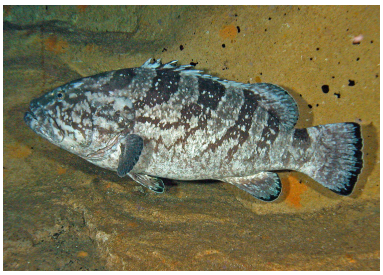
NSW GOVERNMENT | Department of Primary Industries

Black Rockcod (*Epinephelus daemelii*) recovery plan

Aquaculture, Conservation and Marine Parks Unit, Port Stephens Fisheries Institute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Executive summary

The Black Rockcod, *Epinephelus daemelii* (Günther, 1876), is listed as a vulnerable species under the NSW *Fisheries Management Act 1994* (FM Act). It was previously declared as a protected species in NSW waters in 1983. The Black Rockcod is a large reef-dwelling grouper species belonging to the family Serranidae. Black Rockcod occur in the warm temperate and subtropical waters of the south western Pacific, including off south eastern Australia, Lord Howe Island, Norfolk Island, the Kermadec Islands and northern New Zealand.

Black Rockcod grow to a large size of about 2 m in length and more than 80 kg in weight, although most individuals are substantially smaller. Black Rockcod is a slow-moving, curious and territorial fish that may occupy a particular cave for many years. This behaviour, combined with its slow growth, make Black Rockcod vulnerable to overfishing. Black Rockcod are similar in appearance to other large *Epinephelus* species such as the Bar Rockcod (*Epinephelus ergastularius*), the Queensland Groper (*Epinephelus lanceolatus*) and the Goldspotted Rockcod (*Epinephelus coioides*), and can sometimes be confused with these and other closely related species.

The historical range of Black Rockcod in Australia extended from southern Queensland to Kangaroo Island off South Australia. Sightings have been reported from northern Bass Strait waters but not along the coast of Tasmania. Black Rockcod are the dominant serranid grouper species around Lord Howe and Norfolk Islands and around Elizabeth and Middleton Reefs in the northern Tasman Sea. Black Rockcod are known to occur along the entire NSW coastline, with larger numbers found in northern waters.

The numbers of Black Rockcod have been depleted in the past by line fishers and spearfishers to a level where it is now unusual to find large Black Rockcod in areas where they were once common. Historical evidence suggests that Black Rockcod were in decline as far back as the early 20th century.

Two key threatening processes (KTPs) of relevance to Black Rockcod have been listed under the FM Act including '*Hook and line fishing in areas important for the survival of threatened species*', and the '*Introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW*'. In addition, unlisted threatening processes that are likely to affect Black Rockcod are anthropogenic predation through other forms of fishing including commercial estuarine mesh netting, commercial trapping, commercial trawling aquarium collecting and spearfishing.

This recovery plan was first published in February 2011 in accordance with the provisions of the FM Act and was revised in February 2012 in response to submissions received from the public; to incorporate updated information; and to reflect the Australian Fish Names Standard AS SSA 5300. The recovery plan has been prepared assist in the recovery of the species through the implementation of a range of strategies. The plan summarises the current state of knowledge of Black Rockcod and uses a risk assessment framework to identify the threats to the species and rank them in terms of highest to lowest risk. This process is used to identify and prioritise recovery actions to address these risks with the aim of ensuring the recovery of Black Rockcod populations in NSW.

NSW Department of Primary Industries (NSW DPI) will coordinate and lead the implementation of the recovery plan, with support from relevant government agencies, commercial and recreational fishers, scuba divers, councils and the community. The recovery plan will be resourced by a combination of existing recurrent funding, supplemented by external funds. Many of the actions identified in the recovery plan can be implemented as part of the core functions of NSW DPI. Implementation of the recovery plan does not require or propose the need for additional recurrent funds. However, the implementation of some recovery actions will be subject to securing additional funding from grant programs.

1. Introduction

1.1 Legislative context

The conservation of threatened species of fish, aquatic invertebrates and marine vegetation in NSW is covered by Part 7A of the FM Act; administered by NSW DPI. Part 7A deals with the protection and recovery of threatened species, populations and ecological communities of fish and marine vegetation, the listing of KTPs, and the preparation of a Priorities Action Statement (PAS) and recovery and threat abatement plans.

The conservation of remaining threatened biota in NSW other than fish and marine vegetation is covered by the *Threatened Species Conservation Act 1995* that contains parallel provisions to Part 7A of the FM Act. The *Threatened Species Conservation Act 1995* is administered by the NSW Office of Environment and Heritage (OEH).

The FM Act:

- sets out processes for nominating, assessing and listing threatened biota and KTPs;
- establishes threatened species offences and defences;
- provides for the declaration of critical habitat for endangered and critically endangered species; and
- provides for the preparation of a PAS and recovery and threat abatement plans to recover threatened biota to a position of viability in nature and to manage KTPs.

Species, populations and ecological communities of fish and marine vegetation and threatening processes nominated for listing are assessed against listing criteria in the *Fisheries Management (General) Regulation 2010* by the NSW Fisheries Scientific Committee. The NSW Fisheries Scientific Committee makes determinations to the Minister for Primary Industries regarding amendments to the threatened species lists and is responsible for making the amendments.

1.1.1 Listing status

Black Rockcod are listed as:

- vulnerable under the FM Act;
- near threatened under the IUCN Red List of Threatened Species; and
- vulnerable by the Australian Society for Fish Biology.

Two KTPs of relevance to Black Rockcod listed under the FM Act include:

- *'hook and line fishing in areas important for the survival of threatened species'*; and
- *'the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW'.*

1.1.2 Offences and defences

Once listed, it becomes an offence to harm, buy, sell or possess threatened biota or to damage their habitat or critical habitat. Penalties for harming vulnerable species or their habitat range up to $55,000 and/or 1 year imprisonment. Maximum penalties for offences relating to critically endangered and endangered species and critical habitat include $220,000 and/or 2 years imprisonment.

The FM Act also contains defences to prosecution for a range of activities that may harm threatened species or their habitat. In general, these activities tend to be of low impact or have been assessed and approved under other legislation.

1.1.3 Critical habitat

Critical habitat can be declared for endangered and critically endangered species. Declaring critical habitat establishes certain environmental impact assessment obligations and creates additional offences for habitat damage. Activities within critical habitat areas can also be regulated to mitigate impacts.

Black Rockcod are listed as a vulnerable species and as such their habitat is not eligible to be listed as critical habitat.

1.1.4 Priorities Action Statement

The Director-General of NSW DPI is required to prepare and adopt a PAS in accordance with the FM Act. The PAS is a statement that:

a) sets out the strategies to be adopted for promoting the recovery of each threatened species, population and ecological community to a position of viability in nature and for managing each KTP;

b) establishes relative priorities for the implementation of recovery and threat abatement strategies;

c) establishes performance indicators to facilitate reporting on achievements in implementing recovery and threat abatement strategies and their effectiveness;

d) contains a status report on each threatened species, where information is available; and

e) sets out clear timetables for recovery and threat abatement planning and achievement.

A key recovery strategy for Black Rockcod identified in the PAS includes the preparation of a recovery plan. Additional information about the recovery strategies identified for Black Rockcod may be found in the PAS at www.dpi.nsw.gov.au .

1.1.5 Recovery planning

The Director-General of NSW DPI may prepare recovery plans for threatened species. Timetables for recovery planning and achievement are set out in the PAS.

Recovery plans are prepared to promote the recovery of a species, population or ecological community to a position of viability in nature. The contents of recovery plans, and the process to prepare them are specified in the FM Act (Appendix 1). Approved recovery plans are statutory documents. Ministers and public authorities need to take appropriate actions to implement the measures in the plan for which they are responsible, and to ensure their decisions are not inconsistent with the provisions of the plan without consulting the Minister for Primary Industries. The FM Act also requires public authorities (other than local councils) with identified responsibilities in a recovery plan to report on the implementation of actions in their annual report to Parliament. Local councils must report on actions in annual State of the Environment reports.

Under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), relevant recovery plans must also be considered by consent authorities (e.g. local councils), determining authorities (e.g. State government agencies), and the Director-General of NSW DPI (as a concurrence authority) when they are exercising a decision-making function under Parts 3, 4, 5 or 5.1 of the EP&A Act.

1.1.6 Recovery plan implementation

NSW DPI is the lead agency responsible for coordinating the implementation of this plan. However, achievement of the plan's objectives and the long-term recovery of Black Rockcod will require action by all levels of government, organisations and the community who either have an interest in the conservation of the species or whose actions and decisions have the potential to affect its survival. NSW DPI has a statutory obligation to encourage the conservation of

threatened species by the adoption of measures involving co-operative management. The NSW Marine Parks Authority (MPA) is also identified as having implementation responsibilities.

Other public authorities identified as potential partners for implementing actions in this plan include the NSW Office of Environment and Heritage (OEH), local councils and Catchment Management Authorities situated in coastal areas. Some actions will also require cooperation with organisations such as the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC).

Other stakeholders that have been identified as having a part to play in implementing some recovery actions include recreational scuba diving groups, spearfishers and commercial and recreational fishers.

1.2 Related statutory frameworks

1.2.1 *Environmental Planning and Assessment Act 1979*

The FM Act integrates the conservation of threatened species into development control processes established by the EP&A Act. As part of the development assessment process, consent authorities are required to assess development impacts on threatened species, and to consider if activities are of a class of development recognised as a KTP. Recovery plans must also be considered by determining authorities for activities under Part 5 of the EP&A Act, and by concurrence authorities for developments under Part 4 of the EP&A Act. Where such actions are likely to result in a significant impact on a threatened species or its habitat, a detailed species impact statement must be prepared. The consent or determining authority must then seek the concurrence of the Director-General of NSW DPI, or in certain circumstances, consult with the Minister for Primary Industries.

Activities and developments that do not require approval under the EP&A Act may require licensing under the FM Act if they are likely to harm a threatened species, population or ecological community, or their habitat.

1.2.2 *Marine Parks Act 1997*

The objects of the NSW *Marine Parks Act 1997* are:

a) to conserve marine biological diversity and marine habitats by declaring and providing for the management of a comprehensive system of marine parks;

b) to maintain ecological processes in marine parks;

c) where consistent with the preceding objects:

   (i) to provide for ecologically sustainable use of fish (including commercial and recreational fishing) and marine vegetation in marine parks; and

   (ii) to provide opportunities for public appreciation, understanding and enjoyment of marine parks.

The NSW Government has been developing a comprehensive, adequate and representative system of marine protected areas in NSW since 1997. At the time this plan was prepared, marine parks had been declared in three of the five marine bioregions along the NSW Coast including Tweed-Moreton Shelf (Cape Byron Marine Park and Solitary Islands Marine Park), Manning Shelf (Port Stephens-Great Lakes Marine Park), and the Batemans Shelf (Batemans Marine Park and Jervis Bay Marine Park). The offshore Lord Howe Island province (included in NSW waters) contains the Lord Howe Island Marine Park.

The establishment of sanctuary zones and habitat protection zones within Marine Parks provides protection for a range of marine species including Black Rockcod. Dedicated research, compliance and management functions are also associated with the marine parks.

