ASSESSMENT OF THE SUSTAINABILITY OF SELECTED FISH SPECIES MARKETED IN NEW SOUTH WALES:

a report to OceanWatch Australia Ltd.

- Robert Kearney, Emeritus Professor of Fisheries, Institute of Applied Ecology, University of Canberra. April 27, 2009.

Terms of Reference for this Report (from OceanWatch)

"to undertake the task of producing a précis description of the status of the stocks for five identified species based on the Scoping Document from the Stakeholder Scoping Workshop.
The five species are identified as follows;
• Orange Roughy
• Yellowtail Kingfish
• Mulloway
• Yellow Fin Bream
• Eastern Sea Garfish"

The Status of the Stocks of the Five Species (and issues that affect their sustainability, both as species and as seafood).

Executive Summary of the Five Assessments

- ***Orange Roughy***

The limited catches that are taken from the few fisheries that currently exploit orange roughy in Australia have been rigorously assessed. These assessments have been accepted by the relevant conservation agency to confirm that the fisheries for orange roughy are ecologically sustainable under the current management regime, but the status of the species as 'conservation dependent' confirms that continue wise management is essential. Not only do current Australian fisheries not pose a significant threat to the long-term survival of the species, but they appear to be appropriate to ensure the recovery of previously overfished populations.

Most of the orange roughy consumed in Australia is captured in fisheries in New Zealand. Even though several of the many stocks of orange roughy in New Zealand have been reduced to levels below that which would produce the maximum sustainable yield the management of the sustainability and eventual recovery of these stocks appears to be in hand. The current management of this species in New Zealand is, like in Australia, an economic, fisheries management issue and not one of conservation of the species. Even the exploited orange roughy stocks are maintained at levels well above those that would represent any concern for the sustainability of the species and many areas remain unexploited.

- ***Yellowtail Kingfish***

Current indicators are that this species is demonstrating a classical recovery after having been overharvested to an extent which reduced the economic and social returns from the numerous fisheries but did not seriously threaten the sustainability of the species or even the level of recruitment to the fisheries. The overfishing that did occur more than a decade ago triggered additional management that appears to have corrected the problem. The history of the exploitation of this species provides an excellent example of effective management response to growth overfishing before a conservation issue arose. The status of the stocks of kingfish in NSW continues to improve and there is no known current threat to the sustainability of this species and the fisheries based on it.

- ***Mulloway***

There are several indicators of recent declines in catches of mulloway and fishing does appear to be implicated. However, other possible causes, such as disease, pollution and habitat destruction cannot be discounted. The wide distribution of the species around Australia and in the broader Indo-Pacific region represents insurance for the sustainability of the species. Current declines are indicative of growth overfishing that does not threaten the sustainability of the species in NSW, but clearly must be corrected if the economic and social returns from the exploitation of the species are to be optimized and any possible consequences of reduced populations of an apex predator constrained.

- ***Yellowfin Bream***

Considering the progressive declines in the available nursery habitats for bream, the continuing degradation of many of NSW estuaries and the resultant obvious fish kills and far less obvious sub-lethal insidious effects of pollution in many forms it is remarkable that the stocks of yellowfin bream have remained so apparently healthy. Current fishing practices are very clearly not a threat to the sustainability of the species or even to the sustainability of total catches.

- ***Eastern Sea Garfish***

Eastern sea garfish is reported to be overfished and in accordance with the Government requirement for any species that is overfished a recovery program has been developed and implemented. The existing recovery program for eastern sea garfish is currently under review, but it already appears that the species is recovering, albeit only slowly, under the revised management arrangements of the existing plan. The species does not appear to be in immediate danger of further declines. In fact the best available evidence, although limited, suggests that current catches are sustainable and that the status of the stocks is likely improving.

BACKGROUND

In the Scoping Report for the OceanWatch "Sustainable Seafood Information Portal" the key statement on the definition of sustainable seafood is, "*We define sustainable seafood as from sources, whether fished or farmed, that can maintain or increase production into the long-term without jeopardizing the structure or function of affected ecosystems*". Even though the primary objective of this current project is consideration of the status of the wild stocks of the five species listed in the Terms of Reference at least two of these species, mulloway and yellowtail kingfish, and to a limited degree a third, yellowfin bream, are produced from both capture fisheries and aquaculture. Therefore, while acknowledging the definition in the Scoping Report, in keeping with the terms of reference for this review, the bulk of this report concentrates on the assessment of the status of the species in the wild and of the sustainability of the capture-fisheries based on them. However, in order to fully comply with the Scoping Report's definition of sustainable seafood consideration is given to both the "*fished or farmed*" forms.

As the factors that relate to the sustainability of aquaculture are generic (they are much less species specific than assessments of the stocks of individual species in the wild) they have been collectively discussed at the end of the Introduction. The assessments of the stocks in the wild of the five chosen species that follow specifically cover the capture fisheries of each species.

In order to truly test the difficulty of evaluating the sustainability of common fish species marketed in NSW the species covered in this review were deliberately chosen to include species known to be amongst the most 'overfished' in NSW: the two most 'overfished' (considered to be 'growth overfished' and possibly even 'recruitment overfished') species in marine fisheries managed by NSW are mulloway and eastern sea garfish. Yellowfin bream was included as a typical estuarine species that has demonstrated great resilience to heavy commercial and recreational fishing pressure.

