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Benefits and opportunity costs of Australia's Coral Sea marine protected area: A precautionary tale

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abstract

The paper analyses the benefits and costs of the Coral Sea Marine Reserve which, together with the contiguous Great Barrier Reef World Heritage Area, creates the largest marine protected area in the world. The benefits are found to be minimal, in both anthropocentric and ecocentric terms. Nevertheless establishment and management costs could be in the order of $A20 million and $A13 million, respectively. Meanwhile, serious depletion of the vital fish stocks of the largest tuna fishery in the world in the Western and Central Pacific Ocean—in which Australia is a management partner—continues, as does the rapid erosion of the unique and outstanding values of the Great Barrier Reef. It is concluded that current investment in the creation and management of the Coral Sea Reserve—in the face of the demonstrably urgent needs for investment in the management of marine resources in the near region and in Australia – is problematic.

1. Introduction

In 1998, the Australian Government and state and territory governments agreed to develop the National Representative System of Marine Protected Areas (NRSMPA) and in 2002 Australia joined other nations at the World Summit on Sustainable Development in committing to establish networks of representative protected areas within their maritime jurisdictions by 2012.

The main goals of the National Strategy for the Conservation of Australia's Biological Diversity are to protect biological diversity and to maintain ecological processes and systems. In the marine environment, the NRSMPA is a centrepiece of this national approach to the conservation of marine ecosystems, habitats and species, forming part of an integrated strategy for marine conservation and management.

Australia's Oceans Policy of 1999 outlines commitments and actions to the ongoing establishment of the NRSMPA for conservation purposes and to give regional security for industry access to ocean resources and their sustainable use. The integration of environmental, economic, social and cultural ocean uses is fundamental to the broad principles established in the Oceans Policy [1].

The Coral Sea MPA of 0.99 million km^2 is by far the largest in the network and together with the existing and contiguous Great Barrier Reef Marine Park will create the largest marine reserve in the world, covering 1.3 million km^2 [2] (Fig. 1). According to Australian Environment Minister Burke [4], the Coral Sea is the jewel in the crown of the proposed Australian network of marine protected areas (MPAs). It supports critical nesting sites for the green turtle and is renowned for its diversity of big predatory fish and sharks, and all the Coral Sea reefs are protected.

The paper analyses the benefits and costs of the Coral Sea MPA given its overwhelming size and the importance attached to it; Section 2 outlines the methods adopted.

2. The benefits and costs of the Coral Sea Marine Reserve (CSMR)

The analysis focuses on the conservation benefits afforded by the reduction in the removal of commercial fishing and fish, both target and bycatch species.

The criteria adopted in this paper for the removal of fisheries from the CSMR are as follows:

1. The fishery displaced by the Reserve has no alternative or very limited alternative fishing grounds.
2. The fishery displaced by the Reserve has alternative fishing grounds but the effort transferred to those grounds and the increase in intensity of effort would likely affect the viability of all operators in the fishery.

The Commonwealth administered fisheries that meet the criteria for removal from the Reserve are the Demersal Trawl, Demersal Longline of the Coral Sea Fishery, which are displaced from all zones, and the Eastern Tuna and Billfish Fishery (ETBF), a

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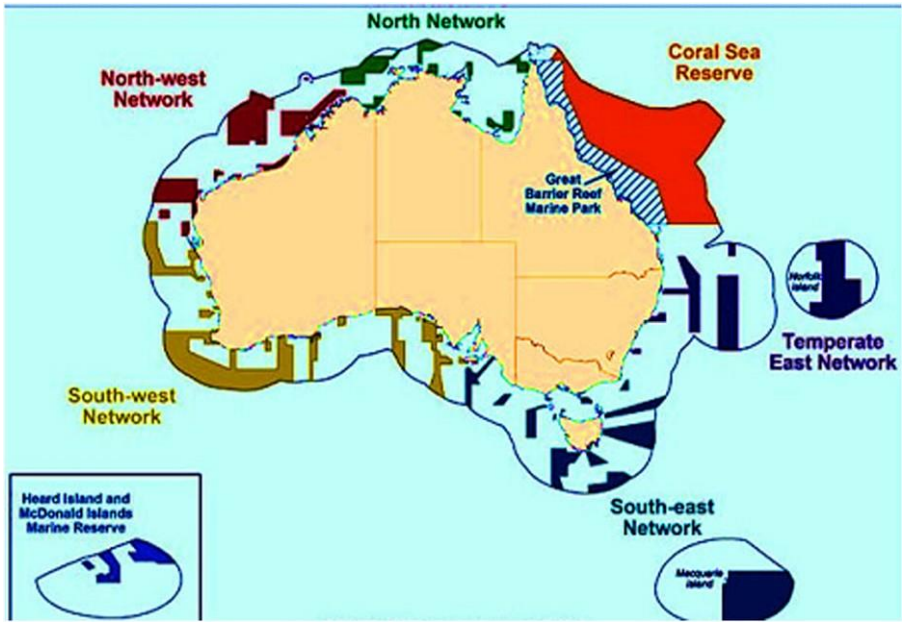

