will be largely voluntary and monitoring the rate of compliance would be difficult.

Table E1.16 Summary of management responses relating to discarding of under-sized commercial species in reducing bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Discarding of undersized commercial bycatch	1	1.1	*b) Implement series of closures to trawling .. including closure of all reefs & depths greater than 1100 metres*	2B
			c) Continue prohibition on using fish trawl nets north of Smoky Cape; implement additional BRD requirements for prawn trawl nets south of Smoky Cape	3B
		1.2	*a) Design & implement scientific observer program to collect information on the use and effectiveness of Bycatch Reduction Devices*	3A
			b) Refine & improve methods for reducing incidental catches; introduction of more effective BRD for prawn trawl nets	2B
			d) Develop a "Code of Conduct" for ocean trawl fishers to: *i) encourage use effective BRD, avoid fishing in areas &/or at times when juvenile or small fish are abundant* *ii) promote best practice handling of bycatch*	2A
			e) Identify areas and/or times of problem incidental catch to target catch ratios & restrict trawling appropriately; implement closures to trawling around river entrances during times of high river discharge	2B
	2	2.1	*e) Ensure selectivity of gear is appropriate to biology of species targeted. In particular:* *i) restrict prawn trawl net cod-ends to 150 meshes round (hanging ratio of 1:1), single twine maximum 4 mm diameter, mesh size 40- 50 mm* *ii) restrict fish trawl net cod-ends to 100 meshes round (hanging ratio of 1:1), single twine maximum 6 mm diameter, minimum mesh size 90 mm*	2B/3B
			f) Maintain & enhance the effectiveness of the "juvenile king prawn" closures; in particular: *iii) make all juvenile king prawn closures year-round closures, except when sufficient quantities of school prawns are present if size of school prawns exceeds a count of 100 prawns per half-kilogram and bycatch levels are acceptably low* *iv) investigate need to extend juvenile prawn closures adjacent to mouths of all major estuaries along the NSW coast, aim of harvesting prawns at size greater than 50 king prawns & 100 school prawns per half kilogram*	2B
			i) Review the efficacy of minimum size limits for fish species taken in the ocean trawl fishery, including need for minimum legal sizes to be implemented for additional species; regulations pertaining to fish with a minimum legal length captured in prawn trawl nets south of Smoky Cape	1A

Table E1.16 Cont'd

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Discarding of undersized commercial bycatch	2	2.2	*b) Minor harvester of an overfished species, contribute to the development of any recovery programs for that species, adopt measures required by recovery program, in particular:* *i) determine if additional measures are needed to improve the selectivity of fish trawl nets for redfish* *ii) implement the provisions of the recovery program for gemfish to be developed under the Ocean Trap and Line FMS.*	2A
	5	5.2	*a) Manage fishing effort in the ocean trawl fishery by:* *iv) investigating efficacy of limiting number of days/nights each boat may work in the prawn trawl and fish trawl sectors of the fishery.*	2A

v) Discarding of non-commercial bycatch

Discarding of non-commercial species is addressed in six management responses (Table E1.17). Quantification of the non-commercial component of bycatch via well designed observer studies will also be an essential precursor to reducing risk to this component of bycatch (see discussion E1.3(a)). Introduction of the most effective BRD (MR 1.2(b)) will reduce impacts on non-commercial bycatch in the prawn trawl sectors (with the exception of BRD used when targeting whiting, as discussed in Section E1.3(b)(iii)). Not all groups of species will benefit from the BRD. As noted earlier elasmobranchs are particularly prone to being caught in trawl nets because of their larger size, body shape and swimming behaviour. Liggins (1996) found that approximately, 12% of the non-commercial bycatch was made up of elasmobranchs in fish trawls and this is likely to be an underestimate. The most effective management of elasmobranch bycatch is to avoid catching them. Results from the observer program (MR 1.2(a)) on the spatial and temporal variability of catch composition will aid in determining the most effective means to (MR 1.1(b)) reducing the impact on this group of species. The Code of Conduct should include specific methods for handling shark bycatch to aid the survival of shark species on returning to the water. In addition, survival of discarded non-commercial species should also be investigated to provide information on reducing the risk to bycatch.

Table E1.17 Summary of management responses relating to discarding of non-commercial species in reducing bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Discarding of non-commercial bycatch	1	1.1	*c) Continue prohibition on using fish trawl nets north of Smoky Cape; implement additional BRD requirements for prawn trawl nets south of Smoky Cape*	2B
		1.2	*a) Design & implement scientific observer program to collect information on the use and effectiveness of Bycatch Reduction Devices*	3B
			b) Refine & improve methods for reducing incidental catches; introduction of more effective BRD for prawn trawl nets	2B
			c) Investigate alternative handling practices to improve survival of incidental species returned to sea; in particular: *i) prohibit finning sharks & discarding carcasses* *ii) ban "riddling" of prawns* *iii) restrict use of "spikes" to times when other handling methods are a occupational health or safety risk*	2A
			d) Develop a "Code of Conduct" for ocean trawl fishers to: *i) encourage use effective BRD, avoid fishing in areas &/or at times when juvenile or small fish are abundant* *ii) promote best practice handling of bycatch*	2A
	2	2.1	*e) Ensure selectivity of gear is appropriate to biology of species targeted. In particular:* *i) restrict prawn trawl net cod-ends to 150 meshes round (hanging ratio of 1:1), single twine maximum 4 mm diameter, mesh size 40- 50 mm* *ii) restrict fish trawl net cod-ends to 100 meshes round (hanging ratio of 1:1), single twine maximum 6 mm diameter, minimum mesh size 90 mm*	2B

The continued ban of fish trawling north of Smoky Cape ensures there will be no expansion of discarding from fish trawling and therefore not increase the risk to non-commercial bycatch species. The discussion evaluating the effectiveness of a Code of Conduct for undersized commercial bycatch also applies to the non-commercial bycatch (see Section E1.3(a)(iv)).

Alternative handling practices from the use of spikes for sorting catch on board vessels could increase the survival of some non-commercial species. However, this management measure is likely to have only a minimal affect on reducing the risk to non-commercial bycatch for two reasons. First,

spikes will continue to be used on the most dangerous species, such as some stingrays, and therefore the survival of most elasmobranchs caught will not be improved by this management measure. Second, there is no information about the rates of survival of non-commercial bycatch species, including elasmobranchs, after being discarded in the OTF. Studies done in other trawl fisheries on survival of discards have shown that the time spent on the deck is important in determining a species' ability to survive discarding (Hill and Wassenberg, 1990; Stobutski *et al*., 2002). However, these studies have only been done in tropical waters of northern Australia which clearly have different environmental conditions (e.g. warmer air temperatures and shallower depths) than those in the OTF. There is no research proposed in the draft FMS to investigate the survival of discards, including the survival from being spiked. To effectively reduce the risk, the draft FMS would need to prevent the use of spike on all bycatch, and alternative discard methods should be used instead. There appears to be few species normally discarded using a spike that could not be discarded using an alternative, less harmful implement.

Improving the gear selectivity of trawl nets for commercial species (MR 2.1(e)) could potentially change the quantity and composition of the non-commercial bycatch positively or negatively. When such improved gear selectivity is introduced monitoring any changes in the bycatch (via the observer studies) will be essential.

Bycatch reduction methods in fish trawls are much harder to determine than in prawn trawl because of the wider range of species targeted. Closures are the most effective at reducing risk to bycatch since it excludes all form of fishing induced mortality. The draft FMS seeks to reduce bycatch of non-commercial species in fish trawls using closures in two ways (MR 1.1(b), MR 1.2(e)). The proposed closure of 75% of state waters south of Barrenjoey Point would provide a substantial reduction in risk to bycatch in fish trawlers as long it included current trawling grounds. The effectiveness of temporary closures around river entrances during periods of high flow will depend on how "unusually high" the ratio of incidental to target catch is defined. Whilst it is recognised that there will be substantial spatial and temporal variability in this ratio, it is very important for this ratio be determined for each river mouth to ensure adequate risk reduction.

vi) Knowledge of food provisioning by the OTF bycatch

There are no management responses in the draft FMS on gaining knowledge of whether discards are a substantial source of food for marine scavengers. While it would be limited to surface-dwelling scavengers, some data on provisioning could be included in the proposed observer programs (MR 1.2(a)). Research investigating the diet of marine scavengers around trawl vessels is recommended.

1.4 Protected and Threatened Species and Communities

a) Overall effectiveness of proposed mitigation measures

In summary, the measures proposed to mitigate risk to threatened and protected species in the Ocean Trawl fishery are focused on obtaining better information on interactions between these species and the fishery. The development of a code of conduct based on that used in the Commonwealth South East Fishery may also reduce the risks to these species. Given the relatively low levels of risk to threatened species identified in Section B2, the proposed mitigation measures are considered adequate. It will be important, however, as provided for in the draft FMS, to ensure that information gathered is fed back into the management of the fishery in a timely manner, so that effective measures (e.g. closures) are used to manage any risks that are identified in future.

b) Likely changes in risks to threatened species

In general, risks to threatened species from trawling under the present management arrangements are low or moderately low and there is no change to these risks under the draft FMS. Risks to threatened species that are moderately low do not require a direct management action, but need ongoing monitoring to ensure that risks do not increase as activity changes. Furthermore, the risk assessment identified a lack of information about fishery interactions with many threatened species. To address this lack of information, the draft FMS proposes several mechanisms for obtaining better information. The measures contained within the harvest strategy and the research plan satisfy the requirements for ongoing monitoring of interactions and gathering of new information. The specific measures are listed below.

Harvest strategy

- Data on interactions between ocean trawl fishers and turtles will be obtained through changes in reporting forms and through onboard observer studies.
- Modification to the monthly catch return forms which will incorporate mandatory reporting of fishers' interactions with threatened species during fishing operations (see MR 3.1(a)); it should be noted that mandatory reporting carries with it an element of potential bias against mentioning them at all; therefore it will require careful policing and verification from the observer program
- The implementation of an observer-based survey that will *inter alia* collect data on occurrences of threatened species in catches and feeding on discards (see MR 1.2(a)) of the draft management strategy).
- Advice from fishers via the Ocean Trawl MAC about negative impacts from external activities could alert NSW Fisheries to potential threatened species issues outside the fishery, however, any action to deal with such impacts is probably beyond the scope of the FMS. Cross-jurisdictional collaboration to consider consistent management regimes would promote consistency in policies for reducing harm to threatened species. This could reduce risks to threatened species, but to what extent risk would be reduced cannot be determined.

Research plan

- The strategy seeks to improve the accuracy of information available on interactions between the ocean trawl fishery and threatened species using research projects undertaken through threatened species recovery plans.

The proposals listed above would contribute to the protection of threatened species through the improvement of knowledge on how the fishery interacts with threatened species. Provided this information is fed back into the management of the fishery and action to reduce any risks identified are implemented, the measures would reduce the risk to threatened species.

Management responses

Goal 3 of the draft FMS is specifically aimed at conserving threatened species, and has its objective to: "Identify and minimise or eliminate any impacts of fishing activities on threatened species, populations, ecological communities and habitats...and promote their recovery".

Specific management responses proposed to achieve this objective are:

3.1(a) - Modify reporting arrangements to enable collection of information on interactions with or sightings of threatened or protected marine species, and gear interactions with other threatened or protected species;

3.1(b) - Implement the provisions of any threatened species recovery or threat abatement plan;

3.1(c) - Promote the use of fishing techniques that avoid the capture of or interaction with protected fish and fish protected from commercial fishing;

3.1(d) - Determine, through the on-board observer program, the level of interaction between the fishery and marine turtles and seals (protected under the *Threatened Species Conservation Act 1995*) and assess the need to introduce Turtle or Seal Excluder Devices, or other measures to minimise impacts on these species

Management response 3.1(b) is a continuation of existing management arrangements and therefore does not contribute to any reduction in immediate risk, but ensures that the FMS is responsive to new recovery plans, including newly identified "critical habitat" areas. Responses 3.1(a) and 3.1(d) address the need for more information and therefore could contribute to risk reduction, provided that any issues identified are acted upon. Management responses 3.1(c) and 3.1(d) are a practical measures that could lead directly to reduced catches of (or other negative interactions with) threatened species, and increased survival of certain threatened species that are caught by trawlers (e.g. turtles).

In addition to the management responses dealing directly with Goal 3, certain management responses under Goals 1, 2, and 4 are listed in the draft FMS as also contributing to Goal 3. These are discussed below.

Management responses under Goal 1

1.2(a) Design and implement a scientific observer program to document the degree of interaction of trawl fishing with non-retained species, and obtain other important data.

1.2(d) Develop a "Code of Conduct" for ocean trawl fishers.

Response 1.2(a) addresses knowledge gaps with regard to capture rates of threatened species and has the potential to document other interactions such as the species feeding on discards, etc. Provided that it is fed back into other management responses (e.g. 1.1(b)) - closure of areas to fishing) and used to reduce impacts, gathering such information would contribute to reduction of risk. The "Code of Conduct" (MR 1.2(d)) would contribute to reducing the risks to threatened species assuming there was substantial voluntary compliance.

Management responses under Goal 4

4.3(a) Restrict 'offshore' prawn trawlers to depths less than 150 fathoms (275 m), and 'deepwater' prawn trawlers to depths between 200 and 600 fathoms (365 to 1100 m).

Although not intended for protection of threatened species, this response would reduce the area available for prawn trawling (i.e. no trawling between 150 and 200 fathoms), and thus may incidentally provide a refuge for some threatened species (e.g. Herbst's nurse shark) in these areas. Given a lack of knowledge about the biology of these species, it is unclear to what extent the risk would be reduced.

Management responses under Goal 6

6.3(b) Modify the arrangements for trawling in the area south of Barrenjoey Point (within 3 nautical miles) to achieve greater complementarity with the management of the adjacent Commonwealth Southern and Eastern Scalefish and Shark Fishery and to manage fish stocks in State waters on a sustainable basis and minimise other environmental impacts, as provided for in Appendix D3.