INTRODUCTION

Capture Fisheries

In accepting the definition of sustainable seafood provided in the Scoping Report, and considering its relation to assessment of the sustainability of fisheries in NSW and of fish that may be caught and/or marketed in this State, two of the principles contained in that definition require elaboration:
First, sustainability is about the 'long-term'. Fish stocks in many areas have, without human intervention, fluctuated widely over geological time scales; the record of periodic displacement of sardines with anchovies and *vice versa* in California and South Africa contained in scale deposits in sediments dating back more than 100,000 years are two well documented examples. At times when one species is not in the ascendency its stocks may be reduced to a small percentage of its more abundant levels. Australia's current conservation criteria, which are based in part on declines in population levels, may well qualify the reduced species during each period as threatened or even endangered. Modern

fishing has increased the frequency of species displacement, such as the ‘flip-flop’ phenomenon in sardines and anchovies. The degree to which fishing impacts ecosystem balance and the degree to which this is a long-term problem are both poorly understood and somewhat contentious. Fish populations do fluctuate naturally and fishing can trigger similar change that is not necessarily of concern to the future of the species. It is noteworthy that the Californian and South African sardines and anchovies referred to above have tended to pass into a state of equilibrium at lower population levels while the other is in the ascendency and that populations of the species in question continue to bounce back with changes to the fisheries management arrangements. Notable exceptions occur when there is gross mismanagement of total fishing effort, normally in developing countries with inadequate governance and an inability to prevent illegal fishing, or when the management of shared stocks is thwarted by failure of international arrangements to restrain effort (‘the tragedy of the commons’), such as in many fisheries, including those for sardines and anchovies, managed by the European Union (EU).

Many species of fish are harvested in Australian commercial fisheries and there is no doubt the total biomass of stocks of most of them have been reduced as a result of fishing, often considerably. However, the long-term record of the resilience of fish and crustaceans to fishing is remarkable. It is often argued there has never been a species of fish driven to extinction from fishing. Indeed it is difficult to find a single species that is harvested in Australia that is serious danger of extinction as a result of fishing. On the other hand there are many examples of successful fisheries management to not only conserve the viability of the species, but also to facilitate the restoration of overfished stocks to levels more aligned with economic efficient and sustainable use of resources (ESD). Australia has had much less success in conserving terrestrial species of animals, birds and plants, or even in restoring fish stocks that have been threatened by non-fishing activities, most notably in our freshwater environments.

The term ‘over-fished’ in relation to Australian fish species almost exclusively describes stocks that have been assessed to be below the level that will produce the maximum sustainable yield (or the more desirable in at least some cases, maximum or optimum economic yield). As such ‘over-fished’ is more often an indicator of economic or social mismanagement with short-term implications. It is seldom an indicator of long-term environmental disaster. This is most evident in the marine fisheries managed in NSW where only two of the 60 species considered in the official DPI “Status of Fisheries Resources”, mulloway and eastern sea garfish, are listed as ‘overfished’ to a degree where there is concern about the levels of recruitment. Both these species are discussed below. It must be noted that several species found off NSW but taken in Commonwealth managed fisheries, most notably gemfish and orange roughy, are classified as ‘overfished’ to the extent of concern about recruitment: orange roughy is later discussed.

The second key point in the Scoping Report definition of sustainability is consideration of impacts on “the structure or function of affected ecosystems”. Here several issues warrant mention. While it is acknowledged that fishing can adversely impact non-target species and associated ecosystems Australia has progressively adopted a more ecosystem based approach to fisheries management. As such the management of the impacts of fisheries beyond those on target species feature more prominently is fisheries management plans. Obvious examples include the pioneering development and implementation of effective measures to reduce interactions with sea-birds in long-line fisheries and the impressive achievements in the management of unwanted by-catch in prawn-trawl fisheries. Also, most management plans for fishing practices that are known to have deleterious impacts on associated benthic species or habitats, such as board-trawling for fish, include total prohibition of access to key areas (the orange roughy fishery discussed below is a relevant example). In general in Australia, where there are threats from fishing to the structure or function of aquatic ecosystems these are managed (this is not so in all countries). However, most significantly, the threats from non-fishing activities to the ecosystems that support fisheries are largely inadequately managed, or not managed at all, even in Australia. This is most obvious in freshwater systems, estuaries and near-shore coastal waters. The devastating effects on aquatic ecosystems from pollution in many forms, inadequately controlled extraction of fresh water, inappropriate urban and agricultural development, government infrastructure projects (such as airport runways and shipping terminals) and introduced aquatic animals, plants and diseases continue without adequate management. These are the real threats to the structure and function of aquatic ecosystems and to the sustainability of the species dependent upon them.

The background information in the Scoping Report also draws attention to the key issue that "despite significantly improved fisheries management arrangements, the consumer generally was not aware of such changes". Not only are consumers not aware of the current status of fisheries management arrangements in Australia but they continue to mislead by ill-informed inferences from overseas examples that are simply not relevant to the sustainability of Australia's fisheries. Examples include unqualified references to; destruction of fisheries resources in countries that make no attempt to effectively manage fisheries, failure of international agreements to control fishing practices by rogue states, or where destructive practices such as dynamiting and cyaniding of reefs are classified as fishing.

In addition to not being aware that almost all Australian fisheries are ecologically sustainable, Australian consumers are also not generally aware that most fishing is remarkably environmentally benign. This is particularly so when fishing is compared to Australia's other form of primary production of food, agriculture. Fishing does not begin by clearing native vegetation, ploughing the surface soil and then culturing introduced species. Nor are marine ecosystems constrained by the lack of connectivity, such as that which makes the conservation of remnant pockets of undisturbed terrestrial ecosystems particularly difficult; it is actually more difficult to prevent connectivity in marine ecosystems than it is to obtain it. But even where fishing does modify environments it must be acknowledged that food security is a critical issue and eating seafood, like eating non-native meats, vegetables and grains, is very much part of Australia's culture and way of life. There is increasing demand for seafood for both health and life-style reasons and it is the sustainability of meeting that demand that is threatened. Australia's seafood sustainability is threatened much more by the ever-increasing non-fishing impacts on the marine environment than it is ever likely to be by current or even past Australian fishing practices.