1.2.3 Commonwealth *Fisheries Management Act 1991*

Black Rockcod are listed as protected from commercial fishing under section 15 of the Commonwealth *Fisheries Management Act 1991*.

1.3 Related policy, strategy and planning frameworks

1.3.1 Interactions with recovery and threat abatement plans

Black Rockcod is one of several marine fish species that have undergone major declines in distribution and abundance and have been listed as threatened under the schedules of the FM Act. These include:

- Greynurse Shark (*Carcharias taurus*) – critically endangered;
- Green Sawfish (*Pristis zijsron*) – presumed extinct;
- Southern Bluefin Tuna (*Thunnus maccoyii*) – endangered; and
- White Shark (*Carcharodon carcharias*) – vulnerable.

The implementation of recovery strategies and actions activities for some of these species will also benefit the recovery of Black Rockcod.

In addition, KTPs listed under the FM Act of relevance to Black Rockcod include '*hook and line fishing in areas important for the survival of threatened fish species*' and '*the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW*'. The implementation of threat abatement strategies for these KTPs should also benefit the recovery of Black Rockcod.

1.3.2 Fishery management strategies

In December 2000 the NSW Government made changes to the way that designated fishing activities are managed in NSW. Designated fishing activities are set out in Schedule 1A of the FM Act. In particular, the changes were aimed at ensuring that the environmental impacts of designated fishing activities were adequately assessed and sustainably managed. Fishery management strategies set out the management arrangements for each designated fishing activity and have been subject to comprehensive environmental assessment.

Fishery management strategies are prepared and assessed in accordance with the provisions of Division 5 of Part 5 of the EP&A Act and Part 1A of the FM Act. In addition to being guided by the principles of ecologically sustainable development (the precautionary principle, inter-generational equity, conservation of biological diversity and ecological integrity and improved valuation, pricing and incentive mechanisms), fishery management strategies must have regard to threatened species conservation as required by the EP&A Act.

Fishery management strategies contain general mitigating measures to reduce impacts on threatened species, but also recognise that recovery plans provide the best platform for protection as they use a species-specific, multi-sector approach to threatened species management. Fishery management strategies on the other hand focus on the effective and efficient management of a fishery, taking into consideration the structure, extent, methods and species of each fishery to create viable fisheries while at the same time ensuring equitable sharing of the resource. That equity also extends to the protection of threatened species, and fishery management strategies are designed to be consistent with and subservient to recovery plans as they are able to apply protective measures across all fishing sectors and other threat sources in a more comprehensive manner. This emphasises the need for recovery plans to correctly identify and mitigate all sources of risk to threatened species. As Black Rockcod and Greynurse Sharks occupy many of the same areas of rocky reef, provisions in this recovery plan will also assist with the recovery of Greynurse Sharks.

Each of the eight designated fishing activities listed under Schedule 1A of the FM Act are managed by a Fishery Management Strategy that has been environmentally assessed. Seven of

the designated fishing activities are commercial fisheries (Table 1). The eighth, Freshwater Fish Stocking, is irrelevant to Black Rockcod and will not be discussed.

Of the seven commercial fisheries, the Ocean Trap and Line Fishery is recognised as posing a moderately-high risk to Black Rockcod (and high risk to Greynurse Shark) (NSW DPI 2006). Although some mitigating measures are being implemented, the fishery still poses some risks to both Black Rockcod and Greynurse Sharks. The Estuary General Fishery also uses methods that could affect juvenile Black Rockcod as they occur in the lower reaches of estuaries, particularly on the north coast. The impact assessment methodology for the Estuary General Fishery differed to that of the Ocean Trap and Line Fishery, but a retrospective assessment based on methods and overlap indicates that it poses a moderately-low risk across the fishery. The methods of these two fisheries (with the exception of the spanner crab netting in the Ocean Trap and Line Fishery) will be investigated in more detail in the risk analysis section of this recovery plan. The nature and location of the fishing methods for the remainder of the commercial fisheries limit any potential overlap and interaction with Black Rockcod. As such they are considered low risk activities and are not included in the risk analysis.

Table 1 – Designated commercial fisheries in NSW and associated methods

Fishery	Methods
Ocean trap & line	Fish trap, spanner crab net, setline, driftline, poling, handline, jigging, dropline, trolling
Estuary general	Handline, trap, hauling net, mesh net, hand collecting
Ocean trawl (fish & prawns)	Otter trawl net
Ocean hauling	General purpose haul net, garfish haul net, purse seine net
Lobster	Trap/pot
Abalone	Diving
Estuary prawn trawl	Otter trawl net

The other fisheries managed by NSW DPI of relevance to Black Rockcod are the recreational fishery (including the installation of fish aggregation devices and artificial reefs) and the recreational charter boat fishery. These fisheries are not designated fishing activities under Schedule 1A and as such they are not formally subject to environmental impact assessment and/or Fishery Management Strategy processes. However, they may be environmentally assessed and have management strategies developed for them via alternative processes. As hook and line fishing, a KTP relevant to Black Rockcod is the predominant method used in the fisheries, any assessments and/or strategies developed for recreational and charter boat fisheries will need to be consistent with the requirements of this recovery plan.

2. Description

2.1 Names

Common: Black Rockcod

Other names: Black Cod, Saddled Rockcod, Needletooth, Spotted Black Grouper (New Zealand)

Scientific: *Epinephelus daemelii* (Günther, 1876)

2.2 Systematic position

The Black Rockcod is a large reef dwelling grouper species belonging to the family *Serranidae*, subfamily *Epinephelinae*. Black Rockcod are similar in appearance to other large *Epinephelus*

species such as the Bar Rockcod (*Epinephelus ergastularius*), the Queensland Groper (*Epinephelus lanceolatus*), the Camouflage Grouper (*Epinephelus polyphekadion*), the Flowery Rockcod (*Epinephelus fuscoguttatus*) and the Goldspotted Rockcod (*Epinephelus coioides*), and can sometimes be confused with these and other related groper species. Epinephelus species are commonly referred to as 'Groupers' in the United States and in Australia they are usually known as 'Cod' or 'Groper'.

2.3 Appearance

The colour of Black Rockcod is highly variable: it can change quickly from a uniform dark grey-black colour to a blotched or distinctively banded dark and light pattern (Figure 1). The species is usually black in estuaries but with clearer waters on coastal reefs it generally has a banded pattern (Kuiter 1993). In New Zealand it was found that a single fish could change from the extreme of one colour to the other in just a few seconds, depending on their 'mood' and the colour of the background (Ayling and Cox 1982).

Young Black Rockcod often have a number of distinct black markings that tend to fade as the fish grows. The markings include a distinct black spot or 'saddle' just forward of the tail, and five diagonal sloping dark grey to black bars which generally fade towards the belly. Some Black Rockcod have small black spots and occasional whitish blotches on the body and/or fins and often have white margins on the fins.

Figure 1 – Some of the colour variations of Black Rockcod (Illustrations by Pat Tully).

3. Distribution and habitat

3.1 Distribution

Black Rockcod are known to occur in warm temperate and subtropical waters of the south-western Pacific Ocean. In Australia, the species has been recorded from southern Queensland to Kangaroo Island off South Australia (however, the South Australian record probably represents a 'straggler' or 'expatriate' fish from the east coast), and around Lord Howe and Norfolk Islands. Sightings have been reported from northern Bass Strait waters but Black Rockcod have not been recorded from the coast of Tasmania (Heemstra and Randall 1993). The distribution of the species in NSW is shown in Figure 2. The species' broader distribution in Australia is centred on the NSW coast.

Recent studies in NSW indicate the region from the Solitary Islands to Fish Rock is the most important area for Black Rockcod abundance in NSW and along the mainland coast of eastern Australia, particularly for large males (Malcolm 2011, Malcolm and Harasti 2010). Important sites that have been identified in recent studies include the outer islands in the Solitary Islands Marine Park (North Solitary Island, South Solitary Island and North West Rock), Pimpernel Rock, and Fish Rock (Malcolm and Harasti 2010). Research undertaken in the Port Stephens-Great Lakes Marine Park from 2009-10 has identified the Pinnacle Reefs off Forster as being an important site for Black Rockcod (Harasti 2011). Harasti (2011) also found Black Rockcod were significantly larger in sanctuary zones and sites located offshore and were more regularly observed during warm water periods compared to periods of colder water temperatures.

Black Rockcod are considered to be common around Elizabeth and Middleton reef systems, two offshore reefs in Commonwealth waters in the northern Tasman Sea (Leadbitter 1992). Black

Rockcod are also found in northern parts of New Zealand. Francis (1996) noted this species was common around the Kermadec and Three Kings Islands, but they are considered rare elsewhere in New Zealand.

It is not known whether the Black Rockcod populations from coastal NSW, Lord Howe and Norfolk Islands, Elizabeth and Middleton reefs and the Kermadec Islands represent separate genetic stocks or one panmictic population (i.e. no group structures or mating restrictions in the population). However, genetic evidence from one study undertaken by van Herwerden et al. (2009) suggests that the Elizabeth and Middleton Reef populations are not distinct and rather are part of a larger single stock. The same study also suggested that Elizabeth and Middleton Reef populations are not distinct from the coastal population on the Australian east coast; however, the coastal sample was too small to consider this evidence definitive.