The closure of 75% of state waters south of Barrenjoey Point will substantially reduce the probability of vessels interacting with threatened and protected fish, marine mammals and reptile species provided that the closed areas correspond to areas these species are likely to be found and include some current trawl grounds.

c) The Eight Part test

A summary of the eight-part test for threatened and protected species is provided in Table E1.18.

Factors to be considered in the 8-part test.

1. "In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,... "

Evaluation of the likelihood of a local extinction occurring as a result of the activity is based on the risk assessments for threatened species if the draft FMS were implemented (Table E1.18). Viable local populations of a threatened species are likely to be placed at risk of extinction if the risk level is intermediate or greater (see Table B2.27 for interpretation or risk levels). None of the threatened species considered had intermediate or greater levels of risk. Information supporting the risk levels assigned to threatened species can be found in Section B2.4.

2. "...in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,..."

Disruption of the viability of an endangered population as a result of the activity is based on the risk assessments for threatened species under the draft FMS (Table E1.18). Any assigned risk level of intermediate or greater is considered likely to significantly compromise the viability of the population (see Table B2.27 for interpretation or risk levels). Information supporting the risk levels assigned to endangered populations can be found in Section B2.4. The only endangered population that may be disturbed by the OTF is the Little penguin colony at Manly in Sydney Harbour (see Appendix B2.10). However, it is considered that any interactions between the OTF and the endangered population of little penguins at Manly should only have a negligible impact on the

population as a whole, resulting in a low level of interaction with the fishery (for details see Appendix B2.10).

3. "…in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,..."

Proposed trawling activities as set out in the draft FMS are not considered to modify the habitat of any threatened species, with the possible exception of Herbst's nurse shark, for which there is little information on habitat use. Therefore, for Herbst's nurse shark the answer to this question cannot be determined.

4. "...whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,... "

The activity of trawling as set out in the draft FMS is unlikely to isolate areas of habitat.

5. "...whether critical habitat will be affected,..."

Critical habitat has been declared for four of the species considered here (wandering albatross, shy albatross, grey nurse shark and little penguin). Except for the grey nurse shark, this habitat is mostly terrestrial (extending to 50 m from shore, both inland and out to sea, for the little penguin), therefore would not be affected by the fishery. Grey nurse sharks have 10 designated areas of critical habitat along the NSW coast. These habitats are all complex rocky reefs, which are unsuitable for trawling. Therefore, it is unlikely that they will be affected by the OTF even though trawling is not among those activities prohibited from occurring within the sanctuary zones of grey nurse critical habitats. The remaining species have no declared critical habitat, so this question is not applicable. When additional critical habitats are declared the FMS should review whether trawling is likely to impinge on these habitats.

6. "...whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,..."

Many of the species considered here travel long distances in search of food or as part of their natural migration. Included in this group of highly mobile species are the birds, mammals, turtles and sharks (with the possible exception of Herbst's nurse shark, for which there is little information on movements). While they may occur in conservation reserves at times, it is likely that, for the majority of the time, these species would be very poorly represented in nature reserves. In fact, for such highly mobile and wide-ranging species, it has been argued that marine reserves are necessary but not sufficient to protect the species from the processes that threaten them (Allison *et al*., 1998). Therefore the majority of species are not considered to be adequately represented in conservation reserves.

Species of fish that are represented in conservation reserves are the black cod, blue groper, weedy seadragon and the grey nurse shark. Black cod and grey nurse shark are known from Cook Island Aquatic Reserve, Solitary Islands Marine Park, Jervis Bay Marine Park, Cape Byron Marine Park, and Lord Howe Island Marine Park. Grey nurse are also known from Long Reef Aquatic Reserve and the other areas of critical habitat not covered in marine parks, namely Fish Rock (South West Rocks), Green Island (South West Rocks), The Pinnacle (Forster), Big and Little Seal Rocks (South of Forster), Little Broughton Island (North of Port Stephens), Magic Point (Maroubra), Bass Point (Shellharbour), Tollgate Islands (Batemans Bay) and Montague Island (Narooma). The

restrictions in force around these areas include a ban on fishing with bait from anchored or moored vessels within 200 metres, and a ban on commercial drop, drift and set line fishing within 1000 metres of the site.

Blue groper and a variety of the other rocky reef fish are likely to occur in many of the marine protected areas that contain rocky shores, and juveniles of the species are likely to occur in marine protected areas containing seagrass beds. The weedy seadragon occurs in Halifax Park Aquatic Reserve (Port Stephens), and Jervis Bay Marine Park.

7. "...whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process...",

No aspect of the Ocean Trawl fishery constitutes a recognised threatening process for any of the species considered here. (Note that trawling north of 28°S is a key threatening process for marine turtles, but the Ocean Trawl fishery does not operate north of 28°S).

8. "...whether any threatened species, population or ecological community is at the limit of its known distribution."

Several of the species considered here are at the limit of their distribution.

Table E1.18 Summary of the results of eight-part tests for the impacts of the Ocean Trawl fishery on threatened and protected species listed under the FM Act, TSC Act and/or EPBC Act.

Information supporting the answers to each part can be found in Section B2.5 or Appendix B2.10. Answers that would contribute towards a determination of a significant impact on a threatened species are shaded. n/a indicates that the particular factor is not applicable to this species.

Species common name	Factors considered in the 8-part test							
	1	2	3	4	5	6	7	8
Endangered species								
Fish								
Grey Nurse Shark	no	n/a	no	no	n/a	yes	no	no
Green Sawfish	no	n/a	no	no	n/a	no	no	yes
Birds								
Gould's petrel	no	n/a	no	no	n/a	no	no	yes
Northern royal albatross	no	n/a	no	no	n/a	no	no	yes
Southern giant-petrel	no	n/a	no	no	n/a	no	no	no
Wandering albatross	no	n/a	no	no	no	no	no	no
Mammals								
Blue whale	no	n/a	no	no	n/a	no	no	no
Dugong	no	n/a	no	no	n/a	no	no	yes
Southern right whale	no	n/a	no	no	n/a	no	no	no
Reptiles								
Loggerhead turtle	no	n/a	no	no	n/a	no	no	yes
Endangered population								
Little penguin population	n/a	no	no	no	no	no	no	yes
Vulnerable species								
Fish								
Black cod	no	n/a	no	no	n/a	yes	no	yes
Great White Shark	no	n/a	no	no	n/a	no	no	no
Whale Shark	no	n/a	no	no	n/a	no	no	no
Birds								
Antipodean albatross	no	n/a	no	no	n/a	no	no	yes
Black-browed albatross	no	n/a	no	no	n/a	no	no	no
Black-winged petrel	no	n/a	no	no	n/a	no	no	yes
Buller's albatross	no	n/a	no	no	n/a	no	no	yes
Campbell albatross	no	n/a	no	no	n/a	no	no	yes
Fleshy-footed shearwater	no	n/a	no	no	n/a	no	no	no
Gibson's albatross	no	n/a	no	no	n/a	no	no	yes
Grey ternlet	no	n/a	no	no	n/a	no	no	no
Indian yellow-nosed	no	n/a	no	no	n/a	no	no	yes
Kermadec petrel (western)	no	n/a	no	no	n/a	no	no	yes
Little shearwater	no	n/a	no	no	n/a	no	no	no
Northern giant-petrel	no	n/a	no	no	n/a	no	no	no
Providence petrel	no	n/a	no	no	n/a	no	no	no
Red-tailed tropicbird	no	n/a	no	no	n/a	no	no	no
Salvin's albatross	no	n/a	no	no	n/a	no	no	no
Shy albatross	no	n/a	no	no	no	no	no	no
Sooty albatross	no	n/a	no	no	n/a	no	no	yes
Sooty tern	no	n/a	no	no	n/a	no	no	yes
Southern royal albatross	no	n/a	no	no	n/a	no	no	yes
White tern	no	n/a	no	no	n/a	no	no	yes
White-bellied storm-petrel	no	n/a	no	no	n/a	no	no	yes
White-capped albatross	no	n/a	no	no	n/a	no	no	yes

Table E1.18 Cont'd

Species common name	Factors considered in the 8-part test							
	1	2	3	4	5	6	7	8
Vulnerable species								
Mammals								
Australian fur-seal	no	n/a	no	no	n/a	no	no	yes
Humpback whale	no	n/a	no	no	n/a	no	no	no
New Zealand fur-seal	no	n/a	no	no	n/a	no	no	yes
Sperm whale	no	n/a	no	no	n/a	no	no	no
Reptiles								
Green turtle	no	n/a	no	no	n/a	no	no	yes
Hawksbill turtle	no	n/a	no	no	n/a	no	no	yes
Leatherback turtle	no	n/a	no	no	n/a	no	no	no
Species protected from fishing (FM Act, Section 19)								
Ballina angel fish	no	n/a	no	no	n/a	no	no	yes
Eastern blue devil fish	no	n/a	no	no	n/a	yes	no	yes
Elegant wrasse	no	n/a	no	no	n/a	yes	no	yes
Estuary cod	no	n/a	no	no	n/a	yes	no	yes
Giant Queensland groper	no	n/a	no	no	n/a	yes	no	yes
Herbst's nurse shark	yes	n/a	§	no	n/a	no	no	no
Weedy seadragon	no	n/a	no	no	n/a	yes	no	yes
Species protected from commercial fishing (FM Act, Section 20)								
Groper, blue, brown or red	no	n/a	no	no	n/a	yes	no	no

Note: § - Herbst's nurse shark too little information to determine an answer. Answers that would contribute towards a determination of a significant impact on a threatened species are shaded. n/a indicates that the particular factor is not applicable to this species.

1.5 Species Assemblages, Species Diversity and Ecological Processes

The goals, objectives and management responses (MR) dealing with issues for species assemblages, species diversity and ecological processes of the OTF are summarised for each issue in Tables E1.19-20. There were four major issues arising from the risk assessment of these ecological components. If these issues are adequately addressed in the draft FMS then theoretically the risk to these components of becoming unsustainable within 20 years should be reduced. Each issue will be discussed with respect to how well it has been addressed by the proposed management responses in terms of the stages in risk reduction outlined in Section E1.1.

a) Evaluation of management responses addressing issues from the risk assessment for species assemblages and species diversity

i) Priority on conservation of marine habitats

Conservation of marine habitats is a key issue in reducing the risks to species assemblages, diversity and ecological processes. There were six management responses that contribute to the conservation of marine habitat (Table E1.19). These are discussed in detail in Section E1.6. Overall, they show a commitment to conserving marine habitats, especially management responses 1.1(a, b) and 7.2(a). However, details are lacking to determine whether the closures and research are sufficiently specific and adequate to mitigate risks to species diversity, assemblages and ecological processes. Limiting the size of bobbins on fish trawl gear south of Seal Rocks pending the introduction of reef closures (MR 1.3(a)) will reduce trawling on high profile reefs but continue to enable trawling on low profile reefs. However, this management response will be superseded by the closure of all reef areas under MR 1.1(b). This issue is further discussed in Section E1.6.

Table E1.19 Summary of management responses relating to conservation of marine habitat.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Place high priority on conservation of marine habitats in oceanic waters	1	1.1	*a) Define & map the extent of trawling grounds & determine intensity of trawling on each ground*	1C
			b) Implement a series of closures to trawling to protect a range of ocean habitats & associated biodiversity, including closure of all reefs and depths greater than 1100 metres to all trawling	2A/2B
		1.3	*a) Require the use of trawl gear designs that minimise impacts on habitats & associated biota*	2B
	4	4.3	*c) Manage the multiple use of trawl grounds within ocean trawl fishery & minimise adverse interactions*	2A
	6	6.5	*a) Manage the ocean trawl fishery consistently with other management programs, e.g. marine parks program, aquatic biodiversity strategy, threatened species program, Indigenous Fisheries Strategy*	2A
	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW & the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity & the environment*	1B/1C

ii) Establishment of refuge areas for species diversity, assemblages and ecological processes

The establishment of refuge areas is the most effective means of reducing risk to species diversity, assemblages and ecological processes in the information poor environment of the OTF. Two management responses propose establishing closures for different purposes (Table E1.20). Implementing closures specifically to protect a range of marine habitats, including some oceanic waters outside three nautical miles, will have a positive affect on helping to maintain species diversity and assemblages. There are no details given of the criteria or process by which suitable areas will be determined, what activities will be prevented and how they will be monitored. It is acknowledged that the draft FMS proposes actions that aim to increase knowledge of the fishery and some of its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of some closures can be determined. It will be important to ensure that the knowledge gained is translated into effective management regimes as soon as possible. However, this makes it difficult to assess how effective the closures will be for reducing risk to species diversity and assemblages. Attention to the

size and placement of closures will be critical in ensuring they protect an appropriate range of habitat and species assemblages.

It is acknowledged that the NSW Government's Marine Parks program will contribute to conserving species diversity relevant to the OTF. Three marine parks have been declared on the NSW coast – Solitary Islands, Jervis Bay and Cape Byron. These are designed to incorporate a range of habitats that are representative, adequate and comprehensive of the bioregion in which they exist. Within each park areas are zoned for different purposes, such as habitat protection and general use. In both Jervis Bay and Solitary Islands marine parks all trawling is only permitted in general use zones (note fish trawling is prohibited north of Smoky Cape), which comprise 8 and 34 percent respectively of the total area of the park. Zoning for Cape Byron marine park is currently being developed. Additional marine parks will be established on the NSW coast and the more marine parks the greater their contribution to conserving biodiversity but it depends on where they are sited. It should be noted that these parks extend to 3 nautical miles out to sea from the coast, except Jervis Bay, which extends to less than 1 nautical mile. The operational area of the OTF extends beyond 3 nautical miles north of Barrenjoey Point and, as management response 1.1(b) notes, it is important for there to be closures in these regions also. The Commonwealth Government has the power to introduce marine parks in waters beyond 3 nm, as evidenced by the introduction of the Commonwealth Solitary Islands Marine Reserve, and it has signalled an intent to introduce a national system of marine protected areas as part of the regional marine planning process under the National Oceans Policy (see http://www.affa.gov.au/ministers/macdonald/releases/2004/04006m.html). It would be prudent for the draft FMS to consider the criteria used by the Marine Park Authority in choosing suitable areas for such closures including the proposed 75% of state waters south of Barrenjoey Point (e.g. Avery, 1999).