Consumers are also not aware that marketers, such as the Sydney Fish Market, are required to only sell fish that is caught legally. This is not an inconsiderable issue as the legal sale of fish involves it having been caught and landed by licensed operators in accordance with relevant State and/or Commonwealth fisheries and environmental legislation and mandated practices. These include regulations such as prescribed allowable catches and approved fishing practices and regular and repeated assessments which are required to confirm ecological sustainability to standards set by both State and Commonwealth governments.

Aquaculture, and the sustainability of products.
(*The information provided below is based largely on information and data provided by Dr Geoff Allan, Research Leader, Aquaculture and Director, Port Stephens Fisheries Centre, NSW Department of Primary Industries. However the interpretations of that data are entirely the author's).*

Aquaculture of marine fish has the potential to impact the sustainability of the species being cultured and the aquatic environments in, and adjacent to, areas in which they are cultured. Under the right conditions, hatchery produced fingerlings can contribute to enhanced production of both commercial and recreational fisheries. Aquaculture production of mulloway and kingfish for direct human consumption, currently occurring in sea cages in NSW, South Australia and Western Australia, does help supply market demand and may even be beginning to help alleviate pressure on wild stocks.

Concerns about the environmental sustainability of marine finfish aquaculture include: 1) the use of aquaculture diets containing fishmeal produced from other fish species, 2) potential negative impacts on genetic diversity of wild stocks, 3) negative environmental impacts of effluent from uneaten feed, faeces and other residues, and 4) potential introduction of new diseases or concentration of naturally occurring diseases.

1. The use of fishmeal in aquaculture diets
The basis for the concern about aquaculture diets based on fishmeal is most often that more fish are used in the form of fishmeal in the feeds than are produced through aquaculture. As a result it is feared by some that expanding aquaculture production could increase the fishing pressure on species used to produce fishmeal, to the detriment of the sustainability of those species. These concerns are not supported by the relevant science. The bulk of the world's fishmeal is made from small, relatively short-lived pelagic species that are harvested in the millions of tonnes. There have been several instances when the primary species have been overexploited to the point that total fisheries production has declined or that species replacement has occurred (the change in balance between anchovies and sardines discussed in the Introduction is a case in point), but never at any stage has the sustainability of any of the species been considered to be seriously endangered. Alternatively, fishmeal is manufactured from residues from fish

processing, including bones and offal. In such cases the sustainability of the species being used is not impacted by the environmentally responsible use of residues.

To understand the relationship between the mass of fish used as feed and the resultant production of fish it is necessary to consider the primary factors in fishmeal production and the utilization of fishmeal in aquaculture and other applications. Approximately four kg of wet fish (e.g. small pelagic baitfish such as pilchards, anchovy or mackerel) are used to produce 1 kg of fishmeal. The fishmeal content of aquaculture diets varies considerably between different species and feed companies. It ranges from zero to about 50% with contents of around 25% for marine carnivorous species being common. For the aquaculture of marine fish, such as mulloway and yellowtail kingfish, the typical food conversion ratio (FCR; weight of feed used/wet weight of fish gain) are below 1.5:1 and for some species below 1:1. With fishmeal at 25% of the diet and 4 kg of fish to produce 1 kg of fishmeal, and an FCR of 1.5:1, 1.5 kg baitfish would be used in the production of 1 kg of the cultured fish.

Aquaculture generally has the lowest FCR (i.e. it is the most efficient) for all uses of fishmeal as food for vertebrate animals, with comparative rates for poultry, (2:1), pigs (2.5-4:1) and beef (7-10:1) being higher, primarily because land animals need comparatively more energy for heat generation, protein catabolism, posture (it takes considerable energy to stand up all day but very little to float if you are neutrally buoyant like fish) and locomotion.

An improved understanding of nutritional requirements and research to find alternative protein sources (e.g. terrestrial protein ingredients including grains) and how to make them more digestible by fish have greatly reduced the fishmeal content in aquaculture diets. Continuing reductions will occur, but as for agriculture the conversion of one form of food into another will always be at some cost.

Despite global aquaculture production increasing from 26 million tonnes in 1994 to 60 million tonnes in 2006 and commercial aquaculture feeds production increasing from 4 million tonnes to 23 million tonnes in the same period, the production of fishmeal has remained relatively static at between 5-6 million tonnes. The increased use of fishmeal for aquaculture was largely at the expense of the amount of fishmeal used for other farmed species, most notably poultry.

The competing uses of fishmeal, fish oils and other by-products of industrial scale (‘reduction’) fisheries include not only as human food and animal feeds but also as agricultural and home garden fertilizers, pet foods and as bait and berley in recreational and commercial fisheries. If fishmeal is not used for aquaculture the pressure on fish stocks used to make fishmeal will not be reduced, even if it should be. There will however be an environmental disadvantage if the use of fishmeal is transferred to other, less efficient processes of converting it to other forms of human food. In any case there is absolutely nothing wrong with utilizing the sustainable harvest from one fishery as food for another. The key issue is that the harvests are ecologically sustainable and the species are not threatened by the fishing activity. The anchovies and sardines that support the bulk of the world's fishmeal production are taken in very large, long-established fisheries, most of which have proven to be sustainable at around current catch levels. It is actually when small pelagic species such as sardines and anchovies are targeted for the more lucrative fresh fish market that their sustainability becomes more questioned. This has proven to be particularly so when the jurisdiction for the management of these species is shared across national boundaries, such as in the EU, as discussed above where inadequate management and consequent overexploitation are the norm.