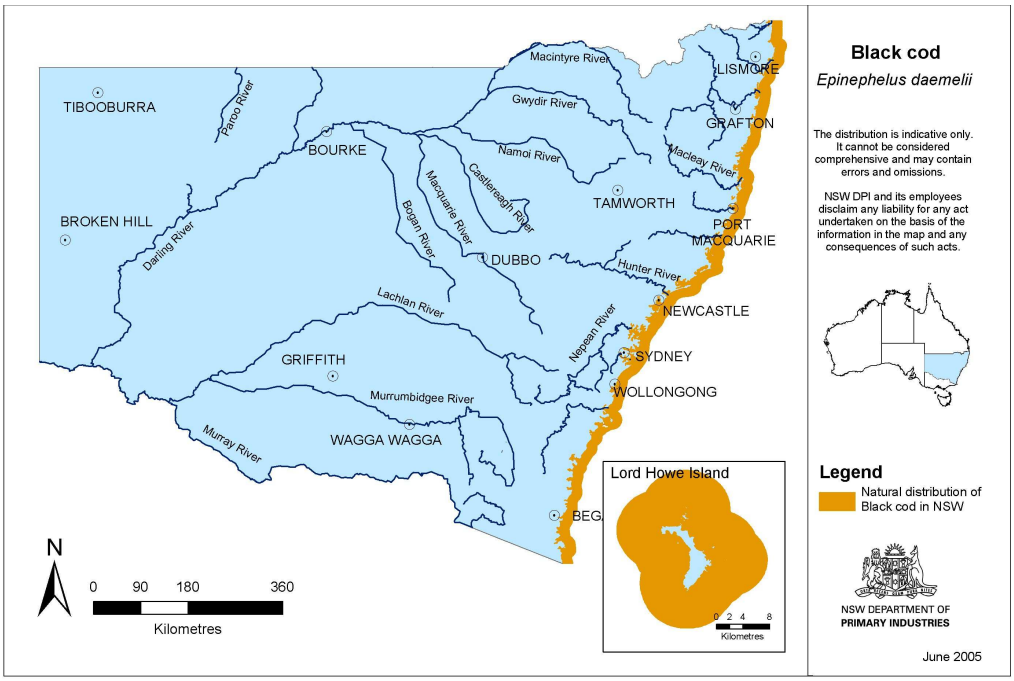

Figure 2 - Distribution of Black Rockcod Epinephelus daemelii *in NSW.*

3.2 Habitat

Adult Black Rockcod are known to occur in caves, gutters and on rocky reefs from near shore environments to depths of at least 50 m (Heemstra and Randall 1993). Recently settled small juveniles are occasionally found in intertidal rock pools along the NSW coastline and larger juveniles are generally captured by anglers on rocky reefs in estuary systems. Estuaries are reported to be important juvenile development grounds for other serranids (*Epinephelus coioides* and *Epinephelus malabaricus*) in northern Australia and the species display considerable site fidelity within estuaries. Hence, if individuals settled at a locality and were later displaced by adverse conditions or fishing pressure, it is unlikely that they would be replaced by immigration from other parts of the estuary (Sheaves 1995). Black Rockcod also occur in relatively deep water and commercial fishers have reported catching the species at depths in excess of 100 m while handlining for demersal species. Black Rockcod are territorial and individuals are frequently encountered in the same location or cave over long periods of time. Individual adult fish can occupy a particular cave for most of their life (Heemstra and Randall 1993). An adult Black Rockcod approximately 1.5 m in length has been identified by divers at an unspecified location off Seal Rocks in NSW. The fish is believed to have resided in the same area for approximately 20 years (Ron Hunter pers. comm.). Similar occurrences of individual Black Rockcod inhabiting the same areas for long periods (over 5 years) have been reported at other

locations along the NSW coast including Fish Rock at South West Rocks and within the Solitary Islands Marine Park near Coffs Harbour.

3.3 Significant habitat

The biological characteristics of marine and coastal environments have been broadly characterised by the Integrated Marine and Coastal Regionalisation for Australia (IMCRA V4) (Commonwealth of Australia 2006). The IMCRA classifies marine and coastal environments on the basis of ecosystem units and forms the basis for further assessment and classification as part of State marine biodiversity assessment and planning processes. In NSW, broad-scale ecosystem units and finer scale habitat classes have been derived within the bioregions (Breen et al. 2004). Black Rockcod habitats can be categorised based on distribution, life history, ecological and biological requirements of the species. Significant habitats are shown in Table 2.

Table 2 – Characterisation of significant Black Rockcod habitats in NSW

IMCRA bioregions	Broad-scale oceanic ecosystem units	Fine scale habitat classes
Tweed-Moreton	Ocean embayments	Island and offshore rocks
Manning Shelf	Tide dominated drowned river valleys	Sub-tidal reefs
Hawkesbury Shelf	Coastal Depth Zone 0 – 20 m	Intertidal rocky shore
Batemans Shelf	Offshore Depth Zone 20 – 60 m	Offshore seamounts
Twofold Shelf	Wave dominated barrier estuaries, lagoons and inter-barrier estuaries	

4. Conservation status

4.1 History

Black Rockcod populations in the vicinity of Sydney were observed to be in decline as early as 1916: 'At one time it (Black Rockcod) was fairly plentiful in the vicinity of Port Jackson, but has become very scarce in recent years, owing to the havoc wrought by fishermen, and the increased shipping' (Roughley 1916).

During the 1950s through to the late 1970s, Black Rockcod were heavily targeted by spearfishers. Many articles in spearfishing and diving magazines of the era, such as *Skindiving in Australia*, detail the killing of large numbers of Black Rockcod. Lincoln Smith et al. (1989) reported that 137 Black Rockcod, averaging 2.4 kg per fish, were caught in NSW spearfishing competitions in 1976 alone. The species was formally protected in NSW in 1983 in response to declining numbers, and was listed as a vulnerable species in NSW in 1999.

Adult Black Rockcod are no longer common on the NSW coast as the species has been slow to recover from the intense line and spearfishing effort of the past, even though they are no longer targeted by either group of fishers. Other *Epinephelus* species that have been unable to sustain high fishing pressure are reported to have decreased average sizes and spawner biomass (Fennessy 1998). Similar to most other *Epinephelus* species that have a home territory, Black Rockcod is presumed to have a relatively low abundance, especially as adults.

5. Biology and ecology

5.1 Reproductive biology

Like most other species in the *Epinephelus* genus, the Black Rockcod is a protogynous hermaphrodite - first developing as a sexually mature female and then changing into a male later in life. Most epinephelids spawn as a female for one or more years before changing sex and

functioning as a male thereafter (Heemstra and Randall 1993). Black Rockcod generally change sex at a length of approximately 100 – 110 cm (Francis 1988).

There is currently little information on the reproductive biology of Black Rockcod including, for example, the trigger for sexual transformation, the formation and composition of spawning aggregations, the extent of territorial ranges, the formation of harems, sex ratios, recruitment patterns, settlement patterns, seasonality, egg dispersal and development.

5.2 Age, growth and longevity

Black Rockcod is considered to be a slow growing species and further information is required on their age-growth relationships and early life history of the species (Malcolm 2011). Otoliths from a 127 cm Black Rockcod retrieved from Lord Howe Island in 2011 were aged at 42 years (Harasti et al. 2011).

The true maximum size of Black Rockcod may have been confounded in the past due to confusion with other similar *Epinephelus* species. In Australia the species is known to grow to at least 1.5 m in total length and a weight of 81 kg (Hutchins and Swainston 1986). Black Rockcod in New Zealand have been recorded as large as 1.8 m but average in size from 40 to 80 cm (Paulin and Roberts 1992). Heemstra and Randall (1993) report that Black Rockcod grow to at least 122 cm in length and 64 kg in weight.

5.3 Diet

Although there is a general lack of detailed information on the diet of Black Rockcod in NSW, it is likely that their diet would be similar to that of other *Epinephelus* species, which are epibenthic predators feeding on macroinvertebrates (mainly crustaceans) and fishes on or near the bottom (Heemstra and Randall 1993). Adult Black Rockcod are believed to prey on fishes and larger crustaceans (McCulloch 1922), while juveniles feed on smaller crabs and fish species (Heemstra and Randall 1993).

5.4 Behaviour

Black Rockcod are considered to be most active at dusk and during the night (Kuiter 1996) and are thought to feed during these times. Observations by fishers and divers suggest that Black Rockcod are slow growing opportunistic carnivores. Most gropers are ambush predators, catching their prey with a quick rush and snap of their jaws (Heemstra and Randall 1993). Some gropers have been reported to follow predatory octopus and moray eels as they forage over the reef in order to catch fish and crustaceans (Diamant and Shpigel 1985). Black Rockcod are known to pursue prey through boulders in a pack-like fashion, while other large predators such as Yellowtail Kingfish, circle above (C. Duffy, New Zealand Department of Conservation, unpub. data).

6. Risk analysis for Black Rockcod

6.1 Introduction

The lack of definitive research and reliable historical records makes it difficult to assess the extent of the decline in Black Rockcod distribution and abundance. A range of historical and current threatening processes have contributed to the decline of Black Rockcod and the importance of these processes varies spatially, temporally and between habitats.

To ensure the recovery of Black Rockcod, it is necessary to identify and assess processes that pose the greatest threat to the species (primary limiting factors). A risk analysis approach has been adopted to identify, assess and objectively quantify the risk associated with each threatening process. This permits the prioritisation of threats which in turn assists in targeting resources to eliminate, mitigate or ameliorate primary threats.

The risk analysis approach adopted in this recovery plan was developed for use in Environmental Impact Statements for Fisheries Management Strategies prepared for designated fishing activities in accordance with the FM Act and EP&A Act (Astles et al. 2006). The methodology is detailed in Appendix 2.

6.2 Risk context

Risk context is the first step in risk analysis and establishes the structure and scope of the analysis and the criteria against which risk will be assessed. For the purposes of this assessment, the risk to Black Rockcod is that threatening processes will continue and further endanger the species in NSW waters. The consequence of any failure to conserve and recover the species would range from, at best, maintenance of the existing situation (i.e. it remains a vulnerable species), or, worse, further declines in the species that would lead to its listing as an endangered, critically endangered or extinct species.

In the absence of species-specific information about the lifecycle of Black Rockcod, the temporal setting for this risk analysis is 10 years, which is consistent with the timeframe for the review of this recovery plan. The spatial extent is all NSW coastal waters seaward to the 4,000 m isobath (60 to 80 nm offshore). This includes State waters (0 to 3 nm) and Commonwealth waters (3 nm to the 4,000 m isobath) in which the 1991 Offshore Constitutional Settlement vested power to NSW to manage certain commercial and recreational fishing activities. The Offshore Constitutional Settlement also encompasses the extent of the recreational fishery managed by NSW DPI.

6.3 Risk identification and characterisation

Risk identification aims to develop a prioritised list of threatening processes affecting Black Rockcod. Identifying the factors responsible for population declines is essential for designing a management strategy that will recover a threatened species (Peery et al. 2004). Risk characterisation prioritises the various sources of risk (i.e. threatening processes) so as to identify the primary threats impeding the recovery of Black Rockcod. These steps are often separated in risk assessment methodologies; however, for ease of interpretation and to reduce repetition they have been combined for this assessment.

Threats that are characterised as moderate to high risk will have specific threat abatement and recovery measures developed. Threats assessed as low risk will be monitored during the life of the recovery plan and reviewed at the expiry of the plan.

The legislative nature of threatened species management means that the majority of the threat identification process has already been completed by the NSW Fisheries Scientific Committee (FSC) in their recommendation to list Black Rockcod as a vulnerable species, and recommendations to list relevant KTPs. Of the seven currently listed KTPs, two are applicable to marine waters occupied by Black Rockcod including '*hook and line fishing in areas important to the survival of threatened species*' and '*the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW*'. The other five KTPs are either related to freshwater habitats or have not been implicated in the decline of Black Rockcod.

In addition to KTPs, unlisted threatening processes that are likely to affect Black Rockcod are anthropogenic predation through other forms of fishing including commercial estuarine mesh netting; commercial trapping; commercial trawling; aquarium collecting and spearfishing.

To standardise the assessment approach, the following sections describe each threatening process, as well as the potential extent and magnitude of impacts on Black Rockcod. The degree of extent and magnitude is based on a suite of criteria, including:

- status (whether the threat is recognised as a KTP);
- extent (the extent of the species range that is affected; whether there are refuges from the threat);

- severity (whether the threat affects individuals or the entire population);
- effect (whether the threat affects range extension, recruitment, or individual survival);
- response (whether the species is resistant and/or resilient to the threat, and the species' and/or habitat recovery speed or potential);
- frequency (how regularly the threat occurs);
- form (the nature of the threat—pulse [acute/short term], press [sustained/chronic], or catastrophic [major and widespread]); and
- historical context (period of significance of the threat: more than 100 years ago; 50–100 years; last 50 years).