Table E1.20 Summary of management responses relating to establishment of refuge areas.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Establish refuge areas for species diversity, species assemblages & ecological processes	1	1.1	*b) Implement a series of closures to trawling to protect range of ocean habitats & associated biodiversity, including closure of all reefs and depths > 1100 m*	2A
	2	2.1	*g) Develop strategies to establish refuge areas & spawning closures for species targeted by trawling*	2A
	6	6.5	*a) Manage ocean trawl fishery consistently with other management programs, e.g. marine parks program, aquatic biodiversity strategy, threatened species program, Indigenous Fisheries Strategy*	2A

iii) Ensure management measures are sufficiently precautionary

Because there is so much that is unknown about the species diversity, assemblages and ecological processes in the OTF and the effects of the OTF on these ecological components it is essential that the management measures are sufficiently precautionary (Auster, 2001). For management measures to be sufficiently precautionary requires two important things. First, as smaller proportion of the ecological components as possible should be exposed to the potential impacts of the activities of the OTF. Second, whatever management measures allow ecological components to be exposed to the potential impacts of the fishery should be closely linked to a learning feedback mechanism, i.e. a scientifically rigorous adaptive management framework (Walters, 1986; Underwood, 1990). This would ensure that many information gaps in our understanding of the

relationships between habitats, species diversity and assemblages and impacts of fishing would be progressively filled.

The most optimum approach to precautionary management is the establishment of large space/time closures to fishing (Walters, 1998). The draft FMS has made a commitment to establishing a number of different types of closures (MR 1.1(b), 1.2(c), 2.1(f,g), 6.3(b,c)). To achieve long term sustainability in the face of high levels of uncertainty the proposed strategy takes a substantially precautionary approach. It is recognised that such a change in management would have some immediate economic implications for fishers and the associated fishing communities. The alternative of not taking a precautionary approach is that there is a substantial risk that the fishery may become economically unviable in the long term due to continued damage to habitats that support species diversity, assemblages and ecological processes. Furthermore, the economic collapse of a fishery also carries with it environmental damage, which may take decades to recover, and in the case of some habitat forms (see Section E1.6) not recover at all, i.e. irreparable damage. Therefore, not establishing major space/time closures in the short term risks postponing a highly likely economic and ecological decline that has serious long term consequences for more than just the fishing community. The fishing industry, scientists, fisheries managers and the government must all come to terms with this prospect and then work together to find amenable solutions.

b) Evaluation of management responses addressing issues from the risk assessment for ecological processes

The risk assessment in section B2.6 identified risks to ecological processes from three of the main activities of the current fishery, namely harvesting, trawling and discarding. Due to a lack of information on ecological processes in south-east Australian waters, the risk assessment was based largely on overseas studies and expert opinion of the impacts of trawling.

Harvesting was found to present risks to trophodynamic processes, which could result in changes in distribution and abundance of both harvested and non-harvested species. Measures to address this include several management responses under goals 1-3 that aim to reduce the ecological impacts of the fishery. In particular, the promotion of research into ecosystem functioning, reduction of bycatch and prevention of overfishing are management responses that would assist in reducing risks to ecological processes due to harvesting.

Trawling (i.e. physical disturbance of the sea bed) was found to have potential consequences for secondary productivity, and also for altering nutrient dynamics. The most effective measure that would reduce the risk is to introduce closures (MR 1.1(b)). Whilst all reef areas will be closed to trawling, other habitat types, such as some soft sediments will also need protection to help in maintaining secondary productivity. Protecting these habitats should be considered when determining areas to close south of Barrenjoey Point.

Discarding was found to have potential risks to displacement of productivity from demersal fish production to benthic and pelagic scavenger production. Reduction of bycatch may go some way towards reducing this potential risk, however this will depend on the effectiveness of any bycatch reduction measures that are introduced.

The management responses in the draft FMS have been written with the intention of reducing the risk to the ecological processes discussed here, however it is difficult to quantify to what extent the risk is reduced for two reasons. First, there is very little actual information on the impact of the current activity to ecological processes, making it difficult to quantify the extent to which impacts

would be reduced under the draft FMS. Second, the draft FMS lacks the necessary detail of how several key responses are to be implemented (e.g. the closures), making assessment of the outcome difficult. It is acknowledged, however, that the draft FMS does propose actions that aim to increase knowledge of the fishery and its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of closures can be worked out. It will be important to ensure that the knowledge gained is translated into effective management regimes in future.

The most effective method of protecting ecological processes on trawl grounds from the effects of trawling is to introduce closures. Ideally, a closure would have clearly stated goals (e.g. larval production of fish species increased by 50% within closed areas), and would take into account biological properties of species (movement, habitat requirements etc.) and use the best available information to ensure success at achieving the goal. In the absence of such information, an adaptive management program would be the best way to proceed, with trial closures based on available information, appropriately rigorous sampling to test their effectiveness and rapid management response to act upon the information gathered.

1.6 Marine Habitats

The goals, objectives and management responses (MR) dealing with issues relating to habitats affected by the OTF are summarised in Tables E1.22-25. There were four major issues arising from the risk assessment of aquatic habitats. If these issues are adequately addressed in the draft FMS, and it is assumed that the management responses will be effective when implemented, then the theoretical risk to aquatic habitats (as defined in the risk context) should be reduced. Each issue will be discussed with respect to how well it has been addressed by the proposed management responses and in terms of the stages in risk reduction outlined in Section E1.1.

a) Overall assessment of reduction of risk to habitats

The strength of the draft FMS is that individual management responses often contribute to multiple management goals. There are a number of management responses (Table E1.21) and also references in the harvest strategy to the establishment of closures which is the most effective way of reducing the risk to marine habitats. However, the effective implementation of the FMS will be dependent on determining the detail for a number of responses (Table E1.21). This is particularly the case in reference to closures, wherein the process by which closures and other measures will be used to achieve their objectives need to be articulated (See Section 2.6(d)). Such a process would include determining a set of criteria for choosing areas to close incorporating input from all stakeholders, stating clear objectives for the closures, and how closures would be evaluated and monitored. For example, the criteria used by the Marine Parks Authority in classifying and selecting habitats needing to be protected provides a useful starting point as a means of formulating criteria for the OTF. In addition, the draft FMS does not address minimising impacts on habitats specific to threatened species under Objective 3.1. However, general habitat protection is provided for in MR 1.1(b) in which all reefs will be closed to trawling and 75% of state waters south of Barrenjoey Point will be closed. In order to conserve threatened species and their populations any habitats important or critical to them need to be protected.

A summary of the management controls proposed and assessment of their potential to reduce risk is given in Table E12.1. Overall, the draft FMS has a minor to moderate influence in reducing the risk to marine habitats associated with the OTF. A significant reduction in risk levels for some habitats is achieved by closing all reefs to trawling and, depending on where they are placed, areas closed south of Barrenjoey Point (MR 1.1(b)).

Table E1.21 Summary of management controls used to reduce risk levels for habitats

	Management control proposed	Potential Risk Reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Refuge areas	uncertain	2A	No details given of criteria used to develop refuge areas	MR 2.1(g)
	Habitat protection & restoration areas	Major for reefs; uncertain for other	2A 2B	(a) Few details given of criteria used to select areas for closures other than reefs (b) Proposed closure of all reefs & depths greater than 1100m	MR 1.1(b)
	Gear modification (a) restrict size of bobbins and chains on trawl nets (b) mandatory use of droppers on prawn trawl nets	 Nil unknown	 2B 2B	Allows possibility for trawling on hard-substrata that will cause irreversible damage Effectiveness for minimising impacts on habitats is unknown	MR 1.3(a)
	Consistent management regimes among jurisdictions (whenever possible)	unknown	2A 2A	(a) Commitment to improve communication but no process outlined (b) Commitment to whole of government approach for management plans, but no process	MR 4.2(c) MR 6.5(a)
Information	Research to fill knowledge gaps	Minor to moderate	1B	Essential information to reduce uncertainty and improve effectiveness of management controls. Many MR's in the draft FMS relate to research issues, however, these should all be regarded as sub-sets of the Research Strategic Plan MR 6.2(a)	MR 6.2(a) see also MR 1.1(a) MR 7.2(a)

Overall risk reduction for habitats	**MINOR to MODERATE (varies among habitats)**

b) Evaluation of management responses addressing issues from the risk assessment for aquatic habitats

i) Fishing practices that cause irreversible damage to habitats

Two habitat types are regarded as being at high risk of irreversible damage from the activities of the OTF. These habitats are: (a) hard-ground substratum having low vertical relief (<2m); (b) the biota associated with hard-ground substratum having low vertical relief (<2m).

A third habitat type, the biota of soft-substratum, was also assessed as being at the highest level of risk from the activities of the OTF. The damage to this habitat type was not regarded as being irreversible, however the very slow dynamics of habitat recovery, particularly for the larger elements of the habitat (see Sainsbury *et al*. 1997), provide a sound justification for the implementation of precautionary management measures.

The draft FMS contains two management responses directed towards reducing the risk to these habitats (Table E1.22).

Table E1.22 Summary of management responses relating to fishing practices that cause irreversible damage to habitats.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Fishing practices that cause irreversible damage to habitats	1	1.3	*a) Require use of trawl gear designs that minimise impacts on habitats and associated biota; in particular:*	2B
			i)Pprohibit use of bobbins on the ground ropes of fish trawl nets north of Seal Rocks; limit maximum size for 'bobbins' on fish trawl nets south of Seal Rocks 100 mm diameter	2B*
			ii) Pending the closure of reef areas, limit the maximum size for bobbins used on fish trawl nets south of Seal Rocks 100 mm diameter	2B*
			iii) Restrict trawl nets to a single ground chain of no greater than 12mm gauge	2B*

* denotes that the management response is inappropriate for reducing risk to some types of habitats. See text for details.

The closure of all reef areas, including low profile reef, to trawling will have a substantial influence in reducing the risk of irreversible damage on these habitats (MR 1.1(b)). This response, therefore, will supersede the response (MR 1.3(a)(ii)) that allows the continued use of bobbins no larger than 100mm diameter on trawl gear.

Management response 1.3(a)(iii) refers to restrictions on the number of ground chains and the gauge of the chain (12 mm maximum) that may be used on the ground rope of fish and prawn trawl nets. The logic of this management response is sound for soft-substratum habitats and their associated biota. The use of lighter ground gear may reduce fishery related impacts on soft-substrate habitats and their associated biota habitats. However, the effectiveness of 'light chains' for minimising impacts on the biota of soft-substratum habitats is unknown. An assessment of the likely reduction of risk to habitats, attributable to this management response, cannot be made until further information is obtained.

ii) Adequate refuge areas are needed to conserve habitats

The most effective way to conserve habitats in the OTF is to introduce a series of closures. The draft FMS has four management responses that take this approach (Table E1.23). Fundamental to establishing closures to conserve habitat is knowing what habitats exist, their spatial distribution and where trawl fishing occurs in relation to these habitats. Management responses 1.1(a) and 7.2(a) make a commitment to obtaining this essential information. This research should have a high priority given the general knowledge of the vulnerability of oceanic habitats (especially biogenic) and damaging effects of trawling has on these habitats known from studies elsewhere (see Section B2.7, Kaiser and de Groot, 2000, Bax and Williams, 2000).

Obtaining knowledge about the type and spatial extent of marine habitats will take time. Therefore, as a precautionary measure the draft FMS will implement a series of closures to protect a range of habitats (MR 1.1(b)). The proposed closure of reefs is an important concrete step to reducing

risk to these habitats with flow on effects to fish productivity and therefore ecological sustainability. Closing depths greater than 1100m will do little to reduce current risks from trawling by the OTF because NSW fishers do not trawl at these depths. However, it will prevent trawling expanding into these depths in the future protecting these deep habitats from potential impacts from the OTF. Closing 75% of state waters south of Barrenjoey Point is a very precautionary approach to habitat conservation but the areas closed must be of a sufficient size to protect continuous types of habitat and include some trawling grounds.

Apart from the reference to closing reefs and depths greater than 1100m, no other details are provided to explain how or where these closures will be established. Studies have shown that marine biota, especially shellfish and finfish, rely on a large range of habitats throughout their life cycle across substantial depth gradients, i.e. from shallow to deep (Love *et al*., 1991; Carr and Reed, 1993; Carr *et al*., 2003). Therefore, effective closures need to encompass a large diversity of habitats to ensure as many requisite habitats over the life of marine biota are included (Carr *et al*., 2003). A possible cost effective way to achieve this for the OTF, with a poor knowledge base about habitats and the desirability of minimising operational complexities and costs, is to establish strip closures at a number of places along the coast, starting at the coastline and extending to the continental slope. Such strip closures would be easy for fishers to comply with and for the department to enforce. Furthermore, monitoring their effectiveness would also be easier. Outcomes of such monitoring can then be fed back into the management regime to improve and refine an integrated system of closures (Sainsbury *et al*., 2000). Until there is more information about how and to what extent the proposed closures will occur it is not possible to fully assess the adequacy of this management response. But it is definitely in the right direction and will contribute to reducing the risks to marine habitats if implemented effectively.

Table E1.23 Summary of management responses relating to adequate refuge areas for conserving habitats.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Adequate refuge areas are needed to conserve habitats	1	1.1	*a) Define & map extent of trawling grounds & determine intensity of trawling on each ground*	1B
			b) Implement a series of closures to trawling to protect a range of ocean habitats and associated biodiversity, including closure of all reefs & depths > 1100 metres	2A/2B
	2	2.1	*g) Develop strategies to establish refuge areas and spawning closures for species targeted by trawling*	2A
	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW and the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity and the environment (including mapping of fishing grounds, the effectiveness of trawl closures and refuge areas)*	1B

Management response 2.1(g) (Table E1.23) refers to the development of strategies that will be used to establish 'refuge' areas and spawning closures for species targeted by trawling. The main focus is to provide these refuge areas for invertebrates and fish targeted by the fishery. However, there needs to be greater recognition of the strong links between habitats and the fish that interact with them in the draft FMS. Essentially, refuges cannot be provided for fish unless careful attention is also paid to protecting their habitats. Whilst the response 2.1(g) has the potential to reduce the risk levels for habitats, the draft FMS does not give details as to how the strategies for establishing refuge areas will be developed nor whether the different requirements of fishes and habitats will be considered in their design. The strategies referred to in the management responses should make use of the abundant literature on marine reserve design and the complex principles that need to be considered it meeting diverse objectives (e.g. see all references in Ecological Applications 13(1) Supplement, 2003; Hooker and Gerber, 2004). This will be especially important when evaluating the combined effects of all closures for the OTF (MR 6.3(c)).