Most of the world's reduction fisheries take quantities of small species that are much greater than can be utilized fresh or even processed for direct human consumption. If demand for human consumption for the species in question increases, the price of these species will increase and more fishmeal will be replaced in aquaculture diets.

2. Impacts on genetic diversity

The genetic composition of fish populations is shaped by environmental factors and each species is evolved by natural selection. Genetic diversity within and among individuals facilitates adaptation to natural environmental change. There is risk that genetic diversity may be lost as a result of habitat degradation or if overexploitation by excess fishing was to occur. In addition, aquaculture can create a risk to genetic resource management unless broodstock are carefully managed, escapees from sea cages minimised and the potential for interbreeding of aquacultured fish with wild stock minimised.

Most marine carnivores currently farmed in Australia (with the exception of salmonids) are produced from broodstock originally sourced from native local populations and to date there has been little genetic alteration. Careful attention has been paid in commercial and government hatcheries to ensure that broodstock are sufficiently numerous and genetically variable to minimise the chances of inbreeding. Escapees from aquaculture establishments are minor. However, as aquaculturists increasingly implement 'genetic improvement' programs (mainly using selective breeding for improvement of production related traits), the potential for genetic impacts on natural resources could increase if management measures do not keep pace with developments. To reduce genetic risks, new technology to culture sterile populations has been developed and will become widely available in the near future. Adherence to the broad policy of producing juveniles for stock enhancement from broodstock sourced from near planned release sites also helps to minimise the genetic risk from stock enhancement programs.

3. Impacts of effluent from sea-cage aquaculture

Potential environmental impacts from sea cage farming of marine species include an increase in dissolved nutrients, biodeposition, primarily from uneaten feeds, faeces and fouling of sea cage infrastructure and the unintentional release of therapeutics and other compounds (e.g. those used for biofouling control). There is an enormous body of data now available, mostly from salmon aquaculture, that demonstrates that problems associated with dissolved nutrients are minimal and generally undetectable in well-selected farming sites. Similarly, while studies show that concentrations of some therapeutics can be measured in the sediments under sea cages, widespread adverse effects on either pelagic or benthic species have not been recorded.

Scientific evidence demonstrates that the greatest environmental risk from wastes from sea cages are associated with changes in the sediments below cages. Importantly, repeated long-term monitoring of sea cage sites has shown that changes in the sediment are confined to the immediate vicinity of the sea cages and that when cages are removed, chemical and biological recovery of the sediments under and around sea cages occurs naturally, without targeted human mitigation. Recovery can occur within weeks or months at some sites and within two to three years at others. Recovery occurs more quickly in warm temperate or tropical areas than the colder temperate areas where salmon are cultured and where the bulk of research has been conducted.

4. Potential problems of disease transmission

Threats to cultured fish arise from diseases, predators and pests present in association with the aquaculture activities or with wild fish present in the area. Threats to wild fish from aquaculture arise from translocation of diseases and pests and potentially from amplification of naturally occurring diseases. In Australia, translocation of new, exotic species for aquaculture is specifically prohibited by most state and Commonwealth legislation. Strict protocols for translocation have been implemented in most jurisdictions, minimising the potential for introduction of diseases in association with transfers of stock.

There is a possibility that aquaculture may increase the risk of the spread of disease by concentrating organisms thus making them more susceptible to disease, or by making disease more readily transmitted among the cultured, concentrated population. This risk does receive ongoing management. Fish held in aquaculture establishments are far more frequently and thoroughly inspected than their counterparts in the wild. Aquaculture therefore can play a role in the early detection and management of diseases. Improvements in diagnosis of marine diseases is making rapid screening a reality for many diseases and thus greatly improving the management of risks, but this research is still in its infancy.

There will always remain some risk to native aquatic flora and fauna from the introduction of diseases. The most likely vector for the transmission of diseases of concern are ballast water and organisms on the hulls of international and inter-state shipping and the importation of live aquatic plants and animals via household aquarium trade and associated activities. Adequate and appropriate quarantine measures, including relevant protocols for aquaculture, which keep abreast of international developments, are essential. Restriction on the movement of live organisms into Australia is likely to remain the most essential requirement. It is most unlikely the retail trade of fish products from aquaculture will represent a significant vector for the spread of disease into and within Australia.

Orange Roughy *(Hoplostethus atlanticus)*

(*The information below is the interpretation by the author of information drawn from several sources, including: The Report of the Threatened Species Scientific Committee, Commonwealth of Australia, to the Minister for the Environment (18/05/2006),AFMA Orange Roughy Conservation Program, AFMA Management Arrangements for Orange Roughy in south-eastern Australia, ABARE Fisheries Statistics, The New Zealand Seafood Industry Council Export Database, the Review of Sustainability Measures and Other Management Controls for 1 October 2008 from the New Zealand Ministry of Fisheries and the 'Fact Sheet' for New Zealand Orange Roughy by the New Zealand Ministry of Fisheries and the DeepWater Group*).

Orange roughy are found worldwide in temperate regions of the Atlantic, Indian and west Pacific oceans, and have been fished commercially off New Zealand, Australia, Namibia and Chile. Other (more sporadic) fisheries occur in the North-East Atlantic and the Southern Indian Ocean. In Australia, orange roughy are known to occur in deep waters, between 700 and 1800 meters, from offshore of Fraser Island in Queensland, southwards around Tasmania, and across the Great Australian Bight to the North West Shelf region of Western Australia. They also occur on seamounts and ocean ridges east of Lord Howe Island, and south of Tasmania in the South Tasman Rise, which straddles the Australian Exclusive Economic Zone (EEZ) and extends into high seas, and in the Indian Ocean west of Western Australia. The species is fished commercially, and relatively intensively, at some locations throughout its range, but the bulk of the area over which it is distributed, such as off the coast of NSW, is not fished.