These criteria are each given a severity rank between 1 (low severity) and 3 (high severity) which are summed to provide an overall 'priority' for each threat to Black Rockcod. A score of 19–24 is considered high risk, 13–18 moderate risk and 8–12 low risk.

A detailed description of the risk assessment methodology is provided in Appendix 2.

Section 8 outlines the recovery actions established to address moderate and high risks to Black Rockcod.

6.3.1 Hook and line fishing in areas important for the survival of threatened fish species

Description

The FSC (2003) defines hook and line fishing as '...any activity that uses a combination of lines and hooks with the aim of catching fish. This includes, but is not restricted to, the use of lines composed of monofilament, wire and cord, with attached lures, hooks and jigs. Hand-lines, set lines, rod and reel fishing, trolling, lure fishing and fly fishing are all included in the activities that may be identified as a key threatening process'. This definition of hook and line fishing specifically embraces the fishing activity, including catch and release, and not just the 'taking of fish'. The incidental capture and subsequent release of fish can cause mortality through a range of impacts, including cumulative sub-lethal physiological disturbance and physical injury (Muoneke and Childress 1994) and the effects of barotrauma (injury caused by depressurisation when fish are taken rapidly out of deep water) (McLeay et al. 2002), including prey regurgitation (De Martini et al. 1996). Bleeding associated with hooking has been found to be a significant predictor of post-release mortality in many fish species (Diodati and Richards 1996).

The above definition does not discriminate between recreational or commercial hook and line fishing, but rather focuses on the activity itself, and this assessment will refer collectively to fishers unless describing unique gear configurations. The FSC (2003) also noted that important areas could include those areas where threatened species form schools or aggregations, perhaps as juveniles, or sometimes for the purposes of spawning or feeding. A number of threatened species are highly vulnerable to the impacts of hook and line fishing at these locations and some of these important environmentally-sensitive areas are identified as critical habitat under Part 7A of the FM Act. At this stage, no areas have been identified for Black Rockcod, although the species is known to occur in most of the critical habitats and other key aggregation sites of grey nurse shark, further emphasising the importance of these areas. There are 10 critical habitat areas currently declared for grey nurse shark (see www.dpi.nsw.gov.au). Critical habitat areas extend 200 m out from the relevant natural feature (e.g. rocky outcrop/reef, island), with an additional 800 m buffer zone encircling the area.

Overlap and interaction

Hook and line fishing, in its broadest sense, can be undertaken across almost the entire range of Black Rockcod within the waters managed by NSW (i.e. out to about 80 nm). Exceptions include some gear and area restrictions in critical habitats for the grey nurse shark, sanctuary zones and some habitat protection zones in marine parks, aquatic reserves, intertidal protected areas, marine components of national parks, and fishery-specific closures. Commercial setlining,

droplining and driftlining are prohibited in critical habitat and associated buffer zones, as is fishing using wire trace whilst anchored or moored. Bait fishing whilst anchored or moored is prohibited in the critical habitat zone, however it is allowed in the buffer zone. Five of these 10 areas are located within sanctuary zones in marine parks, which prohibit line fishing and in all cases extend beyond the critical habitat zones. The importance of these and other closed areas for Black Rockcod is unknown, and collectively they account for only a small proportion of the species potential distribution in waters managed by NSW.

Fishers use a wide variety of fishing gear to take pelagic and demersal fish species in coastal waters. Despite the considerable potential overlap, the actual extent of fishing interaction with Black Rockcod is currently unknown and different types of hook and line fishing have different potential for, and magnitude of interaction. These differences can be determined by refining the KTP into three sub-components: non-baited lines (e.g. lure, fly and jig); surface-set baited lines (e.g. driftlining or trolling); and bottom-set baited lines (e.g. setlining, handlining, trotlining).

Non-baited lines (e.g. lure, fly, jig, commercial poling) have the potential to catch Black Rockcod. As the name suggests, these methods utilise artificial devices that mimic fish or crustaceans and are usually cast and quickly retrieved or trolled behind boats. Historically, they have primarily been used to target pelagic (i.e. surface) fish such as Yellowtail Kingfish, tunas, bonito and mackerels by locating schools of fish at the surface and/or by using burley to attract the fish. Recently, however, recreational anglers are increasingly using soft silicone based lures and jigs (often referred to as 'soft plastics') to target reef fish such as Snapper. Soft plastic lures closely mimic the physical features and swimming patterns of fish or crustaceans and many are scented with natural or synthetic additives. They are reportedly very effective at catching a wide range of species, including many deepwater and reef-dwelling fish and anglers have reported catching Black Rockcod using these lures. Their popularity is probably increasing the potential for interaction with Black Rockcod.

Surface-set baited lines (e.g. driftlining, trolling, and commercial poling) have limited potential for capturing Black Rockcod and to date there have not been any such reports. These methods are also used to primarily target the same pelagic species as non-baited lines, but can also include larger species such as sharks, marlin and other billfish, often using live baits.

Bottom-set baited lines (e.g. setlining, trotlining, handlining) are probably the most widely used and the more indiscriminate of the hook and line methods. In the case of the commercial methods of setlining and trotlining (also called demersal longlines), these are passive methods that are deployed along or parallel to the seabed and left to fish for an unspecified period depending on weather and current conditions. They target species such as Wobbegong Sharks, Gummy Shark and Snapper in waters to about 80 fathoms (approximately 150 m), and Redfish, Blue-eye Trevalla, Hapuku and other deepwater species in waters ranging from 100 to 600 fathoms (NSW DPI 2006). They are thought to be the primary commercial methods by which Black Rockcod were harvested prior to their protection in 1983, and are still used to catch the closely related Bar Rockcod (*Epinephelus ergastularius*). Identification problems associated with serranids means it is possible that the occasional Black Rockcod is amongst the landed catch and/or caught and subsequently released. These methods have historically been linked to declines in Black Rockcod numbers and distribution and continue to have the potential for interaction.

Droplining is another commercial method that can be bottom-set with bait, but unlike setlines and trotlines, are suspended vertically in the water column with a weight at the bottom and float at the surface. Droplining is mostly restricted to waters in excess of 100 fathoms (183 m), and usually takes place adjacent to offshore drop-offs and submarine canyons to target species such as Blue-eye Trevalla and Hapuku.

Bottom-set baited handlining is undertaken by both commercial and recreational fishers in all habitat types and at almost all depths, and as such catches a wide variety of species, including Black Rockcod. Black Rockcod are known to take baited hooks that are dropped within the vicinity of their cave or habitat. Over the past few years, divers have reported sightings to NSW

DPI of Black Rockcod with gang and single hooks visible in their jaws at dive sites within the Solitary Islands Marine Park and also at locations off Forster and South West Rocks.

Prior to 2006, there was little capacity for commercial fishers to report the catch and release of Black Rockcod (or any threatened species) on their catch returns, so there is currently limited data for released Black Rockcod; however, anecdotal reports suggest that it does happen occasionally. Changes to commercial catch returns now provide for the reporting of bycatch and/or interactions with threatened species, however this data will require onboard observers to provide some form of independent validation. The catch and release of Black Rockcod is infrequently reported in recreational fishing magazines, and reports are usually of juveniles in the lower reaches of north coast estuaries or adults from offshore reefs. The species is commonly misidentified in magazines as the closely related and protected Goldspotted Rockcod (*Epinephelus coioides*), indicating that current reporting arrangements for interactions with threatened species are likely to under-report the capture of Black Rockcod. The threatened and protected species sightings database maintained by NSW DPI has six records of anglers catching Black Rockcod at Nambucca Heads, Hat Head and Ulladulla.

The threatened status of Black Rockcod means that fishers are required to return Black Rockcod to the water causing them the least possible harm. Whilst this may occur, it is likely that any capture is going to result in some form of injury to Black Rockcod. Even with careful handling techniques, the capture and release of fish can cause many physiological impacts (Muoneke and Childress 1994), especially for fish such as Black Rockcod that occur in waters up to 100 m depth and are vulnerable to the effects of barotrauma (McLeay et al. 2002).

Mortality from the impacts of barotrauma may be of particular concern for Black Rockcod. Research conducted on a related species, Red Groper (*Epinephelus morio*), reported mortality rates of 9–16% for fish caught in depths less than 44 m and approximately 75% for fish from deeper waters (Wilson and Burns 1996). Mortality of West Australian Dhufish (*Glaucosoma hebraicum*) increased with depth of capture from 21% at 0–14 m and up to 86% at 45–59 m, and some degree of barotrauma occurred for fish from all depths of capture (St John and Syers 2005). Although not in the same family as Black Rockcod, West Australian Dhufish are very similar in that they are slow-growing, long-lived, have a small geographic range and are vulnerable to localised depletion due to their site fidelity (St John and Syers 2005). Anecdotal reports suggest that Black Rockcod caught in deeper waters off northern NSW by commercial and recreational fishers generally do not survive after being released at the surface as they suffer severely from the effects of swim-bladder decompression (Pogonoski et al. 2002).

Accidental hooking could also have sub-lethal effects on Black Rockcod, for instance by affecting their ability to feed or mate. There have been several reports to NSW DPI by divers who have found Black Rockcod with large hooks embedded in their jaws, which may hinder feeding ability.

Risk

Non-baited lines (e.g. lure, fly, jig, commercial poling) other than soft plastic lures are considered a low risk to Black Rockcod due to the limited potential for capture using these primarily surface-fishing methods and to date there have been no reports of Black Rockcod being caught using these methods. Surface-set baited lines (e.g. driftlining, trolling, and commercial poling) are also considered a low risk to Black Rockcod.

Soft plastic lures are becoming widely used across the range of areas where Black Rockcod are found. They mimic characteristics of live baits and catch a wide range of demersal species. As a result they are considered a moderate risk to Black Rockcod.

Bottom-set baited lines (e.g. setlining, trotlining, handlining) are the most widely used and indiscriminate method of fishing with the potential to have a pronounced effect on Black Rockcod numbers and distribution. Bottom-set baited lines continue to have the potential for interaction with Black Rockcod and are therefore considered a high risk to the species.

Droplining, another bottom-set and baited method, is considered a low risk to Black Rockcod as it is predominantly used in waters in excess of 100 fathoms (183 m). However, it is also used in shallower waters, targets large reef-dwelling species and as a general classification and precautionary approach this method is considered a moderate risk to Black Rockcod.