The lack of detailed information about the establishment and design of proposed refuge areas makes it difficult to determine the level of risk reduction for habitats. It is acknowledged that the draft FMS proposes actions that aim to increase knowledge of the fishery and some of its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of some closures can be determined. It will be important to ensure that the knowledge gained is translated into effective management regimes as soon as possible. However, until such details are provided this management response can only be assessed as providing minor risk reduction for habitats.

iii) Inconsistent fishery management regimes among jurisdictions – implications for habitats

There were two management responses proposed to address the issue of inconsistent management regimes across jurisdictions (Table E1.24). Man-made boundaries that define the extent of different areas of jurisdiction do not constrain the distribution of geological features or the distribution of biota in the real world. The problems of managing shared fish stocks, which occur across several jurisdictions but are managed differently in each jurisdictional area, have received due attention in the scientific literature (Hilborn and Walters, 1992; Mitchell, 1997; Hoel, 1998). This same concept must also apply to habitats on which populations of fish rely for their survival. Therefore, inconsistency in management approaches must pose similar problems for the ecologically sustainable management of shared fish stocks and the sustainable management of important habitats. The outcome of inconsistent management regimes across adjacent jurisdictions is to increase the risk level for habitats. This occurs because the effectiveness of any management initiative taken in a single jurisdiction is weakened by the lack of consistent or complimentary action in the adjoining areas.

Table E1.24 Summary of management responses relating to inconsistent management regimes among jurisdictions.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Inconsistent fishery management regimes among jurisdictions - implications for habitats	4	4.2	*c) Use cross-fishery & cross-jurisdictional consultation to discuss & manage issues relating to multiple use of specific fishing grounds, collaborative research, fair & equitable access to stocks, complementary management arrangements & other interactions between fishing sectors*	2A
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2A/2B
		6.5	*a) Manage ocean trawl fishery consistently with other jurisdictional or natural resource management requirements, such as the marine parks program, aquatic biodiversity strategy, threatened species program, Indigenous Fisheries Strategy & other relevant strategies*	2B

Efforts to improve communication and consultation to better coordinate consistent management responses across jurisdictions (MR 4.2(c), 6.5(a)) should lead in the long term to better resource management (fish stocks and habitats) and hence should lead to a reduction in levels of risk. Management response 6.3(b) specifically aims to achieve greater complimentarity between the OTF and the Commonwealth SESSF south of Barrenjoey Point. However, the effectiveness of the management measures outlined in Appendix D3 are likely to be minor and depend upon the resolution of several issues – for full discussion see Section E1.2(b)(vi)). Whilst the draft FMS does not prevent state waters south of Barrenjoey Point from being transferred to Commonwealth jurisdiction in the future the outstanding resolution of issues needed to achieve greater complimentarity means that the reduction in levels of risk for habitats attributable to these management responses is assessed as minor.

iv) Major information gaps

The risk assessment identified four main information gaps. The draft FMS contains many management responses that either directly or indirectly attempt to address these issues (Table E1.25). Essentially, the draft FMS proposes a Research Strategic Plan (see MR 6.2(a)), which should provide the direction and assignment of priorities for research proposals in consultation with the MAC. This Research Strategic Plan should be expected to cover all aspects of research relating to habitats and fishery-related impacts on habitats. Thus, the remaining management responses that are linked to specific information gap issues should be seen as subsets of the Research Strategic Plan.

The management responses in the draft FMS (see Table E1.25) acknowledge the need for research to fill these critical habitat information gaps for the OTF. However, all of the management responses dealing with research issues do not provide detail but are linked to the research plan. A more detailed assessment of proposed research in the draft FMS is given in Section E5.2.

As highlighted in the risk assessment (Section B2.3) increased knowledge of the distribution of habitats, the distribution of fishing effort, and the spatial overlap between habitats and fishing effort are needed to enable reduction in the risk to habitats. Management response 7.2(a) indicates initial work on identifying habitats associated with trawl grounds will be conducted in conjunction with mapping of trawl grounds in management response 1.1(a). This will be a good start but it is important that mapping of marine habitats be undertaken both within and outside of trawled areas under NSW jurisdiction for the OTF, to which management response 7.2(a) is committed.

High priority should be given to undertaking research on the distribution of broad habitat types, particularly those habitats assigned high-risk levels. Unless the distribution of habitats is known it will be impossible to accurately determine the spatial extent or magnitude of fishery-related impacts on habitats nor in determining where reefs are.

Table E1.25 Summary of management responses relating to information gaps.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Major information gaps	6	6.2	*a) Develop & implement a Research Strategic Plan for ocean trawl fishery taking account of the priorities for research outlined in harvest strategy*	1B
(a) Identification of fishing grounds and mapping the distribution of fishing effort.	1	1.1	*a) Define & map the extent of 'trawling grounds' & determine intensity of trawling on each ground*	1B
(b) Identification and mapping the distribution of broad habitat types.	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW and the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity and the environment (including mapping of fishing grounds, the effectiveness of trawl closures and 'refuge' areas)*	1B
(c) Assessment of the effect size of fishery impacts on habitats.				1B
(d) Lack of biological and ecological knowledge for biogenic habitats.	1	1.1	*d) Promote research & collaborate with research institutions to improve understanding of ecosystem functioning & how it'saffected by trawling*	1B
	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW and the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity and the environment (including mapping of fishing grounds, the effectiveness of trawl closures and 'refuge' areas)*	1B

2 Biophysical Environment

It is expected that the draft FMS will not result in any major increase in impacts on water quality, noise and light or greenhouse gas emissions (including air quality). The commitment to developing a Code of Conduct (MR 1.2(d)) in which specific reference is made to minimising pollutants and reducing marine debris (MR 1.2(d)(iv, v)) will contribute to reducing impacts to the biophysical environment. The only potential concern may be greater localised turbidity due to increased trawling in soft sediments as a result of restricting fishing to these habitats and closing reefs (Section D3(b) MR 1.1(b)). The draft FMS is committed to mapping habitats in the OTF including soft sediments (MR 1.1(a)) which will be essential in determining to what extent localised turbidity due to trawling may occur. It is suggested that once soft sediment habitats have been described within the OTF area that turbidity levels from trawling be determined and whether any mitigative action is needed. Such a study could be incorporated as part of the proposed research on effects of trawling on ocean ecosystems (Section D4(e)(i)).

3 Economic Issues

This report is a summary of the main report on economic issues undertaken by Dominion Consulting Pty Ltd and presented in full in Volume 4. This report has been compiled by Dominion Consulting Pty Ltd from a limited amount of existing information augmented by new economic and social surveys by Roy Morgan Research, a number of reports prepared by NSW Fisheries and access to ABS data on NSW fishers.

This assessment has been done under the understanding that NSW Fisheries is in the process of finalising the share allocation criteria, and that the criteria for the ocean trawl fishery will differentiate between active and inactive entitlements based on validated catch history.

3.1 Economic Assessment

The Ocean Trawl Fishery Management Strategy (OTFMS) proposed a number of management responses to address the key issues in the fishery. As required by the guidelines, we assessed these responses to "**outline the potential change in economic viability of ocean trawl operators**" (DIPNR, 2003) with a focus on assessing:

- the ability of fishers to pay increased management costs;
- the likely changes in patterns of investment;
- the likely changes in employment;
- the likely changes in economic returns to fishers; and
- the likely changes in overall risks to the economic viability of the fishery.

a) Potential change in economic viability of ocean trawl operators

The category 1 share scheme provides significantly more security of access for fishers than the current *restricted fishery* regime or the previously proposed move to the category 2 scheme. The category 1 right would apply to access only, as the OT fishery does not have catch restraining measures, such as the ITQs in the NSW Abalone and Rock Lobster fisheries.

The FMS indicates an intent to limit the activation of latent effort, but the level of structural adjustment or the means to achieve it are not specified. Limiting the activation of latent fishing capacity can happen through a range of adjustment tools, such as the share allocation criteria and the implementation of the minimum shareholdings limits, higher requirements for new entrants, surrenders, and buybacks – each tool would have different implications for fishers. Attempts to improve profitability in the fishery through reduction of active effort may in fact give an incentive for latent effort to activate. Removal of latent effort would require a 39% reduction in endorsed boats and would reduce the fleet from 410 to 252, a reduction of 158 boats. Given the multi endorsed nature of fishing businesses, improvements in OT fishery profitability may cause fishers with low levels of effort in several fisheries to increase their effort in the OT component of their fishing business. The FMS needs to more clearly propose the steps to contain or remove latent effort, and cater for the potential rise in effort from multi endorsed fishers. Addressing these issues is essential to the maintenance of long term business viability in the OT fishery.

Minimum shareholdings would probably lead to latent entitlement holders and those businesses grossing below $10,000 revenue per year exiting the fishery. Shares will be more readily purchased by remaining businesses in economic surplus. Removing latent effort will only eliminate potential risk to the fishery from effort activation and will not increase economic viability. Increasing

total economic returns to fishing businesses depends on the amount of active effort reduced from the fishery.

Vessel capacity restrictions such as horsepower and other unitisations will remain in place. In an input-based control strategy there is always a possibility of substituting controlled inputs by other inputs. Therefore, economic benefits from vessel capacity restrictions will depend on the regulations that maintain total capacity in the fishery.

The FMS proposes a full recovery of management charges within 5 years and assumes the industry will be sufficiently profitable in this adjustment period to meet these charges. Thus the intention to establish "a maximum level of fishing effort within 10 years" may not sufficiently improve profitability in the next five years as costs recovery impacts fishing businesses. Containing total effort may also be made more difficult by rises in fishing effort in response to fishery adjustment initiatives which are not specified in the FMS. A major risk is the inability to contain total effort in the fishery without limits being imposed on individual producers.

Limiting the number of days/nights fished would have a positive impact on controlling total effort in the fishery. Ideally the days and nights should be tradable to realise economic efficiency. Equity would need to be a key consideration when considering the allocation of days/nights in the fishery, for example, having regard to share holdings and past restrictions on vessel capacity.

As management restricts effort in the fishery, the capacity of the resource to yield optimal sized fish becomes more important. Optimising the biological yield will have significant long-term bio-economic implications for resource productivity, stock rebuilding and hence viability of the industry. The economic benefits of optimising biological yield for each species can be modelled by age and price structured bio-economic analysis. This requires research into optimal harvesting, inter-relationships between estuarine and ocean prawn fisheries in particular and on the selectivity of trawl gear for both prawn and finfish production.

Improving post-harvest practices are important to increase economic returns to the fishery. For example, minimizing waste, adding value, developing new products, increasing consumers' safety and confidence, and ensuring consumers that the product was harvested in a sustainable manner are some of the areas for consideration.

The risk of having insufficient area closures and refuges for fish and prawns is potential stock depletion. In the case of prawn species, ocean trawl fishers and estuary prawn trawl fishers must cooperate with each other as both fisheries depend on the same species. The Prawn Resource Forum deals with issues relating to improved management of species in each estuary by incorporating prawn and species capture outside the estuary and the optimum size and time of harvest (EPT EIS, 2003).

Fishers in the ocean trawl fishery may bear higher operational costs in using BRD, with some potential benefits from improved catch quality, and hence higher prices to fishers, reduced catch sorting time, and potentially satisfying growing consumer preferences for seafood harvested using environmentally sustainable practices. However, there is a possibility of reduction in total catch. The resultant outcome may have a positive or negative impact on total revenue and net income.

The potential economic benefits of rebuilding any overfished species may be significant. But these benefits will largely depend on the rate of recovery and they must be weighed against the short term costs of recovery programs.

The FMS specifies a performance measure to monitor the commercial viability of fisheries at a fishery level. Developing performance measures for monitoring viability at the individual fishing

business level is not the recommended way to monitor economic viability / performance in a fishery (ABARE, 2000). There are inherent confidentiality and privacy issues involved in monitoring individual business activities. In addition, monitoring costs may increase depending on the level of monitoring and how it is done.

Assuming that there was a reduction of 158 (latent) fishing business numbers in the fishery, the total charges for an average fishing business are estimated to increase from current $2,035 to $4,620 per annum assuming an increase in management charges due to the new programs in the FMS and adjustment initiatives reducing business numbers in the management cost levy base. Fishers also may face costs associated with structural adjustment, depending on the adjustment tools used and the adjustment timeframe. The cost to industry will depend on the suite of policies adopted to address latent effort and overcapacity. A business remaining in the fishery for the long term would expect to have to pay a portion of the capital value of a business in restructuring costs, depending on the adjustment measures taken. It is important that the development of cost recovery and structural adjustment plans do not lead to an increase effort to the detriment of the fishery.

Fuller incorporation of effective and efficient management requires a framework for improving fishery management services. There should be specification of each of the services to be delivered and clarification of acceptable performance standards within the agreed costs of management.

b) Potential change in overall risks to the economic viability of the fishery

Even if fishing capacity were to be capped at the currently active level, this may not necessarily contain total effort at the current level as vessels may fish more days/nights and/or use more advanced technology to make vessels more efficient (technology creep). Implementing a minimum shareholding limit at a level which removes all latent effort, would eliminate the risk of potential activation of latent effort in the fishery. However active effort levels may rise as fishers may increase effort to meet new payments.

Recovering management costs in 5 years depends on the effectiveness of the policies limiting total effort, so that profitability is maintained in the fishery. Total effort may be controlled by limiting the number of days/nights fished by each fisher. If implemented, fishing days/nights should be transferable and tradable in order to increase efficiency and the value of the shares.