Although there is ongoing debate about the structure of the Australian orange roughy population, there is evidence to suggest that besides spawning migrations, which are well documented, orange roughy in Australia are thought to be relatively sedentary with probably little short-term movement between each of the known areas where they are relatively abundant. It is therefore believed that the Australian orange roughy population may be comprised of a number of sub-populations. Genetic research also indicates some distinction between the New Zealand and Australian orange roughy populations.

The earlier AFMA management strategy for orange roughy allowed for the 'fishing down' of the species to 30% of the pre-fishery biomass to be followed by an annual Total Allowable Catch (TAC) that had been assumed to be sustainable. The TAC was based on the available information on the stock size and the relevant biological characteristics of the species, particularly the natural mortality of the species and its reproductive capacity. In the case of orange roughy the longevity of individuals of the species, perhaps of the order of 150 years, coupled with their not reaching sexual maturity until approximately 25-30 years of age, are major factors which influence the estimate of natural mortality and subsequently constrain the TAC to a relatively small proportion of the available total biomass of the species.

Assessments conducted over the past several years indicate a very high probability that the current biomass of orange roughy is below the prescribed level (30%) in most management sectors, apart from the Cascade Plateau, the Great Australian Bight and in the area of the Western Deepwater Trawl Fishery, where it is considered 'uncertain'. It is therefore apparent that the management of a deliberate reduction in stock levels to 30% of unfished biomass did not adequately constrain catches and actually resulted in a decline of over 70% in the orange roughy stocks that occur within many of the areas of the managed fishery. Without appropriate management, declines were likely to continue within these areas where fisheries continued to take more than the sustainable yield. The historical record of catch rates of orange roughy supports this likelihood.

Total allowable catches (TACs) were generally (in most management sectors) reactively reduced in response to the declining catches and did not appropriately constrain catches. Combined catch data for orange roughy show an overall decline in catch rate by around 90% since the peak landings between 1989 and 1992. Here it must be noted that peak catch rates occurred, as expected, during the fish-down period when biomass was being reduced from levels higher than that which would produce the long-term maximum sustainable yield.

In considering all the available scientific evidence the Commonwealth Threatened Species Scientific Committee (TSSC) advice to the Minister for the Environment (18/05/2006) concluded that orange roughy was eligible for listing as endangered as it met *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Criterion 1 - (Regulation 7.01) in that the species had *'undergone or is suspected to have undergone or is likely to undergo in the immediate future a severe reduction in numbers.'* Orange roughy did not meet the other four criteria for listing as endangered, but a species need only meet one of the five EPBC Act criteria to make it eligible for listing.

The recommendation in 2006 to the Minister that orange roughy qualified for listing was as clearly stated in the TSSC documentation, solely the result of meeting criterion 1, which the best science available at the time clearly indicated the species did meet. However, the TSSC was constrained in assessing the conservation status of orange roughy by being bound by criteria that had been derived directly from terrestrial management paradigms. They had never been modified to accommodate the contrasting biology and environmental conditions that characterise marine organisms, in particular fish such as orange roughy, which are heterogenously distributed over an enormous area, much of which is not fished for orange roughy or other species.

The Department of Environment and Heritage realized the limitations for marine species of the criteria as they had been set and that consequently, inappropriate management recommendations could be mandated if they were not carefully applied. The need for changes in the management process was particularly acute for marine species that were the subject of managed fisheries where population levels could undergo major reductions as part of deliberate and approved management strategies and where ongoing research was adequate to monitor changes in appropriate indicators of the status of the stocks. As a result a new category of classification, 'Conservation Dependent' was developed.

"A native species is eligible to be included in the conservation dependent category at a particular time if, at that time the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximized" (Environment Protection and Biodiversity Conservation Act 1999, s179(6)(b) Commonwealth of Australia, 2007). In 2006 orange roughy was listed as Conservation Dependent.

In response to this listing AFMA established the Orange Roughy Conservation Programme (ORCP). The ORCP was established with the aim to protect orange roughy from overfishing and to ensure that the species does not become vulnerable, endangered or critically endangered under the EPBC Act within a period of five years. The principal management strategies of the ORCP are closures of areas and depths to orange roughy fishing and progressive reductions in TACs to further restrict fishing. Specifically, the commercial fishery can now only target orange roughy in one zone, the Cascade Plateau, and in this area the biomass must be maintained above 60% of estimated virgin levels. The intent of this apparently very conservative biomass level is so that not only is this population protected but also the population is of such size as to ensure that fishing in this zone does not negatively impact the recovery of depleted populations in other zones, which assumes an interchange of fish between zones.

It is most significant that since the introduction of the new management program, the ORCP in 2006, not only have catches of orange roughy in all other zones been restricted to unavoidable by-catch, but that the actual catches in all zones have not reached the TAC in any year.

The logical conclusion for consumers of Australian caught orange roughy is that the limited catches that are taken from the remaining fisheries have been rigorously and repeatedly assessed by the relevant conservation agency to be ecologically sustainable. Not only do they not pose a significant threat to the long-term survival of the species, but they appear to be more than adequate to ensure the recovery of previously overfished populations.