Table 3 – Hook and line fishing in areas important for the survival of threatened fish species

Threat	Severity of each criteria	Rank for each criteria	Overall risk and priority
Hook and Line Fishing non-baited (other than soft plastic lures) & surface-set baited i.e. lure, fly, jig, poling, driftlining, trolling	Listed KTP	3	LOW (score of 11)
	Limited extent in terms of habitat	2	
	Limited to few if any individuals	1	
	Limited effects	1	
	Resilient due to limited effects	1	
	No recorded captures	1	
	Short term if it ever occurs	1	
	Limited historical impact	1	
Hook and Line Fishing soft plastic lures	Listed KTP	3	MODERATE (score of 16)
	Limited extent in terms of habitat	2	
	Limited to few if any individuals	2	
	Limited effects	2	
	Resilient due to limited effects	1	
	No recorded captures	3	
	Short term if it ever occurs	2	
	Limited historical impact	1	
Hook and Line Fishing bottom-set baited i.e. setlining, trotlining, handlining	Listed KTP	3	HIGH (score of 22)
	Limited extent in terms of habitat	3	
	Limited to few if any individuals	3	
	Limited effects	3	
	Resilient due to limited effects	3	
	No recorded captures	3	
	Short term if it ever occurs	2	
	Limited historical impact	2	
Hook and Line Fishing bottom-set baited i.e. droplining	Listed KTP	3	MODERATE (score of 14)
	Limited extent in terms of habitat	1	
	Limited to few if any individuals	2	
	Limited effects	2	
	Resilient due to limited effects	2	
	No recorded captures	2	
	Short term if it ever occurs	1	
	Limited historical impact	1	

6.3.2 Introduction of non-indigenous fish and marine vegetation to coastal waters of NSW

Description

The FSC (2004) reported that little detailed information is available on the impacts of non-indigenous fish and marine vegetation in NSW waters. However, Australian and overseas studies provide evidence that the introduction of non-indigenous fish and marine vegetation into NSW waters is likely to be deleterious to native species and ecological communities in several ways. These include direct competition for resources (habitat, food, etc.), predation, introduction of disease, introduction of toxic species, and degradation of habitats.

Overlap and interaction

With the exception of Pacific oysters and the alga *Caulerpa taxifolia*, most introduced species are largely restricted to their current range. Wild Pacific Oysters occur in most estuaries south of Wallis Lake, and Pacific Oysters are also cultivated in several NSW estuaries in accordance with the NSW Oyster Industry Sustainable Aquaculture Strategy. *Caulerpa taxifolia* is reported to occur in estuaries ranging from Lake Macquarie to St Georges Basin and appears to out-compete native seagrasses in some areas. Green Shore Crab (*Carcinus maenus*), New Zealand Screw Shell (*Maoricolpus roseus*) and European Fan Worm (*Sabella spallanzanii*) are mostly found around Eden, and Broccoli Weed (*Codium fragile* ssp. *tomentosoides*) is also found at Eden and some locations near Sydney. Introduced gobies, including Japanese Goby (*Tridentiger trigonocephalus*), Striped Sandgoby (*Acentrogobius pflaumii*), Hasselt's Flaphead Goby (*Callogobius hasseltii*) and Yellowfin Goby (*Acanthogobius flavimanus*) are reported from Sydney Harbour, Pittwater and/or Port Kembla, and are all thought to compete with native species of gobies.

Currently the introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW is unlikely to directly affect Black Rockcod as none of the known introduced species are reported to interact with Black Rockcod. However, there may be some unknown indirect impacts on the prey resources and/or habitat of Black Rockcod. For example, the invasive alga *Caulerpa taxifolia* has been reported to support fewer species, higher abundances of gobies, and few or no seahorses and leatherjacket species than adjacent, native seagrass beds (York et al. 2006). New Zealand Screw Shell and European Fan Worm are also thought to out-compete native species, inhibiting their settlement to the point of localised extinctions of native species. Such changes in fish assemblages could have implications for the diet of juvenile and adult Black Rockcod. In the absence of information about the diet of Black Rockcod the impact of such factors is speculative and offers little to the assessment. It does, however, highlight the need to collect basic biological and ecological information on Black Rockcod.

Risk

None of the currently known introduced species are thought to directly or indirectly affect Black Rockcod and as such the risk of this KTP is considered low.

Table 4 – Introduction of non-indigenous fish and marine vegetation to coastal waters of NSW

Threat	Severity of each criteria	Rank for each criteria	Overall risk & priority
Introduction of non-indigenous fish and marine vegetation	Listed KTP	2	LOW (score of 9)
	Limited extent in terms of habitat	1	
	Limited to few if any individuals	1	
	Limited effects	1	
	Resilient due to limited effects	1	

Threat	Severity of each criteria	Rank for each criteria	Overall risk & priority
	No recorded captures	1	
	Short term if it ever occurs	1	
	Limited historical impact	1	

6.3.3 Mesh netting (estuarine) and fish trapping

Description

The commercial Estuary General Fishery uses a range of gear, including mesh nets and fish traps, to target finfish within estuaries. The fishery also uses prawn seines and haul nets to catch prawns and hand gathering of beachworms and Pipis occurs from ocean beaches. The major species caught by mesh netting include Mullet, Luderick and Yellowfin Bream. Yellowfin Bream, Blue Swimmer Crabs and Silver Trevally comprise a significant proportion of the catch in fish traps.

A meshing net consists of a length of mesh secured between a headline ('cork line') on the top, and a footline ('lead line') on the bottom. The headline is designed to be buoyant by using a series of floats attached along the length of the net and the footline is weighted to keep the net vertically suspended in the water. The meshing net entangles fish as they move through the estuary (NSW Fisheries 2001). A standard meshing net is a maximum length of 725 m, with mesh size of not less than 80 mm.

A meshing net can be used in two ways, either by setting for a period (other than between sunrise and sunset), or by splashing; where the net is placed in the water and the surrounding water splashed to encourage fish to swim into the net. While spatial and temporal closures generally control the use of meshing nets in particular estuaries, additional controls apply to the setting of meshing nets. These include three hour maximum sets for all estuaries during September-November and February-April; the use of splash netting only during December and January; overnight setting in all estuaries during June-August; a maximum of three hour sets in May in all estuaries north of Crowdy Head, and overnight sets south of Crowdy Head in May (NSW DPI 2003).

Fish traps are generally made from wire mesh supported by a frame. They are set on the bed of the estuary and are baited to attract fish inside. Entrances to the trap are tapering funnels that make it hard for fish to escape once they have entered, although underwater video footage shows that some species move relatively unimpeded in and out of fish traps (NSW Fisheries 2001). Standard trap dimensions are a maximum of 2 m long, 1.5 m wide and 1 m high. To minimise the capture of juvenile fish, the trap mesh must not be less than 50 mm. Commercial fishers generally check fish traps in the morning on a daily basis or, occasionally, every two or three days.

Fish traps used in ocean waters by fishers endorsed in the Ocean Trap and Line Fishery are similar to estuarine traps and are usually 2 m x 1 m x 1 m, although they can have maximum dimensions of 2 m x 2 m x 2 m. They are also now required to have an escape panel with a minimum mesh size of 50 mm x 75 mm in the entire back panel of the trap. This is to reduce the bycatch of juvenile and small fish, particularly Snapper, Grey Morwong and Silver Trevally. Fish traps are baited and set on or adjacent to reefs at depths of 10 m to 150 m to target Snapper, Silver Trevally, and various leatherjacket and morwong species.

Overlap and interaction

Prior to 2002, the Estuary General Fishery was conducted to some degree in approximately 130 of the larger estuaries along the NSW coast. Since 2002, the development of the Estuary General Fishery Management Strategy, the creation of 30 recreational fishing havens and

closures related to marine protected areas restricted mesh netting and fish trapping to approximately 50 and 87 estuaries, respectively. Although most of the estuaries where meshing is permitted are south of Sydney, effort has historically concentrated in the larger systems of the north and central coast, with the Clarence River, Port Stephens, Wallis Lake, Tuggerah Lakes and Lake Macquarie accounting for 50% of total mesh netting effort. Lake Macquarie is now a recreational fishing haven and parts of Port Stephens are closed to mesh netting due to the creation of the Port Stephens-Great Lakes Marine Park. Similarly, trapping effort is highest in the northern estuaries of Wallis Lake, the Clarence River, Port Stephens, the Camden Haven River and the Hawkesbury River. The winter months provide the peak of activity in these areas although this pattern of activity is not reflected in other areas (NSW Fisheries 2001).

There is significant potential overlap between the broad geographical range of Black Rockcod and the trap component of the Ocean Trap and Line Fishery, as well as significant overlap at the smaller scale of rocky reef habitats. Although some areas are now closed to trapping through the establishment of sanctuary zones and trapping closures in habitat protection zones within marine parks, these areas represent a small proportion of its potential distribution and it is unknown how important they are for Black Rockcod.

As previously mentioned, information about catch rates or interactions with threatened species has not historically been recorded as part of commercial catch returns hence there is limited data upon which to base an assessment of magnitude. Some commercial catch records indicate that 'cod unspecified' have been included in the landed catch, and the Estuary General Fishery Management Strategy (NSW Fisheries 2003) acknowledges that incidental captures of estuary cod may occur. Given the obvious problems of misidentification and the species use of lower estuarine areas, it is likely that captures of Black Rockcod, particularly juveniles, have occurred. Unfortunately it is not possible to determine the number captured or the method of capture, but considering the methods of the Estuary General Fishery and the habitat preferences of Black Rockcod, any captures are likely to be by either trapping or mesh netting. Serranids can also be reported as 'cod unspecified' in the Ocean Trap and Line Fishery, and many other serranids are landed in this fishery including Eastern Wirrah, Maori Rockcod and Bar Rockcod, although these are predominantly caught by line methods. Many finfish targeted by fish traps, such as morwong, Silver Trevally and sweep are also likely to be prey for Black Rockcod, hence the fishery may also impact on the food source for Black Rockcod.

Historically, the largely indiscriminate nature of these methods, their widespread use and the greater abundance of Black Rockcod has probably meant that captures were previously more common than they are likely to be today. Mesh netting is now restricted to less than 50 estuaries, most of which are on the south coast, and there is a variety of spatial and temporal restrictions within each estuary governing their use, which further limits any potential interaction. Estuarine trapping remains widespread in its extent and although potential interactions are likely to be limited and restricted to juveniles, it should be acknowledged because traps can be deployed in the lower reaches of estuaries where break walls and rocky shores are common and thus more likely to provide habitat for Black Rockcod. Inside 3 nm, the potential for interaction between Black Rockcod and oceanic fish trapping has been reduced by the establishment of sanctuary zones, predominantly in areas of rocky reef. Beyond those zones, interactions in ocean waters are likely to be restricted to competition for food resources, although captures are also possible.

Risk

The majority of risk associated with the impact of mesh netting and fish trapping surrounds the lack of data about the frequency of interactions and species misidentifications and subsequent misreporting. The overall risk to Black Rockcod from these methods is considered to be low; however, the issues warrant attention when determining recovery actions, especially with respect to trapping.

Table 5 – Mesh netting (estuarine) and fish trapping

Threat	Severity of each criteria	Rank for each criteria	Overall risk & priority
Mesh netting (estuarine) and fish trapping	Listed KTP	1	LOW (score of 12)
	Limited extent in terms of habitat	2	
	Limited to few if any individuals	1	
	Limited effects	2	
	Resilient due to limited effects	1	
	No recorded captures	2	
	Short term if it ever occurs	1	
	Limited historical impact	2	

6.3.4 Aquarium collecting

Description

The large size and predatory nature of Black Rockcod is likely to have restricted collecting for aquarium purposes to the larger commercial operations. Sydney Aquarium and Manly Oceanworld each hold several Black Rockcod in aquaria. These specimens were collected under permits issued by the former NSW Fisheries; however, no further collection permits are currently being issued by the Department. The legal practice is no longer thought to affect Black Rockcod, although the existence or extent of any illegal collecting is unknown. Sydney Aquarium and Manly Oceanworld now assist in educating the public about the vulnerable status of Black Rockcod and provide some insight into the behaviour of Black Rockcod. For example, in aquaria Black Rockcod have been observed displaying mating activity, including colour changing, swimming together to mid-water and synchronous gestures/dancing (Colin Henrisson, Sydney Aquarium, pers. comm., September 2006).