Under the FMS, the costs of management and restructuring will increase, but the ability of fishers to pay for this increased cost will only increase with further reductions in total active fishing effort. Risks from insecure access rights can be reduced under Category 1 share management which increases access security, but does not automatically improve business viability, which is dependent on containing effort levels. Many fishers will see the security of category 1 shares as a form of superannuation. This will hopefully give fishers the incentive to increase the value of the shares through limitation of effort. Failure to do this may see a share values reduce with economic and social implications for fishers.

The monitoring of economic performance should be a priority area for future research.

3.2 Conclusions

In summary, the FMS reflects the current move to category 1 share management, which will provide a significantly more secure right, and incentive, for fishers. The FMS signals the intent to limit latent effort, but the level of structural adjustment or the means to achieve it are not specified. Fishing

businesses remaining in the fishery in the long term will likely incur costs in reducing fishing capacity, depending on the adjustment tools used, the extent of restructuring and the pace of adjustment. Limitation of total effort could be an issue as fishers face increased management charges with an incentive to increase their effort, although this may be offset if individual returns improve as a result of restructuring.

A regime with a more specific limited number of days/nights per fisher may be inevitable in the 5 year view, to support a structural adjustment plan and to augment category 1 share management Other available management strategies that provide fishers with more incentives, in addition to moving towards category 1 share management, warrant further investigation. For example, implementing more advanced input and output control management systems should be evaluated during the next 5 years, taking account of the outcomes of adjustments in fishing effort and improvements in gear.

Fishing capacity and fishing effort levels must be addressed if a viable fishery is to be achieved long term. It is important that the FMS provide for a high level of industry involvement in decision making with regard to structural adjustment and that the decisions to improve long term viability are implemented.

4 Social Issues

This report is a summary of the main report on social issues undertaken by Dominion Consulting Pty Ltd and presented in full in Volume 4. This report has been compiled by Dominion Consulting Pty Ltd from a limited amount of existing information augmented by new economic and social surveys by Roy Morgan Research, a number of reports prepared by NSW Fisheries and access to ABS data on NSW fishers.

This assessment has been done under the understanding that NSW Fisheries is in the process of finalising the share allocation criteria, and that the criteria for the ocean trawl fishery will differentiate between active and inactive entitlements based on validated catch history.

4.1 Social assessment

The Ocean Trawl Fishery Management Strategy (OTFMS) proposed a number of management responses to address the key social issues in the fishery. The potential social impacts of implementing the draft OTFMS are assessed against the following criteria:

- likely changes in social impacts on fishers, their families or any local communities;
- whether the level of job satisfaction among commercial fishers is likely to change;
- likely employment fate of any fishers exiting the industry; and
- whether the risk of social impacts are changed.

The major social changes in the FMS involve the potential displacement of fishers, due to the removal of overcapacity in the fishery. The actual impacts will be dependent on the extent of restructuring, its timing and the way in which it is achieved, as well as how these factors interact with fishers retirement. For example a scenario of adjustment in the ocean trawl fishery in the economic issues section indicates that 104 of 311 OPT and 54 of 99 OFT fishing businesses maybe removed in the 2003-2008 period. Such a change would probably impact part-time and older fishers, and latent endorsement holders, or fishing businesses grossing less than $10,000 per year. Displacing latent effort may potentially impact 39% of total dependents of ocean trawl fishers, approximately 144 dependents.

On implementation of the OT FMS different areas along the coasts will be impacted. For the OPT fishers in Tweed, Richmond, Clarence, Coffs Harbour and Hastings, and OFT fishers in Hastings, Hunter, Port Stephens, Sydney North, Batemans Bay and Far South Coast, are probably most vulnerable to changes from the socio-economic impacts under the strategy.

The social impact of the FMS could also be noticeable in ocean trawl fishing communities, given the lack of alternative employment for many aged fishers. However, it could potentially enable elderly fishers to retire with a payment from the sale of shares. Opportunities for greater value adding may also arise. Importantly, the FMS creates the platform to move the fishery to a sustainable and viable basis in the longer term, in consultation with industry providing that the risks identified to viability are addressed. Further research should prioritise understanding of fishing communities, to reduce the cumulative impacts from successive management strategies.

As a result of implementing the OTFMS, we envisage the following changes in overall social risks in the fishery:

- the move to the category 1 share scheme will significantly improve access security over the current situation;

- fishing will be seen more as a commercial activity than a way of life, which may have negative impact on some fishers whose main objective is not maximising economic returns from the fishery;
- the need to create alternative employment opportunities for outgoing fishers will increase and may increase unemployment in rural areas and place an extra burden on alternative fisheries and on the social security system;
- there may be some rise in conflict as allocation of access rights and compliance issues are introduced. They are comparatively well addressed in the FMS though there is a risk of new conflicts over the allocation of access rights, sharing responsibilities, authority and accountability of policy decision-making and management, and funding future research programs; and
- monitoring social aspects in the fishery is likely to increase because of increased emphasis on socio-economic research.

Conclusions

In summary, the move to the category 1 share scheme provides significantly greater security and certainty for fishers, their families and local communities. However, the FMS may have significant social impacts on some parts of the ocean trawl fishing community in rural NSW as reducing overcapacity inevitably displaces a number of people associated with the fishery. Fishers with ownership in a licence will be able to sell their shares, if they wish to leave the fishery or reduce their fishing operations. Crew members will be displaced with a resultant loss of income.

Outgoing fishers may face difficulties in finding alternative employment or business opportunities, though some fishers are latent in the OT fishery as they fish elsewhere and others may retire. The nature of the fishery will change. Fishers who remain in the fishery will see fishing more as a commercial activity than a lifestyle, being able to develop long-term business plans and increase their economic returns.

4.2 Health and safety

The draft FMS will not result in any change to the health and safety risks of OTF. The only potential area of concern is banning the use of spikes (MR 1.2(c)(iii)). Fishers use these on a variety of animals including those that are more dangerous to handle, such as stingrays. However, it is proposed that use of spikes will be restricted to a specific list of species, generated by fishers in the OTF. Along with developing improved handling practices (MR 1.2(d)(ii)) this will mitigate any problems associated with safety in handling animals on deck.

5 Assessment of Performance Reporting, Monitoring and Research

5.1 Assessment of Performance Reporting and Monitoring

The performance monitoring and reporting in the draft FMS is intended to serve two functions. First, they are to monitor the performance of the draft FMS in achieving its seven broad goals (DIPNR guidelines D4, 2003). Thus the performance indicators and trigger points were set at the goal level not individual management responses. Second, the performance monitoring and reporting are to monitor the impacts, as identified in the risk assessment stage, of the fishery on the environment (DIPNR guidelines E5(a), 2003). Therefore, the assessment of the performance monitoring will be based on these two aspects – management and environmental.

Two basic questions were used to assess the performance monitoring and reporting

a) Does it adequately measure and report the performance of the draft FMS against its goals ?

b) Does it adequately monitor the potential impacts of the fishery ?

a) Performance Monitoring and Reporting

The performance monitoring and review in the draft FMS consists of the following components:

i) Performance indicators and trigger points

ii) Monitoring and information collection

iii) Reporting and review

These were assessed in terms of how adequately they measure and report on the performance of the draft FMS against its goals using a series of questions illustrated in Figure E5.1.

i) Measuring and Reporting

The following criteria were used to assess the adequacy of the performance indicators (PI) and trigger points (TP) for monitoring the draft FMS against its goals. They were adapted from those developed by Rochet and Trenkel (2003):

a) Relevance – is the PI connected either directly or indirectly with the expected outcome of the goal ? (Poor – little or no direct or indirect connection to goal outcomes; Moderate – mainly indirect connection to goal outcomes; Good – directly connected to goal outcomes)

b) Expected effect of management – How does the PI change under the application of the management controls ? There are three possible categories of change:

   i) unpredictable
   ii) change in direction, either up or down with respect to a reference direction
   iii) change in value with respect to a reference point such as a known value defined as a limit.

c) Measurable – are TP measurable and detectable ?

d) Interpretable – can the changes in the TP be interpreted unambiguously as a result of management action and not other influences ? Is there a clear reference point or baseline on which to make an interpretation ?

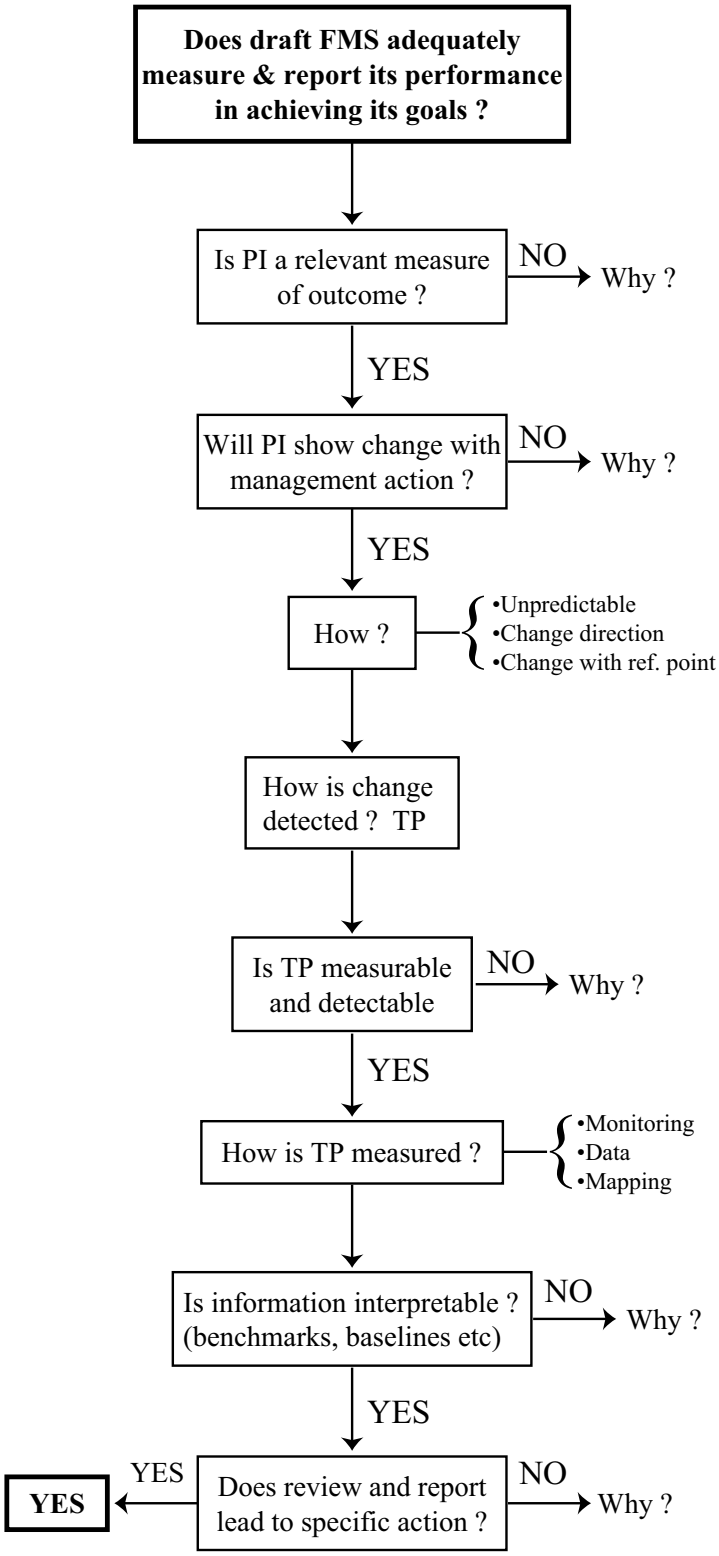

Figure E5.1 Diagram showing logical steps used to assess the adequacy of the performance monitoring and reporting in the draft FMS of the OTF.

Note: PI – performance indicator, TP – trigger point

Tables E5.1 and 2 summarise how each PI and TP meet these criteria. A little under fifty percent were directly connected to the goal outcomes covering mainly goals 1, 3 and 7. Therefore the performance of the FMS against these goals is being measured relatively well, but could be improved in a number areas. Those PI that were moderately relevant (43.75%) were for areas where there are currently no standard types of indicators and further work is flagged to improve them. For example, in Goal 4 PI 1 is the proportion of primary species etc taken by each sector (including recreational and indigenous). By defining what is meant by "appropriate share" in the goal a more relevant PI can be developed. Goal 1 PI 4 was moderately relevant because it is a less effective measure of the performance of Goal 1 as a measure of actual area closed. Ideally, the total area closed should also be included with the number of areas closed to trawling. Research has shown that it is the size of closed areas and not just the number of closed areas that is important in conserving biological diversity (Shanks *et. al*., 2003). Two PI had a poor relevance to the goals because they did not measure the outcome of the goal (Table E5.2). Goal 2 PI 2 measures changes in targeting between sectors of the OTF rather than changes in sustainability in the stocks. However, tracking changes in targeting is related as it may signal secondary species becoming primary species. In Goal 6 PI 2 the number of meetings of the management advisory committee for the OTF, whilst a statutory requirement, does not track the outcome of the goal, i.e. effective and efficient management.

The majority of PI (75%) had the ability to detect change under the effect of the management controls. However, 25% were uncertain as to how they would change (Table E5.1). The uncertainty is due to how relevant the PI is to the goal. For example, Goal 5 PI 1 the median fishery-wide gross return of ocean trawl fisheries may vary for many reasons other than due to the FMS (Table E5.2).

The majority of the TP were both measurable (93.8%) and interpretable (68.8%). This gives the performance monitoring program substantial rigour in monitoring the performance of the FMS. However, 18.8% had uncertain interpretation (Table E5.1). The uncertainty of interpretation centres around there being no established reference point with which the TP can be compared. For example, for Goal 1 reference levels of species diversity/richness have not yet been established for the habitats and fishing grounds of the OTF. Nor do we have any estimate about the level of natural variability in species richness in the oceanic environment off the NSW coast. Consequently, TP 1 and 2 for Goal 1 will not be clearly interpretable until some species richness references can be established (Underwood and Chapman, 2003b). This will need to form part of the monitoring process itself as well as the specific research project on developing a biodiversity index relevant to the fishery.