The great bulk of the orange roughy sold in Australia is caught in New Zealand. Imports of roughy averaged approximately 1200 tonnes per annum in 2007 and 2008, the bulk of which was fresh and frozen skinned fillets which constitute between 28% and 29% of the weight of whole fish. These New Zealand imports therefore represent a landed catch of approximately 3000 tonnes of orange roughy per annum. The Australian total catch in the most recent year for which published data are available (2006/07) was 1129 tonnes. However, since that year catches have been considerably restrained by the ORCP to less than 700 tonnes per year, almost half of which is exported. It is therefore apparent that orange roughy consumed in Australia is about seven or eight times more likely to be of New Zealand origin that Australian. The sustainability of New Zealand orange roughy is therefore arguably of more relevance to Australian seafood consumers than is the sustainability of our own resources.

New Zealand has received international acclaim for the pioneering research and management of its orange roughy fishery (the industry levied contribution alone to orange roughy research and management has exceeded $NZ 100 million since 1990).

Management is based on a quota management system (QMS). The goal is to fish-down the initial biomass to the level (Bmsy) which, it is assumed, will support the maximum sustainable yield (MSY), and then to continue to sustainably exploit the resource while maintaining the remaining biomass at or above Bmsy, which is currently assessed to be at 30% (the same as the Australian target biomass) of the biomass that would be expected if there had been no fishing. New Zealand has eight separate orange roughy management areas each with a separate allowable catch that is set by the New Zealand Government.

Due largely to the difficulty in obtaining a precise understanding of the biology and behaviour of orange roughy and estimates of the status of the stocks of any deepwater fish, management of orange roughy in New Zealand has not been without its uncertainty and even mistakes. Several stocks have been fished to levels that have been assessed to be below 30% of unfished biomass. Three of these have since been closed to fishing to allow rebuilding.

The biggest and oldest orange roughy fishery in the world occurs on the New Zealand Chatham Rise, where during the fish-down period annual landings peaked at around 32,000 tonnes. This area continues to produce the bulk of New Zealand's orange roughy catch, even though the total allowable commercial catch (TACC) is being progressively reduced to approximately 9,000 tonnes. The current biomass of orange roughy in this one area has been assessed to be slightly in excess of 100,000 tonnes. At an average weight of 1.5 kg per fish this represents more than 66 million fish in this one fished population alone. As there are currently an assessed 70,000 tonnes (47 million fish) of orange roughy in the other fishery management zones, and an additional 18% of all of New Zealand waters in the depth range occupied by orange roughy are closed to all trawling, there is no need for concern about the impact of fishing on the sustainability of this species in New Zealand. Furthermore, although the relationship between fecundity and spawning success is tenuous, the all too common assertion that the reproductive potential of orange roughy has been damaged by fishing to the extent that the future of the species is threatened is not consistent with the basic numbers. Even though orange roughy is, when compared to other fish, not particularly fecund, each female still lays approximated 23,000 eggs per spawning, thus empowering the current biomass with enormous reproductive capacity of the order of a trillion eggs per spawning cycle (50,000,000 female fish x 20,000 eggs = 1,000,000,000,000).

Even though several of the many stocks of orange roughy in New Zealand have been reduced to levels below that which would produce the maximum sustainable yield the management of the sustainability and eventual recovery of these stocks appears to be in hand. The management of this species in New Zealand is an economic, fisheries management issue, not one of conservation of the species. Orange roughy stocks are maintained at levels well above those that would represent any concern for the sustainability of the species.

Yellowtail kingfish (*Seriola lalandi*)

(*Based largely on interpretation of information contained in Status of Fisheries Resources in NSW 2006/07 Scandol et al 2008 and discussions with researchers within NSW DPI)*

Yellowtail kingfish is a highly migratory, largely pelagic species that is distributed from southern Queensland southwards around to central Western Australia. It also occurs off Lord Howe Island, Norfolk Island, New Zealand and has been reported from New Caledonia. Tagging programs have shown many large scale movements (> 500km) including between NSW and New Zealand.

Kingfish appear to have been overharvested in NSW in the early 1990s, apparently predominantly by trapping, resulting in declining catches up to the late 1990s. Catches have tended to be variable, but marginally higher since the banning of trapping in 1996. Reported commercial catch-per-unit-effort has increased considerably, and relatively consistently, since 1996. Anglers have reported particularly good catches in 2008/09 in central NSW (Steffe, A. NSW DPI Fisheries, pers. com. Jan. 2009).

It is difficult to attribute the role of the recreational fishery in the decline of commercial catches from the mid 1980s to the mid 1990s. The recreational effort is known to have increased considerably since the 1980s and the current catch of between 120 and 340 tonnes per annum is from one to three times the commercial catch. There are no data on trends in the recreational effort or catch of sufficient precision to aid assessment of changes in the status of the stocks.

The species has been listed as growth overfished, but indicators of the status of the stocks derived from data from the commercial fishery suggest the stocks are increasing under existing management arrangements. There is no indication of recruitment problems for kingfish and there is even a suggestion of an increase in the number of medium sized fish in recent years.

Current indications are that this species is demonstrating a classical recovery after having been overharvested to an extent which reduced the economic and social returns from the numerous fisheries but did not seriously threaten the sustainability of the species or even the level of recruitment to the fisheries. The overfishing that did occur triggered additional management that appears to have corrected the problem. The history of the exploitation of this species provides an excellent example of effective management response to growth overfishing before a conservation issue arose. The status of the stocks of kingfish in NSW continues to improve and there is no known current threat to the sustainability of this species and the fisheries based on it.