Overlap and interaction

Historically, aquarium collecting for the larger commercial operations would have had an impact by removing larger fish (probably spawning males) from the population for display purposes. As both aquariums are located in Sydney and there is no indication that the Black Rockcod were widely sourced, initial collections may have contributed to localised depletions related to other forms of fishing. There is also no record of how regularly fish were collected, in what numbers and what kind of initial mortalities were associated with capture and captivity. The vulnerable status and restriction on issuing of permits means that there is likely to be no potential overlap or interaction between aquarium collecting and Black Rockcod.

Risk

The risk posed by aquarium collecting to Black Rockcod is considered to be low given the current restrictions on collection.

Table 6 - Aquarium collecting

Threat	Severity of each criteria	Rank for each criteria	Overall risk & priority
Aquarium collecting	Listed KTP	1	LOW (score of 11)
	Limited extent in terms of habitat	1	
	Limited to few if any individuals	2	
	Limited effects	1	
	Resilient due to limited effects	2	
	No recorded captures	1	
	Short term if it ever occurs	1	
	Limited historical impact	2	

6.3.5 Spearfishing

Description

According to the *Fisheries Management (General) Regulation 2010*, cl. 55, 'spear gun' 'includes a spear, bow and arrow or other similar device'. It is illegal to spearfish when scuba diving; however, spearfishing can be legally carried out when snorkelling in waters other than inland waters or other specified waters in which spearfishing is prohibited. Spearfishing has evolved over the years from basic hand spears to the modern spear gun. Hand spears were powered by stretching a large rubber from one end of the spear towards the other and releasing it such that the spear was propelled through the water. Limited in power and distance, these spears required a skindiver to get quite close to a target before firing. Modern spear guns work on the same principle, but the stretched rubber no longer needs to be held by the diver, rather it is hooked onto a lever on the gun which is released by the use of a trigger situated on the handle of the spear gun, hence the name. Spear guns are considerably more powerful and accurate than hand spears and are less reliant on a diver's skills.

Overlap and interaction

Historically, spearfishing would have had a significant impact on the distribution and abundance of Black Rockcod in shallow inshore waters that can be accessed by divers. From the 1950s until 1983, Black Rockcod was heavily targeted by spearfishers along the coast due to its size and good eating qualities. Large Black Rockcod are extremely curious and easily approached by divers; hence their behaviour made them a very easy target for spearfishers. There are many reports from the magazine *Skindiving in Australia* in the 1970s of spearfishers recording large numbers of Black Rockcod. One spearfishing article stated that '*when we hopped back into the boat we had a half dozen black cod up to 30lb'* (Andrewartha and Kemp 1970s). This article is one of many that illustrate the large numbers of Black Rockcod that spearfishers were able to take in a single spearing session. Lincoln Smith et al. (1989) reported that 137 Black Rockcod, averaging 2.4 kg per fish, were caught in NSW spearfishing competitions in 1976 alone.

Even though the threatened status of Black Rockcod means that they are no longer targeted by spearfishers the activity is likely to exert indirect impacts by removing prey. The activity of spearfishing may also interfere with the species' ability to feed and reproduce.

There are now few reports of spearfishers illegally targeting Black Rockcod. Many spearfishers are actively involved in conservation activities, including the reporting of sightings to NSW DPI threatened and protected species sighting program. Some spearfishers, in an effort to improve their public image, have sought to have a level of accreditation introduced into their sport, which would involve an element of education about species like Black Rockcod and improved species

identification. Despite such efforts, isolated incidents of illegal take of Black Cod continue to occur.

Risk

Spearfishing would have had a significant impact on Black Rockcod from the 1950s to 1970s. The spearing of Black Rockcod continues to occur infrequently and is now considered a low risk to Black Rockcod.

Table 7 – Spearfishing

Threat	Severity of each criteria	Rank for each criteria	Overall risk & priority
Spearfishing	Listed KTP	1	LOW (score of 12)
	Limited extent in terms of habitat	1	
	Limited to few if any individuals	2	
	Limited effects	2	
	Resilient due to limited effects	2	
	No recorded captures	1	
	Short term if it ever occurs	1	
	Limited historical impact	2	

6.3.6 Climate change

Description

Climate change is recognised by all levels of Government in Australia as having the potential to change rainfall patterns, reduce water availability and increase the frequency of severe weather events such as storms. '*Human caused climate change*' is listed as a KTP in NSW under the FM Act.

Climate change has occurred through many ages of the Earth's history (Jansen 2007). The most recent phenomena of global warming are accelerated through the human activity of energy supply, transport, industry, forestry (including deforestation), agriculture and domestic and commercial building. Greenhouse gas emissions from these contributors have increased by 80% during the period from 1970 to 2004 (Bernstein et al. 2007).

The increase in concentration of greenhouse gases in the atmosphere has altered the earth's radiative balance, resulting in more of the sun's heat being absorbed and trapped inside the earth's atmosphere, producing global warming. Without mitigation measures the average global temperature is expected to rise by 1 to 6◦ C by 2100 (Solomon 2007; Cowie and Fairweather 2007).

Overlap and interaction

The impacts of climate change affecting aquatic species in estuarine and marine areas are rising sea level, increasing acidity of marine waters, increasing global temperature and changing rainfall patterns (amount and variability) (Cowie and Fairweather 2007).

In NSW predicted changes will result in alteration of ocean currents, an increase in extreme event storm surges and a decreasing flow of freshwater to estuaries, with a shift in nutrient supply to the near shore coastal waters (Cowie and Fairweather 2007). These alterations will manifest in significant estuarine and near shore habitat changes, changes in trophic (food chain) relationships and shifts in the recruitment patterns of aquatic plants and animals (Cowie and Fairweather 2007). Changes in the range and distribution of species, the composition and

interactions within aquatic communities and the structure and dynamics of communities are predicted to occur.

The ongoing human responses to sea level rise caused by climate change may also negatively impact on estuarine environments. For example, seawalls are a dominant foreshore feature of urban estuaries and the demand to build more and the need to repair existing seawalls is expected to increase in a bid to protect low-lying foreshore infrastructure from sea level rise associated with climate change (Wiecek, 2009).

Risk

Climate change has the potential to affect Black Rockcod across its entire range by altering water chemistry, increasing water temperature and changing rainfall patterns. While the capacity of marine threatened species such as Black Rockcod to adapt to changes to climate is largely unknown, it is likely that such changes would significantly alter marine ecosystems, and consequently the distribution, growth and recruitment of Black Rockcod, as well as their prey and predators. There is evidence to suggest that the incidence of novel marine diseases and frequency of outbreaks is increasing due to climate change and anthropogenic impacts (Harvell et al. 1999, 2002, Ruiz et al. 2000b cited in Dulvey et al. 2003). Species already under pressure from other threats are less likely to be resilient to changes in climate (DECCW 2009).

The human response to sea level rise is also likely to result in the destruction and loss of Black Rockcod habitat and contribute to a reduction in essential ecosystem services. Therefore climate change has been assessed as a moderate risk to Black Rockcod.

Table 8 - Climate change

Threat	Severity of each criteria	Rank for each criteria	Overall risk & priority
Climate change	Listed KTP	2	MODERATE (score of 16)
	Limited extent in terms of habitat	3	
	Limited to few if any individuals	3	
	Limited effects	2	
	Resilient due to limited effects	2	
	No recorded captures	1	
	Short term if it ever occurs	2	
	Limited historical impact	1	

6.3.7 Water pollution

Description

Water pollution is the contamination of water bodies caused by human activities. Water pollution can be derived from point and non-point sources and may be chemical (organic or inorganic), thermal or biological and includes pollution such as run-off from agriculture, rural and industrial developments.

The majority of the NSW population lives close to the coast placing considerable pressure on coastal and estuarine ecosystems through increased development and disturbance of the catchments (DECCW 2009).

The majority of pollution in coastal and marine waters originates from land-based activities and the main pressures arise from human settlement, population growth and urbanisation (e.g. sewage and stormwater discharges, estuarine outputs and marine debris) (DECCW 2009). The 2009 NSW Statement of the Environment Report estimated that approximately 135 NSW

estuaries discharge into marine waters, contributing about 837,000 tonnes of sediment, 2,400 t of phosphorus and 23,000 t of nitrogen annually.

Overlap and interaction

Pollution can have significant impacts on marine water quality and habitats. Water pollution can degrade the quality of habitats, alter the distribution and density of species, increase the levels of contaminants in some species (which have impacts throughout the food chain) and reduce the relative abundance of top-order predators (DECCW 2009).

Pollution disrupts reproductive physiology, mating systems, and life histories of organisms and probably combines with other factors to reduce population persistence (Kime 1995; Jones and Reynolds 1997 cited in Dulvey et al. 2003).

Risk

While the precise impacts of water pollution on Black Rockcod are unknown, it is likely to have a negative impact on the species long-term viability. Estuaries are reported to be important juvenile development grounds for other serranids (*Epinephelus coioides* and *Epinephelus malabaricus*) in northern Australia and the species display considerable site fidelity within estuaries. These areas are subject to the impacts of human activities due to their close proximity to human settlement areas.

The greatest risk of onshore developments affecting aquatic ecosystems is through agricultural and urban runoff, with released effluent and waste potentially impacting plants and animals through heavy metal, organic and hydrocarbon pollutants, increased turbidity, and increased nutrients. Diffuse pollution (e.g. acid sulphate soil discharges, low dissolved oxygen) from agricultural drains on coastal floodplains can also impact on juvenile Black Rockcod habitat by altering the water chemistry within estuaries over extended periods. Therefore there is a moderate risk of water quality continuing to impact on Black Rockcod.

Table 9 - Water pollution

Threat	Severity of each criteria	Rank for each criteria	Overall risk & Priority
Water pollution	Listed KTP	1	MODERATE (score of 15)
	Limited extent in terms of habitat	3	
	Limited to few if any individuals	2	
	Limited effects	2	
	Resilient due to limited effects	2	
	No recorded captures	1	
	Short term if it ever occurs	2	
	Limited historical impact	2	

6.4 Issues arising from the risk analysis

6.4.1 Risk analysis overview

The risk analysis has determined that hook and line fishing (bottom-set baited) setlining, trotlining and handlining has the greatest potential impact on Black Rockcod and therefore is the highest priority when implementing Black Rockcod recovery actions. Other forms of hook and line fishing pose a moderate or low risk to Black Rockcod. There are no current records of Black Rockcod captured using plastic lures; however, due to their increase in popularity and close imitation of fish they are ranked as the second highest priority to be addressed. Climate change has also been assessed as a moderate risk to Black Rockcod. Climate change has the potential

to affect Black Rockcod across its entire range altering marine ecosystems as well as the distribution, growth and recruitment of the species, and their prey and predators.