Table E5.1 Percentage of performance indicators (PI) and trigger points (TP) that meet the criteria for adequacy in tracking the performance of the goals.

NA – not applicable; Good – directly connected to goal outcomes; Moderate – mainly indirect connection to goal outcomes; Poor – little or no direct or indirect connection to goal outcomes

Perfomance Indicators

Categories

Criteria	Good	Moderate	Poor
Relevant	43.75	43.75	12.5
	Yes	**No**	**Uncertain**
Expected effect	75	0	25

Trigger Points

Categories

Criteria	Yes	No	Uncertain	NA
Measurable	93.8	0.0	0.0	6.3
Interpretable	68.8	6.3	18.8	6.3

Table E5.2 Summary of assessment of PI and TP against criteria for adequacy.

R - relevance, E - expected effect under management control, M - measurable, I - interpretable, N/A - not applicable

Goal No.	PI No.	Performance Indicator		Trigger Point		Comments
		Brief Description	**Assessment**	**Brief Description**	**Assessment**	
1	1	Species composition of catch	*R:* Good *E:* Yes, unpredictable	Large area species richness shows a significant shift	*M:* Yes *I:* Uncertain	Significant shift will need to be defined; effectiveness of TP dependent on etablishing a baseline
	2	Proportion & species composition discarded	*R:* Good *E:* Yes, unpredictable	Species richness & quantity doesn't decrease	*M:* Yes *I:* Uncertain	The type of species richness index used for this TP should be established before sampling takes place; as for previous TP a baseline will be essential
	3	Response to marine pest incursions	*R:* Moderate *E:* Yes	Guidelines from Marine Pest and Disease Management program not adhered to	*M:* Yes *I:* Yes	Communication links among Marine Pest and Disease Management program, relevant fishery managers & industry will need to be established and/or maintained
	4	Areas of ocean waters closed to trawling & habitat types included	*R:* Moderate *E:* Yes, increase	Areas closed to trawling doesn't increase & % with adequate habitat type descriptions not increased within 5 years	*M:* Yes *I:* Yes	Area closed should also be measured; on-going measurement of changes in large area species richness should also be done inside & outside closures to determine whether biodiversity is changing as a result of the management action
2	1	Exploitation status of primary & key secondary species	*R:* Good *E:* Yes, Direction up/down	No. primary or key secondary species "overfished" > 0	*M:* Yes *I:* Yes	This will require stock assessments to be done of all species in these two groups and will take time, but are important for the achievement of the goal; see Table D5 & Section D4(b)(vii) for list of species
	2	Ratio - Total Annual landings Secondary species : Total annual landings of primary, key secondary	*R:* Poor *E:* Uncertain	Contribution of secondary species > 5%	*M:* Yes *I:* Yes	Doesn't measure sustainability levels; change in targetting may result in secondary species becoming key secondary & therefore requires revision of primary & key secondary list
3	1	Number & degree of interaction with threatened species	*R:* Good *E:* Yes, should have low negative impacts	Proportion of negative interactions doesn't decrease	*M:* Yes *I:* Yes	Degree of interaction will need to be defined before observer programme commences & then tested on first observer study

Table E5.2 cont'd

R - relevance, E - expected effect under management control, M - measurable, I - interpretable, N/A - not applicable

Goal No.	PI No.	Performance Indicator		Trigger Point		Comments
		Brief Description	Assessment	Brief Description	Assessment	
4	1	Proportion of primary, key secondary & secondary species taken by each fishery (including commercial, recreational & indigenous)	*R:* Moderate *E:* Uncertain	Proportion in any sector increase or decrease by 10% between 2 consecutive years	*M:* Yes *I:* Yes	No defiition of what is an "appropriate share" therefore percentage of change is arbitary & must be reviewed when more information is obtained; Data from recreational & indigenous sectors may not be comparable
5	1	Median fishery-wide gross return of ocean trawl fishers derived from commercial fishing in NSW	*R:* Moderate *E:* Uncertain	Median fishery-wide gross return has not increased by at least 20% four years after the commencement of the FMS	*M:* Yes *I:* Uncertain	No defiition of what is a "viable commercial fishery" therefore percentage of change is arbitary & must be reviewed to determine a more accurate measure and trigger level
	2	Average market value traded shares	*R:* Moderate *E:* uncertain	To be determined	*M:* N/A *I:* N/A	PI should be revised after the share management plan for the fishery has been established & share trading has commenced
6	1	Percentage of inspections resulting in minor & major offences	*R:* Moderate *E:* Yes	Percentage of detections: < 20% minor < 10% major	*M:* Yes *I:* Yes	TP should be reviewed after the first year, may need to be smaller. Reasons for rate of non-compliance, especially for major offences, will need to be investigated to improve efficiency & effectiveness (e.g see Honneland, 2000).
	2	Number of Ocean Trawl MAC meetings held each year	*R:* Poor *E:* Yes	< 2 meetings per year	*M:* Yes *I:* No	Does not measure outcome of goal
	3	Reviews & outcomes of strategic plans for research & compliance	*R:* Moderate *E:* Yes	Plans expire without being reviewed or outcomes of reviews are not acted on	*M:* Yes *I:* Yes	Criteria for reviews must be specified & an accountability mechanism for implementing the review outcomes be established or clarified
7	1	Scientific observer program operated in accordance with specifications developed to meet requirements of relevant MR	*R:* Good *E:* Yes	Observer program does not meet specifications	*M:* Yes *I:* Yes	Effectiveness of PI depends on the rigor of the specifications; different specifications may be needed for different types of observer programs
	2	Number of active research projects with flow-on benefits to OTF & fill information gaps from EIS	*R:* Good *E:* Yes	No. research projects relevant to information gaps < 2 any one year.	*M:* Yes *I:* Yes	List of information gaps should be held by internal fisheries approval processes to ensure proposed projects are relevant
	3	Accuracy of catch return (or daily logboook) data	*R:* Good *E:* Yes	Percentage species records with poor reporting does not decline significantly	*M:* Yes *I:* Yes, if % defined	"Accuracy" needs to be defined & percentage determined

ii) Monitoring and information collection

Data and other information required for the PI and TP will be obtained using a range of monitoring programs and sources (Table E5.3). Much of the information will come from improved catch and effort reporting system for the fishery.

Table E5.3 Sources of information used to monitor PI.

Source	Number of PI using this source
Compliance	1
Observer study	4
Catch data/returns/effort	6
Mapping	1
Other reports	10*
Stock assessments	1

* 5 are external reports

There are 10 PI and TP that require information from reports produced within NSW Fisheries or agencies external to NSW Fisheries. A vast amount of data and information will be needed in order to adequately monitor the performance of the OTF against its goals. Furthermore, given the implementation of FMS's are a relatively new process (for the department) careful attention will be required as the FMS is implemented as to how the results of reports will be coordinated to ensure the appropriate information is passed on to the right group of people for appropriate analysis, interpretation and action.

iii) Reporting and review

Reporting and reviewing is a crucial step in monitoring the performance of the fishery because it provides a path for feedback into the process and opportunities for learning how to improve the management and science of the OTF. Two types of reporting are proposed in the draft FMS – performance assessment and trigger point review. In the former both the performance indicators and implementation of each management response will be included and reviewed annually and reported biannually. The latter reports on any performance indicator that has been triggered encompassing the likely causes for the breach and recommendations for remedial action required, within a specified timeframe. It will be important that there is some mechanism to ensure the recommendations for remedial action from both these types of report are acted on in an appropriate and timely manner. The response taken on any recommended remedial action in the previous year should be included as part of the annual review.

The review and reporting process of the draft FMS will be complex and therefore it will be essential there are clear paths of information transfer and analysis. The draft strategy describes the high level process for the reports, including submissions to the Minister for Fisheries, the relevant MACs and advisory councils and the public. The operational aspects of the reporting and review process, including how information will be disseminated to the relevant scientists and managers within or outside of NSW Fisheries, for their input, will need to be developed as part of the implementation of the FMS.

Many performance monitoring programs in other parts of the world have specific remedial actions already set if a trigger point is breached (e.g. Gray and Jensen, 1993; Caddy and Mahon, 1995; Caddy, 2002) so that management can take action immediately there is a signal something is wrong. These types of programs usually occur in fisheries with well developed stock assessment data and analysis where specific management responses can be identified and are specifically linked to the PI, which is not the case in this and other commercial fisheries of NSW. However, the performance

indicators and trigger points in the draft FMS of the OTF are all at a very preliminary level and until these are refined (via research, monitoring, review, and feedback) remedial actions can't be specified in advance. But it would be highly desirable in the longer term that as the performance indicators and trigger points are improved the review process be adjusted to incorporate pre-determined management action (in consultation with stakeholders, scientists and management) if an indicator is triggered (where a limited number of factors could have triggered it). This would have the advantage of allowing an immediate response to a problem rather than waiting for a lengthy and costly consultative process. Of course it would be essential that the outcomes of such management actions be monitored and reported.

iv) Conclusion

The answer to the question posed at the beginning – "Does the performance monitoring and reporting process in the draft FMS adequately measure its performance in attaining the goals?" - is mostly yes. However, many of the PI and TP are initial suggestions until further work is done to develop the PI and TP further or determine new ones that are more appropriate. It is essential that this further work and development is done.

b) Environmental Impact Monitoring

As discussed at length in Chapter B2 and E5.1 there are numerous ecological impacts that the OTF can have on the marine environment. Monitoring impacts in the sea is very complex. One of the major difficulties is knowing what to monitor, at what spatial and temporal scales and how to measure them (Fairweather, 1991; Underwood, 1995). For some primary species we have a reasonable understanding of what to measure in order to monitor the impact of growth and recruitment overfishing, such as length and sex composition in catches of a species. But for many other impacts it is not clear what to measure, nor how, because the ecological processes that may be affected by the OTF are complex, have multiple interactions and can involve populations and assemblages of species across a large range of spatial and temporal scales (see discussion in Section B2.6(c)(i)). Furthermore, natural variability in marine systems is often large. Therefore, detecting that an impact has occurred requires the ability to distinguish between changes in whatever is being measured (e.g. length of adult fish) from this natural background variability (Fairweather, 1991; Underwood, 1995). There is a substantial body of ecological research that provides many insights into how to detect impacts. (e.g. Fairweather, 1989, Schmitt and Osenberg, 1996, Underwood, 1996). Clearly, the OTF should make use of this research in applying it to understanding the ecological impacts in the oceanic environment off NSW.

Therefore, monitoring for the impacts of the OTF on the marine environment is not a simple case of regularly measuring a set number of entities and watching for when they exceed certain critical levels. Rather, it will require a more diverse approach via research programs designed to increase our understanding of the oceanic environment and how fishing impacts may be occurring in them, that help determine what aspects could be monitored for detecting impacts from fishing. How much of this increased understanding can be done through the ~~draft~~ FMS itself will be limited by its scope and will therefore require collaboration with other research projects within and outside NSW Fisheries.

DIPNR guidelines (2003) for EIS requires that performance reporting and monitoring be assessed in terms of their effectiveness in providing information for monitoring impacts of the proposed FMS of the OTF on the environment. The effectiveness of the information to monitor impacts was assessed using the following questions:

i) For the impacts of overfishing, habitat destruction, changes in biodiversity and threatened species what entities should be measured to monitor them ?

ii) Is the information provided by the performance indicators and relevant management responses adequate to monitor the impacts ?

iii) For other ecological impacts what information is needed to investigate how these impacts manifest themselves in the oceanic environment of NSW and the adequacy of proposed research programs to provide this information ?

iv) How is the information reported and acted upon ?

i) Measures of impacts in the OTF

There were five major ecological impacts of the OTF identified in the risk assessment of Chapter B2. These were:

i. Overfishing (recruitment and growth)

ii. Damage to habitats

iii. Changes to biodiversity

iv. Impeding recovery of threatened species, populations and communities

v. Disruption of ecological processes (which encompasses several processes such as recruitment, dispersal, predator-prey interactions etc)

There were no direct measures for impact (v). Given the lack of knowledge about the ecological processes in the oceanic environment it is difficult to measure disruption to ecological processes directly. However, these types of impacts can have profound long-term effects of the sustainability of a fishery (e.g. Fogarty and Murawski, 1998) and should be taken into account. In reality disruption to ecological processes is the result of the cumulative effects of the other major impacts that have been identified. Therefore, until our knowledge base about the ecology of the oceanic environment improves emphasis must be placed on ensuring that the measures of the other impacts is adequate and analysed as a whole and cumulatively as well as singularly. Murawskl (2000) proposed a helpful way this could be done that should be used as a starting point for the OTF.

Table E5.4 lists the main entities to be measured for each impact i.-iv. This list is not exhaustive for all impacts. It then summarises the information provided by the performance indicators (PI) and management responses (MR) that relate to these entities.

ii) Adequacy of information provided to monitor impacts

Assessment of the adequacy of the information was based on how well the PI corresponded to the entities needing to be measured for each impact i.-iv. (Table E5.4). Overfishing impacts are relatively well monitored via the appropriate PI and MR. Impacts on threatened species, populations and communities are also adequately monitored via information collected through the proposed self reporting and observer program. The remaining potential impacts, however, are only partially monitored by some of the PI and MR (Table E5.4).

The level of detail provided by the PI and MR varies greatly among impacts. Management responses 2.1(a)-(d) provide substantial detail to monitor the impact of overfishing on primary, key secondary and secondary species. The combination of the information from these MR means that detecting this impact is monitored relatively well for these species provided that suitable reference points for what constitutes overfishing for each species can be specified. Whether detection of this impact occurs within a reasonable timeframe is unknown. Information from these MR will contribute to determining the exploitation status of primary and key secondary species, which is one of the PI for Goal 1.

Two potential impacts identified by the risk assessment have entities for which there is no or only partial information provided by either the PI or MR – damage to habitats and changes in biodiversity. The condition of habitats within and outside trawling areas is not measured by a PI and management response 1.1(a) only provides information about the intensity of trawling within trawl grounds (Table E5.4). For the time being this information can be used to infer levels of damage on habitats. However, once habitats are mapped and a possible vessel monitoring system is in place more effective monitoring of impacts on habitats within trawl grounds should occur.