Mulloway (*Argyrosomus japonicus*)

(*Based largely on interpretation of information contained in Status of Fisheries Resources in NSW 2006/07 Scandol et al 2008)*

Mulloway is a nearshore coastal (<100m depth) species that also occurs in estuaries and is found in Pacific and Indian Ocean waters surrounding Australia, Africa, India, Pakistan, China, Korea and Japan. In Australia, mulloway are distributed along the eastern, southern and western seaboards from the Burnett River in Queensland to North West Cape in WA. In light of its wide distribution the survival of the species is unlikely to be seriously threatened by habitat damage, pollution or over-fishing in any one area no matter how damaging such activities may be to localised populations and to the sustainability of individual fisheries based on them.

DPI considers mulloway in NSW to be significantly growth overfished with concerns about possible recruitment overfishing. There is no doubt that total commercial landings have collectively declined consistently and rather dramatically since the mid-1970s. There is also general, but not unanimous, agreement that the apparent availability of larger fish to the commercial sector has decreased considerably, particularly in recent years. The available size and age data on the composition of the commercial catch strongly suggests a marked decline in the proportion of larger and older fish in current catches compared to that in the periods 1986-1990 and 1994 -1999. Unfortunately, conclusions from this limited data set are confounded by the relative similarity of size composition data from current catches with that from the earliest period of available data, 1972 – 1975.

Against the trend of declines in indicators of the status of mulloway stocks, catch rates in the commercial hand-line fishery have remained relatively stable, or even increased slightly in the last fifteen years. Stability in catch rates would suggest that the drop in commercial catches is more closely related to decreased effort than to declines in total abundance. However, great caution is necessary when using catch rate data on species such as mulloway that aggregate episodically, as an indicator of even relative abundance. This is particularly so when the data are from a hand-line fishery.

Assessment of the combined implications of the limited and fragmented data from the commercial fishery is further confounded by the greatly increased recreational catch since the 1960s and the extremely limited information on this catch. The total recreational harvest of mulloway in NSW is estimated to lie between 100 and 500 tonnes per annum. As such it represents between two and ten times current commercial catches. Noting that the recreational targeting of mulloway, particularly for larger fish, increased markedly from about the 1960s it would appear that the recorded declines in the landings from the commercial fishery since that time could be compensated for by increased landings by the recreational sector.

Notwithstanding the uncertainty inherent in the limited available data the current indicators of the status of the stock of mulloway in NSW are concerning. The record of other closely related species (large croakers), where the size of the local populations has declined dramatically as a result of anthropogenic pressures, including degradation of estuarine nursery areas and fishing, over the extent of their distribution, is also worrying. However, the ability of even the largest species (*Bahaba taipingenesis*) to survive the intense human activities of China and Taiwan, albeit at tremendously reduced levels (Sadovy and Cheung 2003), confirms that the plight of mulloway in NSW is, at least for the immediate future, an economic, fisheries management issue and not a major concern for the conservation of the species.

It is not possible to eliminate disease and kills or impairment of juveniles from pollution, or habitat destruction, as causes of, or at least contributors to, the apparent decline in the commercial fishery for mulloway. There have been no reports of significant new diseases specific to mulloway and indeed disease may not be a factor in the apparent decline, however, over the time of the decline in commercial catches there have been known outbreaks of diseases such as redspot which impacts many species, and Californian herpes virus which reduced pilchard populations by an estimated 70%. In the absence of relevant testing of mulloway it is impossible to rule out disease as a factor that may have contributed to the decline in catches. On the other hand the degradation of estuarine habitats, insidious effects of chemical pollutants such as heavy metals and dioxins in key nursery areas and episodic fish kills in estuaries from deoxygenated and acidified water must have had, and continue to have, some negative effect on this and other estuary dependent species. It is also possible that pollution in estuaries may not directly cause the death of mulloway but may cause individuals to alter their behaviour, such as by not being able to use, or selectively avoiding, some estuaries or other previously important habitats.

In addition to targeted fishing mulloway are also taken as juveniles as by-catch in other fisheries, particularly prawn-trawl fisheries in estuaries and intermittently in some areas of near-shore ocean prawn-trawl fisheries. Obviously, reduction in any unwanted bycatch of this species must continue to be pursued. But the following factors have contributed to a decrease in the incidental by-catch of mulloway over the years of the apparent decline in the adult population: prawn trawling has been restricted to only three of the many estuaries in NSW; the total prawn trawling effort has been considerably reduced in recent years; methods to reduce unwanted bycatch have been successfully developed and deployed in this State; areas where seasonal or episodic high catch rates of juvenile mulloway may be taken are closed to trawling. It is therefore, unlikely that the capture of juvenile mulloway as a by-catch of prawn trawling is primarily responsible for the continuing decline in the targeted commercial fishery.

Mulloway does appear to be in need of additional research and management. In the interests of ensuring the fisheries of NSW continue to be free of seriously overexploited species it is imperative that the management of this species is not only effective but seen to be so. If the apparent declines in commercial landings are due to fishing, as they do appear to be at least in part, further fishing restrictions are urgently needed. Because of the highly mobile nature of the species management action will have the greatest chance of being effective if based on catch reductions and size limits across the whole distribution of the stocks that are harvested in NSW. Furthermore as the recreational sector now accounts for between 66% and 90% of the total landings of this species growth overfishing will need to be addressed primarily in the recreational sector. If recruitment has been impaired because of an excessive decline in the spawning biomass then additional management of the recreational fishery becomes more imperative. Reduced bag limits and increased minimum size appear obvious management strategies. Perhaps a maximum size limit may also need to be considered!