Water pollution also has the potential to negatively impact the species long-term viability in certain parts of its habitat and at certain life stages, particularly where the impacts of human activities are concentrated and therefore the risk is moderate.

Section 8 outlines the recovery actions established to address moderate and high risks to Black Rockcod.

The remaining low risk threats to Black Rockcod recovery include:

1. spearfishing;
2. mesh netting and fish trapping;
3. hook and line fishing (non-baited, surface-set baited);
4. aquarium collecting; and
5. introduction of non-indigenous fish and marine vegetation.

Table 10 – Potential risks to Black Rockcod ranked from highest to lowest

Threat	Score	Risk/Priority	
Hook and line fishing (bottom-set baited) – setlining, trotlining, handlining	22	HIGH	HIGHEST
Hook and line fishing (soft plastic lures and droplining)	16	MODERATE	
Climate change	16	MODERATE	
Water pollution	15	MODERATE	
Spearfishing	12	LOW	
Mesh netting (estuarine) and fish trapping	12	LOW	
Hook and line fishing (non-baited, surface-set baited) – lure, fly, jig, poling, driftlining, trolling	11	LOW	
Aquarium collecting	11	LOW	
Introduction of non-indigenous fish and marine vegetation	9	LOW	LOWEST

6.4.2 Limitations in knowledge

There is a lack of detailed information regarding basic aspects of the life history and ecology of Black Rockcod in NSW waters, as well as the specific impacts of fishing and other human activities on this species. For example, addressing the KTP of 'hook and line fishing (but most notably bottom-set bait fishing) in areas important for the survival of threatened species' is complicated by the fact that there is limited information on the spawning, aggregating or recruitment areas for Black Rockcod. The species spatial distribution, patterns of abundance, reproductive biology, population demography, movement patterns and population genetics all remain largely unknown. Pogonoski et al. (2002) identified several areas that need to be included in a research program. In particular, information on age/size classes, the age/size at maturity, sex ratios and fecundity levels are required to determine the proportion of mature adults in a given population and the species' response to threatening processes. Further research to obtain this information is needed to ensure effective threat identification and minimisation and will need to be an integral part of recovery actions.

6.4.3 Community involvement and education

Gaining increased community support and public understanding of issues affecting the recovery and long-term conservation of Black Rockcod will be a vital part of developing a successful recovery program. Educating fishers and divers about the identification of Black Rockcod is particularly important as it is easy to confuse this species with a number of closely related *Epinephelus* species in NSW. Over the past five years NSW DPI has produced community

information brochures, posters and stickers detailing identification information for Black Rockcod, best practice handling techniques for releasing the species when incidentally caught and encouraging reporting of sightings. A key part of this recovery plan is to maintain and enhance these initiatives to ensure community support and involvement in the recovery and long-term conservation of Black Rockcod.

There is a need to further disseminate information to a range of stakeholders including anglers, community groups, relevant councils, planners and government organisations regarding the vulnerable status of Black Rockcod, the threats to its recovery and recovery activities. This can assist in raising the profile of the species and in minimising adverse impacts resulting from human activities.

7. Recovery objectives and performance criteria

7.1 Recovery plan objectives

The overall objective of this recovery plan is to prevent the extinction and ensure the recovery and ongoing viability of Black Rockcod populations in NSW. The plan aims to achieve recovery of the species to such an extent that it can eventually be de-listed from Schedule 5 of the FM Act.

The specific objectives of the recovery plan are to:

- mitigate moderate and high risk threats to Black Rockcod;
- initiate and support scientific research to increase knowledge of the distribution, abundance, reproductive biology, life history, ecology, migratory patterns and genetics of Black Rockcod;
- monitor fishery management strategies where necessary to reduce potential for interaction with Black Rockcod (either directly or indirectly);
- establish an on-going monitoring program to document the status of Black Rockcod populations and their habitats and to evaluate the effectiveness of recovery actions;
- provide enhanced compliance and protection for important Black Rockcod habitats;
- educate the community about the identification of and 'best practice' catch and release methods for Black Rockcod, increase awareness of the status of and threats to Black Rockcod populations, and enhance community support for recovery actions; and
- improve understanding of the threats to the survival of Black Rockcod and contribute to management actions to ameliorate identified threats.

7.2 Performance criteria

The long term success of the recovery plan would be assessed against the criterion that:

- the status of Black Rockcod is de-listed from the schedules of the FM Act within 20 years.

In order to evaluate whether the species has recovered to the extent that it can be de-listed it will be necessary to develop a range of detailed, scientifically sound recovery criteria for the species. These recovery criteria will be informed by the results of research on reproduction, age, growth and mortality, which are needed to estimate the rate of increase (or decrease) of the population. These data could be used to document the recovery of Black Rockcod populations in NSW waters and the success of the recovery plan. In the absence of detailed biological and ecological information for Black Rockcod in NSW waters, these criteria can only be developed as pertinent data become available. Thus, the research actions required to obtain this information are given a high priority. To provide some form of criteria for evaluating the short term and ongoing effectiveness of the recovery plan, each action will include a timeframe that can be reported against during and at the time of major statutory review (10 years from the date of publication) of this recovery plan.

8. Recovery actions

The following recovery actions have been selected in a manner and order to best respond to the risk analysis of threatening processes. The analysis identified methods of hook and line fishing that are bottom-set and use bait (e.g. setlines, handlines) as posing the highest risk to Black Rockcod; however, it is not practical or desirable to prohibit those forms of fishing without additional information. In particular, as the KTP refers to '...areas important to the survival...' of Black Rockcod, then it follows that those areas must first be identified before any mitigation actions can be proposed or implemented. The analysis also identified significant information gaps with respect to the biology and ecology of Black Rockcod. This information is required to help formulate ameliorative actions and to subsequently determine the effectiveness of those actions. As a result research activities are assigned a high priority in this plan.

8.1 Research and investigation activities (RIA)

Objective 1:	**Determine the distribution and abundance of Black Rockcod in NSW**
RIA 1:	Conduct and/or facilitate targeted surveys to determine the current distribution and abundance of Black Rockcod in NSW waters. Use the information to complement Objective 2 and 3.
RIA 2:	Continue to monitor the distribution and abundance of Black Rockcod at important sites to inform population status and to assist in determining the effectiveness of recovery actions.
Responsibility:	RIA 1 – 2: NSW DPI & MPA
Partners:	Universities, recreational scuba diving groups, spearfishers and CMAs
Timeframe:	RIA 1 – 2: Years 1 – 3, Ongoing
Objective 2:	**Initiate and support research into the biology and ecology of Black Rockcod**
RIA 3:	Initiate collaborative projects to investigate the biology and ecology of Black Rockcod (e.g. life history, habitat requirements, fecundity, reproductive biology, movements, response to climate change and water pollution *etc.*).
Responsibility:	RIA 3: NSW DPI
Partners:	MPA, Universities, FSC, CMAs, recreational scuba diving groups, OEH
Timeframe:	RIA 3: Years 1 – 5.
Objective 3:	**Initiate and support research into the impacts of high and moderate risks to Black Rockcod**
RIA 4:	Initiate research projects to examine the impacts of medium and high risk fishing activities on Black Rockcod. In particular, the effects of barotrauma from bottom-set baited hook and line fishing including setlining, trotlining, handlining, and droplining and the effects of hook and line fishing with soft plastic lures.
RIA 5:	Undertake research into 'best practice' release methods and gear types to reduce impacts on accidentally caught Black Rockcod, particularly from barotrauma.
RIA 6:	Undertake research into the impacts of climate change on Black Rockcod including for example rising sea levels, increasing acidity of marine waters, changing rainfall patterns and increasing global temperature.
RIA 7:	Initiate research projects to examine the precise impacts of water pollution on the biology and ecology of Black Rockcod.
Responsibility:	RIA 4 – 7: NSW DPI
Partners:	Universities, CMAs, MPA, OEH
Timeframe:	RIA 4 – 7: Years 1 – 3, Ongoing

8.2 Compliance and regulatory activities (CRA)

Objective 4:	**Identify important areas of Black Rockcod habitat and implement appropriate actions to recover Black Rockcod**
CRA 1:	Incorporate Black Rockcod issues into NSW DPI Annual District Compliance Plans.
CRA 2:	Maximise compliance activities at identified important sites (from RIA 1-3) and, where necessary, increase protection of Black Rockcod at these sites through regulatory controls.
Responsibility:	CRA 1: NSW DPI CRA 2: NSW DPI & MPA
Partners:	MPA, FSC
Timeframe:	CRA 1: Years 1 – 5 CRA 2: Ongoing

8.3 Management activities (MA)

Objective 5:	**Improve the collection of data on interactions between Black Rockcod and fishers**
MA 1:	Contribute to the design of observer programs in the Ocean Trap and Line Fishery and Estuary General Fishery to quantify the extent of interactions between these fisheries and Black Rockcod. Compile and disseminate existing records of the interaction of bottom-set baited hook and line fishing methods with Black Rockcod.
MA 2:	Address identification issues by developing and distributing practical identification materials for fishers and spearfishers and by making them available on the NSW DPI website.
MA 3:	Encourage fishers/spearfishers and managers to record the capture location and approximate length and weight of incidentally caught Black Rockcod in NSW to the Threatened and Protected Species Sighting Program, and via mandatory reporting arrangements for commercial fisheries and shark meshing contractors.
MA 4:	Collaborate with recreational and commercial fishing magazines to enhance publicity about Black Rockcod to improve species identification, the reporting of interactions with Black Rockcod, and to promote best practice techniques for handling and releasing incidentally caught Black Rockcod.
MA 5:	Collate and synthesise data collected through MA 1, 3 & 4 to quantify the significance of high and moderate risk threat interactions with Black Rockcod.
Responsibility:	MA 1 – 5: NSW DPI
Partners:	MPA, recreational and commercial fishing organisations
Timeframe:	MA 1-4: Years 1 – 2 MA 5: Years 2, 4, 6, 8, 10
Objective 6:	**Increase community awareness and support for Black Rockcod issues and recovery actions**
MA 6	Using the results from RIA 4 & 5 promote the use of fishing techniques and gear that eliminate or mitigate the impact of high and moderate risk activities on Black Rockcod. Specifically promote techniques and gear that avoid the capture of Black Rockcod and minimise impacts on accidentally caught fish.
MA 7:	Produce advisory material to assist in raising awareness of the identification of Black Rockcod and the protected status of the species and distribute this information to relevant stakeholders including fishing and dive clubs.
MA 8:	Work with commercial aquaria to increase public awareness of the status and threats to Black Rockcod.
MA 9:	Where appropriate, actively encourage community involvement in aspects of Black Rockcod recovery including for example, research and monitoring programs.
MA 10:	Support community groups involved in the monitoring and recording of the presence of Black Rockcod.
Responsibility:	MA 6 – 10: NSW DPI
Partners:	MPA, aquariums, recreational scuba diving groups, dive charter operators, community groups, CMAs
Timeframe:	MA 6 - 10: Year 1 and ongoing