Numbers of species within trawl grounds will be measured by PI 1 from Goal 1 but not outside of trawl grounds (Table E5.4). Unless the number of species in non-trawl grounds with similar habitats is also measured, it will be very difficult to interpret changes over time and space to species diversity within trawl grounds. Whilst there are no measures of species diversity within particular habitats species composition of discarded catches is an important first step toward monitoring impacts on biodiversity. Much more work in this area is needed to interpret the changes in the measures of biodiversity proposed in the draft FMS.

Table E5.4 List of ecological impacts of the OTF, the entities measured to monitor them and adequacy of the information provided by the PI and MR.

Y – yes, N- no, A – Adequate, P – primary species, K2 – key secondary species, S – secondary species

Potential Ecological Impacts	What needs to be measured to monitor impacts ?	Goal #	PI #	Information provided by PI	A	MR #	Information provided by MR	A
Growth & recruitment overfishing	Size structure of P, K2, S; Landings, temporal variability, exploitation status	2	1	Determining exploitation status will require knowing landings & temporal variability	Y	2.1a	Quantity, length, age, sex composition of landings of P & K2 spp.; Indicates whether there are significant changes in reported landings over time	Y
						2.1b	Age/size at maturity, fecundity, age & sex structure of stocks of P & K2 spp.; Contributes to determining exploitation status of spp.	Y
						2.1c	Landings of P, K2 & S spp.; Indicates any increases in landings over time; Contributes to determining exploitation status of spp.	Y
						2.1d		Y
						2.1j	For sharks & rays - size at maturity, brood size, sex composition of catches; Contributes to determining exploitation status of spp.	Y
	Bycatch/discards	1	2	Measures changes in proportion discarded	Y	1.2a	Observer programme to monitor levels of discards, species & length composition	Y
						1.2e	Area & times of high discards	Y
						2.1j	For sharks & rays - size at maturity, brood size, sex composition of catches; Contributes to determining exploitation status of spp.	Y
	Intensity of trawling over areas			*Not provided*		1.1a	Determine intensity of trawling	Y
Overall Adequacy of Monitoring	Adequate - all enitites being measured by either PI or MR							

Table E5.4 cont'd

Y – yes, N- no, A – Adequate, P – primary species, K2 – key secondary species, S – secondary species

Potential Ecological Impacts	What needs to be measured to monitor impacts ?	Goal #	PI #	Information provided by PI	A	MR #	Information provided by MR	A
Damage/destruction of habitats	Areas & habitats where trawling occurs	1	4	How much of ocean waters are protected from trawling	Y	1.1a	Identifies trawl grounds, identifies habitats within trawl grounds	Y
	Condition of habitats within and outside trawling areas			*Not provided*		1.1a	Level of fishing intensity in trawl grounds; Indicates increases in intensity	Part
Overall Adequacy of Monitoring	Partial - only one entity being measured by both PI & MR; insufficient information provided to determine state of habitats							
Decrease or change in biodiversity	Number of species within and outside trawl grounds	1	1	Within trawl grounds: Number of species in total catch	Part		*Not provided*	
	Species discarded	1	1	Species composition of entire catch	Y	1.2e	Area & times of excessive non-retained bycatch	Part
			2	Species composition of discarded catch	Y	1.2a	Observer programme to monitor levels of discards, species & length composition	Y
	Number of species in each habitat			*Not provided*			*Not provided*	
Overall Adequacy of Monitoring	Partial - one entity measured by both PI & MR; insufficient information provided to monitor & interpret changes to species richness							
Impede recovery and conservation of threatened species	Rate & outcomes of interactions with threatened species, populations & communities	3	1	Measures the rate & degree of interaction of the OTF with threatened species	Y	1.2a	Observer programme to monitor levels of discards, species & length composition	Y
Overall Adequacy of Monitoring	Adequate - enitity measured by PI & MR							

iii) Investigation of other ecological impacts and adequacy of research to provide information

The most fundamental information needed to monitor other major ecological impacts is the description and analysis of patterns of abundance and distribution of various ecological entities, such as non-commercial species of fish, invertebrates and habitat associations, at a variety of spatial and temporal scales (Fairweather, 1989; Underwood, 2000). Unless we understand these ecological entities monitoring the impacts of fishing on these aspects will not be possible. Table E5.5 lists some of these entities and summarises the proposed research programs that may address them. The greatest opportunity presented by the draft FMS to investigate these impacts of fishing is through research on the effectiveness of closures. The research program of the draft FMS has been assessed in detail in Section E5.2. Generally, the research associated with these potential impacts has been given a low commitment compared to stock assessments. Relevant information about these impacts will be best obtained via properly designed large scale experiments using the closures to describe, analyse and interpret patterns in aspects of habitat associations, biodiversity changes and some specific ecological processes. These research projects need to be given higher priority if information to assist in understanding these ecological impacts of fishing is to be obtained.

Table E5.5 Ecological impacts of the OTF and their aspects requiring further investigation.

Ecological Impact	Some Aspects requiring investigation	Proposed Research in draft FMS
Habitat degradation of primary & key secondary species	Patterns of association between species and habitat types, at different spatial & temporal scales	*D4(e)(i) Fifth research area* - effects of trawling on ocean ecosystems & effectiveness of trawl closures in addressing impacts
Changes to biodiversity	Patterns of distribution & abundance of species over a braod range of habitats, spatial and temporal scales	*D4(e)(i) Fifth research area* - effects of trawling on ocean ecosystems & effectiveness of trawl closures in addressing impacts
Disruption of ecological processes	Choosing a key process, such as recruitment, patterns of dispersal, settlement & movement of species	*D4(e)(i) Fifth research area* - effects of trawling on ocean ecosystems & effectiveness of trawl closures in addressing impacts

iv) Reporting on impact monitoring

Measuring and monitoring the appropriate entities is only part of the process of providing effective information for monitoring impacts. What is monitored must also be reported in a coherent and on-going manner. Much of the reporting of the impact monitoring of the OTF will be done via the annual report on the progress of implementing the management responses and performance monitoring, particularly for the primary, key secondary and secondary species. However, there are some impacts which are not specifically covered by the reporting framework of the draft FMS. For example, the draft FMS is committed to mapping ocean habitats within and outside trawl grounds, but there is no clear process for how the condition of the these habitats might be reported on in an on-going manner. One aspect of the process would require re-mapping or some from of field survey of the condition of the habitats in both trawled and non-trawl areas. On-going reporting would be particularly important where areas have been closed to trawling. Both the fishing industry and the community would benefit from knowing how habitats are recovering (or not).

Because the information to monitor the various major impacts of the OTF is dispersed throughout the MR of the draft FMS and distributed according to goals rather than impacts, it would be easy for this information to become disjunct. This is especially the case for impacts other than overfishing. Therefore, it is recommended that a specific list be kept of the entities being measured for

each impact and as part of the annual report on implementing the MR that the results of the impact monitoring be given. This will enable a clearer picture of how impacts of the OTF, especially those other than overfishing, are being managed.

v) Conclusion

The information provided by the draft FMS is reasonably adequate in monitoring most of the impacts of the fishery. There are a number of areas where a greater commitment to gathering relevant information about the patterns and nature of ecological impacts is required. It also needs to be acknowledged that monitoring impacts in the ocean environment is very complex and requires a more comprehensive approach than simply monitoring a few entities. Finding cost effective ways to do this presents a challenge.

5.2 Assessment of Research Plan

a) Method of assessment

DIPNR guidelines (2003) for EIS requires that proposed research be assessed in terms of its effectiveness in identifying and prioritising research that fills information gaps for sustainable management of the fishery. The key element in the assessment is "effectiveness". Two criteria were used in assessing whether the proposed research will be effective.

a) Does it address information gaps identified in the risk assessment or arising from the draft FMS itself ?

b) Is the research sufficiently targeted to answer the questions raised by the knowledge gap ?

Information gaps that were not addressed by the draft FMS are discussed separately.

b) Assessment of Proposed Research

i) Stock assessments of primary species

Twelve primary species were identified as requiring stock assessments. They were ranked according to either their economic importance, large proportion of landings, decline in landings, previous history of growth overfishing or time since previous stock assessment. Of the first five species two had moderately high levels of risk (eastern king prawn and school prawn) and one a high risk level (fiddler shark). The latter has the least amount of information currently available for stock assessment. However, collection of basic biological data for all major elasmobranchs is part of a specific management response in the draft FMS (MR 2.1(k)). Silver trevally, which was given a moderately high level of risk was ranked twelfth in the order of priority for stock assessments largely because a preliminary assessment had been done in 2000 (Rowling and Raines, 2000). The remaining species had either low or intermediate levels of risk. Therefore, the proposed priority for stock assessments on primary species appears to be appropriate. The class of assessment (according to Scandol, 2003a) to achieve for each of these 12 species was not specified therefore it is difficult to determine the adequacy of the proposed assessments in providing information for the sustainable management of the fishery. But as a minimum the assessments should be aimed at a class 3 which requires information on basic biology, such as life history and growth, and mortality of the species.

The proposed stock assessments will adequately cover the information gaps for the primary species with respect to their basic biology and stock information, provided the latter is at a minimum of a class 3 (Scandol, 2003a). The ecology of the species is not addressed by the research on stock assessments (Table E5.6).

Table E5.6 Summary of adequacy of proposed stock assessments in meeting identified knowledge gaps for primary species.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2	Stock assessment of Primary species
Fish stocks (Primary, Key Secondary & Secondary species)	Stock and community structure, and spatial and temporal complexity of fish stocks	B2.3c)	adequate
	Knowledge on the ecology and basic biology of primary and key secondary	B2.6d)	adequate for basic biology, inadequate for ecology

ii) Quantification and reduction of bycatch

Three specific areas of research are proposed for the quantification and reduction of bycatch – development of more effective BRD, effectiveness of BRD under commercial conditions and quantification of the spatial and temporal distribution of bycatch in fish trawls. Research on more effective BRD is continuing in NSW Fisheries and as these become available they will be introduced into the fishery (although proposed measures in Appendices D3 and D5 suggest otherwise). The effectiveness of all BRD currently used in the fishery and any new ones will be monitored. Although not specifically mentioned this will be particularly important for any new gear introduced for the purpose of targeting school whiting (see MR 5.1(c) and Appendices D3 and D5). The quantification of the spatial and temporal variability of the abundance and distribution of bycatch will be a very important step forward in determining effective ways of reducing bycatch in fish trawls which cannot use BRD like prawn trawl nets. The proposed research does not specifically mention quantifying species composition nor whether it will focus on unwanted commercial or non-commercial species or both. This information is important to achieve ecological sustainability and reduce risks.

The proposed research on bycatch will adequately fill knowledge gaps (Table E5.7) in this area provided attention is given to quantifying bycatch from both prawn and fish trawls for both unwanted commercial and non-commercial species.

Table E5.7 Summary of adequacy of proposed quantification and reduction of bycatch in meeting identified information gaps.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2	Quantification & reduction of bycatch
Discards of undersized commercial & non-commercial species	Information on the quantity, composition, frequency and temporal and spatial variability of discarding of unmarketable commercial species & non-commercial	B2.3c) B2.4c)	Unmarketable commercial species not specified, only for fish trawl, adequate if both commerncial and non-commercial are done for fish and prawn trawl
	Motives for discarding of commercial species	B2.3b)	not addressed
Bycatch reduction devices (BRD)	Effectiveness of BRD in reducing unwanted catch of commercial species	B2.3c) B2.4c)	adequate, but unwanted commercial species not specified
	Range of BRD actually used by fishers	B2.3c) B2.4c)	adequate
	Fate and survival of escapees from BRD include the composition, size range, condition, quantity and proportion of each species escaping compared to that caught and the level of behavioural impairment.	B2.3c) B2.4c)	not addressed (This is a difficult area to research)

iii) Impact of trawling of key secondary species

There are two major areas of research proposed to assess the impact of trawling on key secondary species – rudimentary stock assessment information and collection of basic catch data for groups of multiple species, specifically some teleost species and sharks. Key secondary species should be ranked in accordance with their risk levels (see Table B2.18) so that high priority is placed on those at greatest risk.

Data will be collected for groups that contain multiple species. There are three teleost species groups in the key secondary group – leatherjackets, sole and flounder. The latter two have low levels of risk and leatherjackets are at moderately high risk. Consequently, data to identify species and quantify the mix of species in landings should be focused on leatherjackets in the first instance for teleosts. Identification of sharks will be given a high priority as well as collecting more detailed

biological data of the landings of sharks such as sex ratios, size at maturity, fecundity and size composition of catches. Given that sharks are the most vulnerable of the key secondary species the proposed research will be extremely important in ensuring the fishery is managed in a sustainable manner.

The proposed research on the impacts of trawling on key secondary species is focused on gathering very basic biological data such as species identification and size composition. These data will be a substantial improvement to the level of information that is currently available for these species. However, as for primary species, there is no indication that research will be done to collect data for these species to fill information gaps on their ecology (Table E5.8). The importance of this knowledge will be discussed further under Section E5.2 (c) below.

Table E5.8 Summary of adequacy of proposed impact of trawling on key secondary species in meeting identified information gaps.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2	Impact of trawling on key secondary species, elasmobranchs
Fish stocks (Primary, Key Secondary & Secondary species)	Knowledge on the ecology and basic biology of primary and key secondary	B2.6d)	Adequate for some basic biology of species, but inadequate for ecological knowledge

iv) Economic research

See Dominion consultant report in Volume 4 of this EIS

v) Impact of trawling on ocean ecosystems and effectiveness of trawl closures in addressing impacts

There are four direct areas and one indirect area of research proposed to examine the impact of trawling on ocean ecosystems. The four direct areas are:

i) Mapping of trawl grounds

ii) Information on habitat types within and nearby trawl grounds

iii) Frequency of trawling on all trawl grounds

iv) Evaluation of effectiveness of closures

There is a strong commitment in the proposed research for the first three areas. Mapping trawl grounds, habitat types and quantifying the frequency of trawling on these grounds will fill very important information gaps in managing the fishery sustainably. Whilst it is acknowledged that such an undertaking will take time and substantial resources these areas of research should be given a high priority in implementing the FMS.