If the apparent declines in commercial catches are not due to fishing then appropriate management plans will need to be initiated based on the specific problems that are identified. If the declines in catches are due to pollution and/or diseases then these will need to be addressed at their source, which will almost certainly be outside the area of the fishery. Their amelioration will almost certainly be also outside the jurisdiction of fisheries management agencies.

Yellowfin bream (*Acanthopagrus australis*)

(*Based largely on interpretation of information contained in Status of Fisheries Resources in NSW 2006/07, Scandol et al 2008)*

Yellowfin bream are endemic to Australia and occur from Townsville in Queensland to the Gippsland lakes in Victoria. In NSW waters, yellowfin bream are found primarily within estuaries and along nearshore beaches and rocky reefs, although they also occur within the lower freshwater reaches of coastal rivers. Yellowfin bream grow slowly and take about five years to reach sexual maturity at around 22cm in length. The species is considered to be fully exploited in the combined commercial and recreational fisheries.

Reported commercial landings of bream declined during the 1990s. This decline was at least partly attributable to phasing out the use of 'figure-six' trap nets in Port Stephens and adjoining coastal waters. There was also a decline in the amount of fishing effort reported in estuaries during this time. Commercial landings have stabilised in recent years, and the age and length compositions of catches have remained relatively stable, but do possibly indicate a marginal decline in the proportion of older fish.

Yellowfin bream is a very significant recreational species and the recreational catch in NSW of approximately 1000 tonnes per annum is two to three times greater than the commercial catch.

Considering the progressive declines in the available nursery habitats for bream, the continuing degradation of many of NSW estuaries and the resultant obvious fish kills and far less obvious sub-lethal insidious effects of pollution in many forms it is remarkable that the stocks of yellowfin bream have remained so apparently healthy. Current fishing practices are very clearly not a threat to the sustainability of the species or even to the sustainability of total catches.

Eastern sea garfish (*Hyporhamphus australis*)
(*Based on the interpretation by the author of public information, in particular that provided in the Status of Fisheries Resources in NSW 2006/07 (Scandol et al 2008)).*

Eastern sea garfish are found in sheltered bays, coastal waters and occasionally in the lower reaches of estuaries form Moreton Bay in Queensland to Eden in NSW and around Lord Howe Island and Norfolk Island. Catches have declined rather dramatically since the early 1990s to levels more in keeping with those up to about 1980. The catch data are consistent with an assertion that overfishing has occurred. The relevant data are certainly indicative of a decline in relative abundance, but are insufficient however, to definitely attribute this decline to fishing.

The possibility that the drop in relative abundance has been impacted by disease, either directly (if garfish have been susceptible to a disease) or indirectly (by changes in the balance of predator-prey relationships if other species are infected), such as that which reduced pilchard populations in the same area by 70% at about the same time as the decline in eastern sea garfish catches, cannot be ruled out. Not only is it possible garfish may have been infected by this same or a similar disease it is also likely garfish may have become more sought after by predators as a result of the decreased availability of pilchards. Nor can the possibility be ruled out that a drop in abundance or change in the distribution of garfish was, at least in part, associated with the pronounced recovery over the same time period, from historically low levels, of the stocks of one of the major coastal predator species, Australian salmon. It is also not possible to discount negative impact on the distribution and possibly subsequent abundance, of eastern sea garfish from anthropogenic factors such as pollution and habitat destruction, or even human water-born activities other than fishing.

Eastern sea garfish spawn in near-shore areas and have eggs that tend to attach to seagrasses and macroalgae, the distributions of which are known to have been impacted in many coastal environments. Furthermore, the species lives in the surface few centimeters of inshore marine waters and is easily frightened and subsequently dispersed by most forms of aquatic craft such as surf-boards, power boats, jet skis and wind-surfers. With the development of surfing in northern NSW and southern Queensland since the 1950s, sea garfish progressively ceased to inhabit several of the historically most important commercial fishing sites in these areas, and possibly many other areas of NSW near-shore waters. What impact this displacement may have had on the abundance of this species is unknown.

Appropriate size composition data on garfish catches have only been collected since about 2000. The last few years have seen good recruitment, but the majority of fish have not persisted in the fishery beyond the first year. It is reported that a recent increase in the allowable mesh size of nets used in this fishery has been beneficial to the size composition of the exploited population. Further confirmation of a direct relationship between management action in the commercial fishery and apparent abundance and size composition of available stocks throughout their range would help to confirm the relationship between commercial fishing effort and current indicators of stock status.

As the species is currently only fished over a fraction of its total distribution, if the reported declines are indeed due to fishing then this implies it is at least highly mobile and possibly migratory. If it were not it is most unlikely it could be overfished by fishing in only the areas of the current commercial fishery which covers a relatively small part of its total area of distribution. The migratory nature of the species is confirmed by the progressive seasonality of the fishery, from northern waters in autumn and winter to southern waters in spring and summer. Continued management must accommodate the migratory nature of the species.

Future appropriate management of the commercial fishery is likely to be related to gear modifications and seasonal restrictions, but the possibility that selected spawning sites may need protection from all human activity, including but not restricted to fishing, should not be ruled out.

It must be noted that the commercial fishery represents the only source of usable data on this species and there is no other indicator of its well-being, regardless of which factors may represent threats to the status of the species and the fisheries based on it.

Eastern sea garfish is reported to be overfished and in accordance with the Government requirement for any species that is overfished a recovery program has been developed and implemented. The existing recovery program for eastern sea garfish is currently under review, but it is already evident that the species is recovering, albeit only slowly, under the revised management arrangements of the existing plan. The species does not appear to be in immediate danger of further declines. In fact the best available evidence, although limited, suggests that current catches are sustainable and that the status of the stocks is likely improving.