Objective 7:	**Ensure that management authorities carry out appropriate planning and impact assessment and make management decisions which minimise impacts on Black Rockcod habitats**
MA 11:	Ensure that councils, government agencies and other relevant organisations are aware of the location of important areas for Black Rockcod, for example, by providing maps of known and potential habitat and the location of significant populations.
MA 12:	Provide other relevant information to support appropriate planning and impact assessment, e.g. Environmental Impact Assessment Guidelines.
MA 13:	Negotiate with local councils and industry groups regarding the type and scale of development near key areas known to support populations of Black Rockcod.
MA 14:	Consider information on Black Rockcod distribution, abundance and habitat preferences during development and review of Marine Park Zoning Plans.
Responsibility:	MA 11 – 13: NSW DPI MA 14: NSW DPI, MPA
Partners:	OEH, CMAs, local councils, MPA
Timeframe:	MA11 – 14: Year 1 & ongoing
Objective 8:	**Mitigate the impacts of water pollution on Black Rockcod**
MA 15:	Implement the NSW Diffuse Source Water Pollution Strategy to coordinate efforts to reduce diffuse source water pollution impacting on Black Rockcod habitat.
MA16:	Negotiate with relevant authorities to encourage the identification, assessment and modification of natural resource management plans and policies to minimise impacts on Black Rockcod habitats and water quality.
Responsibility:	NSW DPI
Partners:	OEH, CMAs, local councils
Timeframe:	MA15: - 16: Year 1 & ongoing

Acronyms:

NSW DPI – NSW Department of Primary Industries

MPA – Marine Parks Authority NSW

FSC – Fisheries Scientific Committee

CMA – Catchment Management Authority

OEH – NSW Office of Environment and Heritage

9. Implementation

The recovery activities outlined in this plan will be implemented according to the priority assigned to the threatening process and the immediacy of the need for the information to inform other recovery activities. For example, research into the biology and ecology of Black Rockcod is required to assist with formulating ameliorative actions and to determine the effectiveness of those actions. Hence, research activities for Black Rockcod are assigned a high priority. Implementation of recovery activities will also be prioritised according to the results of the risk analysis and therefore activities addressing high risk methods to Black Rockcod (e.g. hook and line fishing that are bottom-set and use bait) will also be assigned a high priority for implementation.

The main costs associated with the implementation of this recovery plan relate to habitat protection, research, monitoring and community liaison and education. Many of these costs will be met by NSW DPI and other government departments or funded through external grant programs such as 'Caring for our Country' or Recreational Fishing Trusts. Wherever possible, recovery activities for Black Rockcod will be linked to existing government or community programs (such as Fishcare) to avoid duplication.

10. Monitoring, evaluation and review

The overall performance criteria of de-listing Black Rockcod from the schedules of the FM Act will be the primary measure used to assess the success of the actions within this plan.

Progress in implementing this recovery plan will be evaluated and reported annually to Parliament and triennially in the PAS review. Summary information will include details of implementation activities, investment, program outcomes, and review against the performance criteria.

The recovery plan will be subject to major statutory review within 10 years of the date of publication.

11. Social, economic and cultural issues

Potential social and economic impacts have been considered during the development of this recovery plan, and the objectives and actions have been formulated with the aim of minimising potential adverse impacts.

The main social and economic effects are likely to result from the costs of its implementation and future research work that is needed to be undertaken. Overall, however, the effects of the recovery plan are expected to be positive. Continued liaison with fishers, divers and the community will help to minimise any social effects arising from the conservation of Black Rockcod.

12. Further information

Copies of the recovery plan and additional information can be obtained from:

NSW DPI
Aquaculture, Conservation & Marine Parks Unit
Port Stephens Fisheries Institute
Locked Bag 1
Nelson Bay NSW 2315
Ph: (02) 49821232

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Appendix 1 - Required contents of a recovery plan

Extract from NSW *Fisheries Management Act 1994*, Part 7A

220ZN Contents of recovery or threat abatement plans

(1) Recovery plans

A recovery plan must:

a) identify the threatened species, population or ecological community to which it applies, and

b) identify any critical habitat declared in relation to the threatened species, population or ecological community, and

c) identify any threatening process or processes threatening the threatened species, population or ecological community, and

d) identify methods by which adverse social and economic consequences of the making of the plan can be minimised, and

e) state what must be done to ensure the recovery of the threatened species, population or ecological community, and

f) state what must be done to protect the critical habitat (if any) identified in the plan, and

g) state, with reference to the objects of this Part:

   (i) the way in which those objects are to be implemented or promoted for the benefit of the threatened species, population or ecological community, and

   (ii) the method by which progress towards achieving those objects is to be assessed, and

h) identify the persons or public authorities who are responsible for the implementation of the measures included in the plan, and

i) state the date by which the recovery plan should be subject to review by the Director.

Appendix 2 - Risk analysis methodology

1. Risk analysis framework and terminology

Risk analysis is the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects (AS/NZS 4360). Risk analysis is an iterative process that has three main steps: risk assessment, risk management and risk communication (see Figure A1). The process is intended to provide insights about sources of risk ('threatening processes' in the case of a threatened species) and their potential impacts, which then enables managers to take action to mitigate the threats to avoid undesirable outcomes.

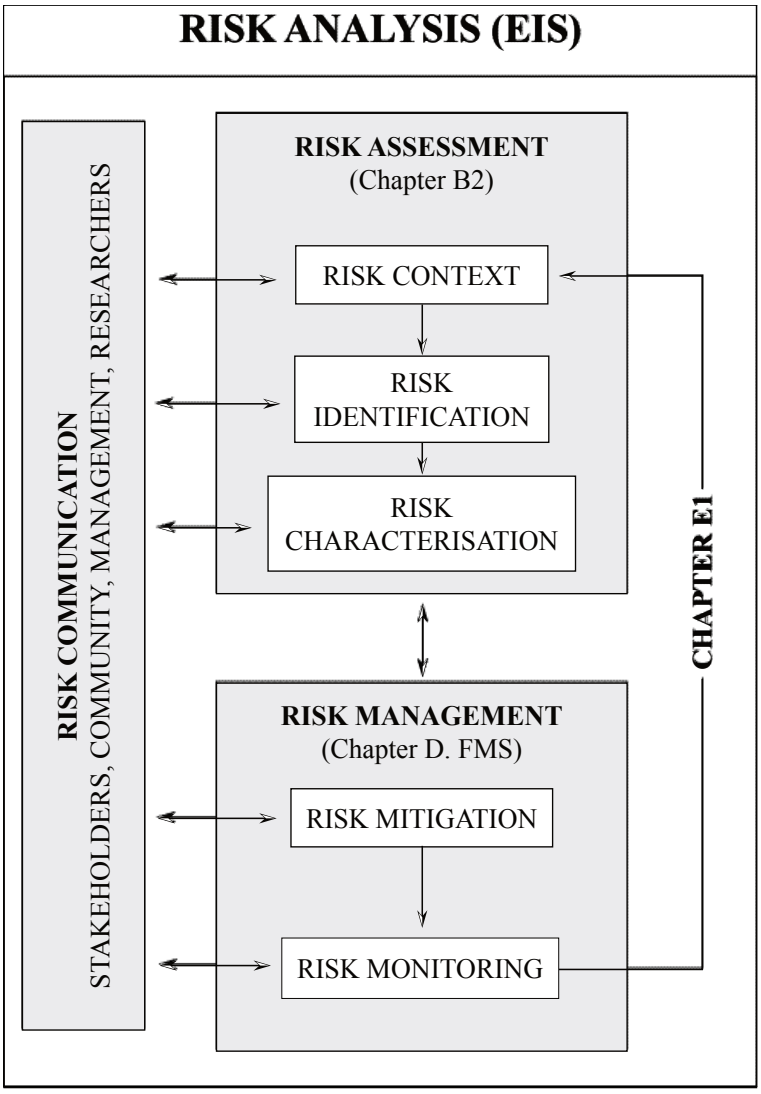

Figure A1 Framework of the risk analysis.

Risk is defined as the probability or likelihood of an undesirable event happening. This definition requires that an *a priori* definition of consequence be given for the undesirable event that is being analysed. In this way, the definition of risk combines the consequence and likelihood of the undesirable event and avoids the confounding problem characterised by other definitions used in qualitative assessments that determine risk by multiplying likelihood and consequence.

1.1 Risk assessment

Risk assessment is the first main step in the risk analysis process. It contains three parts: risk context, risk identification, and risk characterisation.

1.1.1 Risk context

Risk context is the first step in risk assessment and establishes the structure and scope of the analysis and the criteria against which risk will be assessed. It also identifies stakeholders and defines the communication and consultation policies. The context can be clearly defined by specifying three main elements:

- The risk that is to be analysed (which requires a description of the undesirable event that is to be avoided and the consequence of that event);
- The relevant temporal extent of the risk analysis; and
- The spatial extent of the risk analysis.

1.1.2 Risk identification

Risk identification is the second part of risk assessment. The aim is to generate a comprehensive list of the sources of risk. In the case of a threatened species, this will usually be a list of the recognised threatening processes for that species as well as other processes or factors that have been identified since its listing. This can be done using a variety of methods that include: literature reviews, examination of historical records, expert panels, and stakeholder consultation. The results of this risk identification step are often presented as lists, tables, decision factor hierarchies (e.g. Saaty 1980) or component trees (e.g. Fletcher et al. 2002).

1.1.3 Risk characterisation

Risk characterisation is the third part of risk assessment. For the purposes of this assessment, the aim of this part is to prioritise the various sources of risk (i.e. threatening processes) so as to identify the primary threat impeding the recovery of Black Rockcod. This will be done by assigning scores from 1-3 for each criterion and summing them to produce an overall score of the risk posed by each threatening process.

1.2 Risk management

Risk management is the second step in the risk analysis process. Risk management contains two parts: risk mitigation and risk monitoring.

1.2.1 Risk mitigation

Risk mitigation aims to minimise the risk of the undesirable events defined in the risk context. This is done by implementing regulatory and/or non-regulatory (e.g. code of practice) recovery actions that will remove or reduce the pressure imposed by each threatening process. Priority recovery actions are targeted at primary threatening processes to maximise the likelihood of species recovery.

1.2.2 Risk monitoring

Risk monitoring aims to collect information to determine whether implementation of recovery actions implemented during the risk mitigation phase were effective in minimising the risk of the undesirable event. Risk monitoring uses performance criteria or indicators and may include the use of trigger points. Risk monitoring is a valuable and important tool as it both validates recovery actions that have been effective and highlights processes that need revised recovery actions when previous initiatives have been ineffective.

There should be a readily identifiable link between the threat, recovery actions and their performance criteria, which need to be measurable and interpretable (i.e. any changes can be unambiguously interpreted as a result of the recovery action). Risk monitoring provides an appraisal of recovery actions and an opportunity to modify recovery plans in a timely manner.

1.3 Risk communication

Risk communication provides the basis for information flow between stakeholders, managers and scientists. Risk is communicated in several ways including by:

- Development, statutory consultation and implementation of the recovery plan,
- Implementation reporting processes,
- Advisory and community education materials, and
- Interactions with fishery management strategies.