There is less commitment to doing the fourth area of direct research – evaluation of the effectiveness of closures in addressing impacts. The use of different types of closures occurs a number of times in the draft FMS (see Table E5.9). This is entirely appropriate and necessary in a fishery where there is a high degree of uncertainty on the extent of the impacts of trawling on the ecosystem in NSW oceanic waters. Given closures are an important management tool of the draft FMS, it is essential to determine whether the closures are effective in achieving their stated goals (Hilborn *et al*., 2004). Yet the proposed FMS only indicates that research "could be" done in this area, thereby leaving uncertainty about the level of commitment. Whilst it is acknowledged that undertaking such research is long term and requires substantial resources, the consequences of not doing this research will be far more costly to managing the fishery in an ecologically sustainable manner into the future.

There are three important consequences if this research is not done. First, it will result in ambiguity in the interpretation of reported landed catch trends (e.g. are the trends a result of closures or some other phenomenon ?). Such ambiguity will only serve to increase uncertainty when it could have been decreased with the appropriate research. Second, it will result in lack of clarity in demonstrating to commercial fishers (who are most impacted by the closures) the benefits of different types of closures. Lack of clarity could lead to scepticism and reduced cooperation from fishers when further management action is required to be taken on an issue. Third, lack of information on the effectiveness of closures will inhibit fishery management from knowing how to improve and build on the draft FMS in the future. The approach of putting management actions in place and not evaluating their effectiveness is becoming a thing of the past in fisheries management (e.g. McAllister and Peterman, 1992; Underwood, 1995; McAllister *et al*., 1999; Smith, *et al*., 1999; Sainsbury *et al*., 2000; Punt *et al*., 2001). It would therefore be prudent for the department to make a strong commitment to undertake research on the effectiveness of closures in addressing impacts.

Table E5.9 Summary of proposed closures for the OTF.

K2 – key secondary, S – secondary, T – temporary, P – permanent.

MR	Permanent or temporary	Type	Main Purpose
1.1b)	P	Close all reefs	Protect stocks, habitat & biodiversity
	P	Close depths > 1100m	Protect habitat & biodiversity
	P	Habitat types outside 3nm	Protect habitat & biodiversity
1.1c)	P	Close north Smoky Cape to fish trawlers	Minimise overlap of fishing sectors
1.2 e)	T	Close around river entrances during high discharge	Protect juvenile fish & prawns, estuarine species, biodiversity
2.1 f)	P/T	Juvenile king prawn closures	Protect small and & juvenile prawns
2.1 g)	P	Refuge areas for P & K2	Protect primary, K2 & S species biomass
	T or P	Spawning areas	Protect primary, K2 & S species spawning sites, larvae, eggs
4.3 a)	P	Close depths between 150-200 fathoms to prawn trawlers	Minimise overlap of fishing sectors
6.3 b)	P	Close 75% state waters inside 3nm south Barrenjoey, except whiting areas	Protect habitat & biodiversity

The draft FMS would be greatly strengthened if it included a dedicated set of research projects using rigorous scientific methods (Walters, 1986; Underwood, 1990, 1992; McAllister and Peterman, 1992) to test predefined hypotheses about the effectiveness of the different types of closures in protecting oceanic habitats, biodiversity and biomass of primary and key secondary species. As a minimum, the research plan should consider how the results of research from the Marine Parks Authority on the effectiveness of the marine parks could be used to evaluate and test closures made for the OTF.

The indirect area of research proposed in the research plan relates to determining indicators for biodiversity. Instead of a direct research project it is suggested that a combination of other studies by both NSW Fisheries and other organisations could form the basis for appropriate indicators. However, the plan is unclear how the various initiatives referred to could contribute to determining biodiversity indicators. Whilst it is acknowledged that this area of research is very difficult and potentially expensive the research plan does not make a strong commitment to pursuing means of how biodiversity indicators could be identified. It does note that NSW Fisheries currently has a joint

research project with the University of British Columbia (Canada) that will develop an ecosystem based model for fishery management in NSW. Whilst it is hoped this will provide a better understanding of the ecosystem of the OTF it is not clear to what extent it may contribute to developing appropriate biodiversity indicators.

Overall the research proposed on the impact of trawling on ocean ecosystems is effective in filling information gaps for three areas – location of trawl grounds, location and types of habitats and frequency of trawling. But it is inadequate for determining the effectiveness of closures in addressing impacts of trawling and determining indicators for biodiversity, although the difficulties in doing so are acknowledged (Table E5.10).

Table E5.10 Summary of adequacy of proposed research on the impact of trawling on ocean ecosystems and effectiveness of closures in meeting identified information gaps.

Area	Information Gaps from Risk Assessment and draft FMS	Reference in Chapter B2	Effects of trawling on ocean ecosystems
Trawl grownds and fishing intensity	Mapping location & extent of fishing grounds	B2.3c)	adequate
	Frequency the grounds are fished by how many fishers	B2.3c)	adequate
	Spatial distribution of fishing effort	B2.7d)	adequate
Habitats	Knowledge about the identification and spatial distribution of important habitat types	B2.7d)	adequate
	Habitat mapping is needed at various spatial scales.	B2.7d)	Not specifically mentioned
	An assessment of impact effect size on habitat	B2.7d)	not addressed
	Taxonomic status of biota that live on geological habitats and that provide additional biogenic habitat structure	B2.7d)	not addressed
	Understanding of the biology and ecology of the biota that creates biogenic habitats	B2.7d)	not addressed
Non commercial species (including discards)	Information about the ecological processes that are associated with the non-commercial assemblages interacting with the OTF	B2.6d)	not addressed
	Understanding the larval supply and recruitment dynamics of sessile invertebrates that may provide habitat for exploitable species	B2.6d)	not addressed
Species Assemblages	Spatial and temporal distribution and abundance of macroalgae, benthic motile invertebrates and species diversity in the fishing grounds and adjacent areas of the OTF, mapping of habitats	B2.6d)	inadequate
Shifts in trophic interactions	Predator-prey relationships, foodweb dynamics among commercial and non-commercial species including invertebrates	B2.6d)	inadequate

vi) Impact of fishing on threatened species

Three things are proposed to investigate the impact of trawling on threatened species. First, accuracy of information on interactions between threatened species by OTF trawlers will be improved via observer studies and self reporting. Second, recovery plans on threatened species will be used to guide specific research on relevant issues and third, the outcomes of a current research project on broad scale interactions with commercial fishing in NSW will also be used to target research. Overall, these strategies will be effective in filling information gaps about the level of interaction between the OTF and threatened species provided any relevant issues identified by other studies are acted on (Table E5.11).

Table E5.11 Summary of adequacy of proposed research on interactions with threatened species in meeting identified knowledge gaps.

Area	Information Gaps from Risk Assessment or arising from the draft FMS	Reference in Chapter B2	Interactions with threatened species
Interactions with threatened species	Report on fishery interactions with threatened species, including bycatch, provisioning and disturbance	B2.5c)	Adequate
Food provisioning from discards	Information to quantify the importance of trawl discards in the diets of threatened species	B2.5c)	Not addressed, possibly via threatened species recovery plans

c) Information Gaps Not Addressed and the Consequences

Table E5.12 summarises the information gaps that were identified by the risk assessment but have not been addressed by the research plan. The shaded boxes highlight the most important information gaps needing attention and these centre on understanding ecological processes relevant to ocean ecosystems in which the OTF operates.

The probable reason for these areas not being addressed in the research plan is the great difficultly in doing such research both from a logistical and resource perspective and because stock assessment research is considered more directly relevant to managing the fishery sustainably. However, there is increasing recognition in fisheries research that understanding the ecological processes that shape fish communities is as equally important in making predictions about future trends as traditional stock assessment information (Pitcher, 2001; Pauly and Christensen, 2002; Reynolds *et al*, 2002; Holland, 2003). Furthermore, for some commercial species it may in fact be more beneficial to understand some key aspects of their ecology rather than their stock size and dynamics alone.

For example, two genera (*Lethrinus* and *Lutjanus*) that were trawled on the north west shelf in WA declined in abundance over a period of 15 years (Sainsbury, 1988). The reason for their decline was later discovered to be due to their habitat association with sponges and other biogenic fauna, which was gradually almost completely eroded by the physical disturbance of frequent and intense trawling. As a result the fish community changed in composition to poorer value fish species (Sainsbury *et al*., 1997). Had the habitat associations of these two species and the impact of trawling on those habitats been known earlier, then the management arrangements for the fishery could have been designed to minimise the impacts and therefore manage it in an ecologically sustainable manner. Two points are worth noting about this example. First, no amount of stock assessment information alone would have revealed the cause of the decline in these fish species. Second, a well designed ecological study on the species examining their habitat associations could have been conducted in 2-3 years and would not require relying on analysis of long sets of catch history data that may have had

numerous inconsistencies and problems. Therefore, in this particular case putting resources into an ecological study would have been more economical, easier and produced outcomes more relevant to managing the fishery with lower uncertainty than stock assessment studies alone.

Table E5.12 Summary of information gaps not addressed by the proposed research plan for the OTF.

Shaded boxes are most important information gaps.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2
Fish stocks (Primary, Key Secondary & Secondary species)	Knowledge of the ecological processes that are important for the ecological sustainability of primary and key secondary species	B2.6d)
	Knowledge of habitat associations, trophic interactions, intra- and inter-specific competition, distribution and movement	
	Estimate of the spatial and temporal magnitude and variability of fishing pressure being exerted on the key species	
Biological & ecological processes	Ecological processes that interact between primary and key secondary species and other aspects of ecosystems including biodiversity and species assemblages	B2.6d)
	Interactions among fish species and non-target species Interactions of fish with the environment and habitats	
Habitats	Understanding of the biology and ecology of the biota that creates biogenic habitats	B2.7d)
	Understanding the larval supply and recruitment dynamics of sessile invertebrates that may provide habitat for exploitable species	B2.6d)
	An assessment of impact effect size on habitat	B2.7d)
	Taxonomic status of biota that live on geological habitats and that provide additional biogenic habitat structure	B2.7d)
Species Assemblages	Spatial and temporal distribution and abundance of macroalgae, benthic motile invertebrates and species diversity in the fishing grounds and adjacent areas of the OTF	B2.6d)
	Information about the ecological processes that are associated with the non-commercial assemblages interacting with the OTF	
Food provisioning from discards	Assess whether there are any scavenger species that have become dependent or partially dependent on discards as a source of food, particularly during their breeding seasons	B2.4c)
	Information to quantify the importance of trawl discards in the diets of threatened species	B2.5c)
Discards of undersize commercial species	Motives for discarding of commercial species; fate and survival	B2.4c)
Bycatch reduction devices (BRD)	Fate and survival of escapees from BRD include the composition, size range, condition, quantity and proportion of each species escaping compared to that caught and the level of behavioural impairment.	B2.3c) B2.4c)

It is acknowledged that resources are very limited and industry and NSW Fisheries need to be prudent in where these resources are channelled to lower uncertainty and enable more fishery management to be ecologically sustainable. Therefore, it is strongly recommended that serious consideration be given to whether research into some aspects of the ecology of the fish communities of the OTF would be more cost efficient for, or at least add significantly to, its ability to manage the fishery than traditional stock assessment approaches.

The following series of questions could be used to help determine priorities for ecological research:

a) Which ecological process(es) is at highest risk from the major activities (i.e. trawling, harvesting, discarding) of the OTF ?

b) What is already known (even at a very broad level) about the interaction between this process and species at high and moderately high risk ?

AND/OR

Are there any patterns in the reported catch data or other observations that suggest an interaction between this process and these species ?

c) Based on this information what is likely to be the relative importance of this ecological process to the ecological sustainability of these species ?

In other words there needs to be an integration of the outcomes of the risk assessment on the primary and key secondary species with that on the ecological processes, to discern any patterns that may give direction to the most fruitful area of ecological research for the species or fish community.

d) Observer Studies used in the Research Plan

Observer studies are referred to in the research plan as one of the important means by which some of the various research areas will be investigated. There are seven management responses that mention observer studies (Table E5.13) covering six major research areas. Whilst observer studies are appropriate and the most effective means of doing the nominated research, not all the areas of research will be able to be done simultaneously by one observer program. Some of the areas require a different set of tasks to record the information. For example, data collection on abundance and composition of bycatch will be time consuming and may not be able to be done simultaneously with collecting biological data of sharks. Therefore, to maintain the effectiveness of the observer program it will be essential to not overload observers on board vessels with too many tasks with multiple purposes. Either a number of observers per boat or an appropriate separation of tasks for different trips will be required. It should be recognised that the observer work is at two scales. One scale is routine and regular, randomly applied across the fishery. The other requires a more dedicated series of studies for collecting more specific information, such as on elasmobranchs.

Table E5.13 Summary of observer studies in the draft FMS and their main areas of research.

Main Research Areas	MR#	Observer Study
Bycatch	1.2 (a)	Document the degree of interaction with non-retained species
	1.2 (b)	Data will be collected on the levels of use of the approved BRDs and the resulting reductions in bycatch
Bycatch in whiting gear	5.1 (c)	Accurately assess the level of incidental catch taken when using new whiting gear.
BRD	1.2 (a) (b)	Observations on BRD use and effectiveness Analysis of the effectiveness of each of the BRDs approved for use in commercial trawling
Gear selectivity	1.2 (a)	Observations on gear selectivity for retained species
Recovery programmes	2.2 (a)	Assess the effectiveness of the recovery program in preventing the capture and marketing of large numbers of small trevally, including the recording of any discarding of trevally smaller than the new minimum legal length.
Threatened species	1.2 (a) & 3.1 (a)	Observations on any interactions with threatened or protected species.
Shark data	2.1 (j)	Collect additional biological information, including size at maturity and fecundity/brood size data, for the important elasmobranch species taken by the fishery.
	2.1 (j)	Improve the identification of captured sharks and thereby increasing the accuracy of reported catch data, and undertaking targeted research on shark species.
Identification of species	7.3 (b)	Provide first hand information on local names for fish and any patterns in the use of those names