Fig. 1. Proposed network of Marine Protected Areas, Australia. The Coral Sea Marine Reserve covers hectares 990,000 km^2, extending eastwards from the boundary of the Great Barrier Reef Marine Park to the limit of Australia's territorial waters. The Great Barrier Reef and the Coral Sea Reserve will together constitute the largest marine protected area in the world. (Note that the South East Marine Region was established in 2007.) Source: [3].

Table 1
Weight and gross value of production of Commonwealth and Queensland fisheries removed from the Coral Sea Marine Reserve.
Sources: [6,46].

Jurisdiction/ fishery	Average 2001–2010			Year 2009–2010		
Commonwealth	Tonnes catch removed	Percentage removed	GVP removed $'000	Tonnes catch removed, year 2009–2010	Estimate of GVP removed $'000, year 2009–2010	Number of operators, vessels or permits affected, year 2009–2010
Coral Sea fishery						
Demersal longline	39.6	97.6	118			
Demersal Trawl	27.4	98.2	146.1	4	17	Four vessels and 16 permits in total
Dropline	6.0	17.3	62.1			
Handline/rod & Trap & troll	12.1	(not available)	71.1			
Eastern Tuna and Billfish	627.4	9.6	3566.1	417	3391.5	One operator with four vessel permits in the Coral Sea Zone, plus other vessel permits with a total catch equivalent to one average operator
Queensland	Average 2000–2010			Year 2009–2010		
Deep water fin fish fishery	13.4	25.9	98.4	12.95	95	Vessels four; commercial licences seven, active four in 2009–2010
Grand total GVP removed $'000			3963.4		3503.5	

pelagic longline fishery. In the latter, one business with four vessels is responsible for much of the pelagic longlining removed from the proposed Reserve. There are other vessels marginally affected with a catch equivalent to one average vessel (Table 1).

Of the Queensland government administered fisheries in the proposal only the Deep Water Fin Fish Fishery (DWFFF) is affected to any degree. Removal of 25% of this fishery prevents displacement to other grounds already fished (Table 1).

2.1. Estimating the benefits

The benefits are in two parts, anthropocentric and ecocentric, based on the typology of Angulo-Valdés and Hatcher [5, Table 1]. The potential anthropocentric benefits in this case are mainly in the form of a reduction in overfishing. The ecocentric benefits examined are: recovery of depleted populations; prevention of loss of vulnerable species, long-lived species, low reproductive species and migratory species; and habitat benefits.

2.2. Estimating the direct costs

The direct cost of establishment of the CSMR is based on the analysis of the gross value of fishing (the landed value of catch) removed as a result of the proposal. The fisheries assessed as displaced by the Reserve are examined and those whose fishing grounds are excised together with those whose relocation would increase fishing effort elsewhere are assumed to be removed in the implementation phase of the proposal.

The gross value of production (GVP) (landed value of catch by fishery) is the only relevant financial measure available for Australian fisheries and it is a very approximate measure of establishment costs because it does not take account of the value added to landed fish. Moreover direct establishment costs of reserves will in practice depend on the future compensation payments made during the implementation of the proposal by the Australian government to individual businesses affected, both fishing and land-based. Nevertheless the GVP removed can be compared for size with the GVP impacts and the compensation costs [6,7] associated with the increase in no take zoning in the Great Barrier Reef Marine Park in 2004.

The other component of direct costs is management costs and this is derived from the estimations of surveyed employees engaged in the management of the adjacent Great Barrier Reef Marine Park. These costs are mitigated by economies of size in marine park management and complementary with the Great Barrier Reef Marine Park management. However, these economies are somewhat negated by the multiple zoning of the reserve which will necessitate an increase in surveillance costs above those for a uniformly zoned reserve.

2.3. Estimating opportunity costs

Often neglected in cost studies of MPAs are the opportunity costs of their creation and management. There are major conservation issues in the Great Barrier Reef and in the tuna and billfish fishery of the Western and Central Pacific Ocean (WCPO) in which Australia is a management partner. The anthropogenic and ecocentric costs of the paucity of management input in these spheres are presented.

3. Results

3.1. Anthropocentric benefits of the CSMR

There is an aesthetic and a tourism benefit from the facilitation of enforcement of zoning which defines the level of protection afforded. The formal declaration of protection, particularly of reefs, and disallowing fishing in some zones will enhance aesthetic experiences and wilderness opportunities. It should be noted however that the area is remote and visitation is limited.

The main tangible benefit is the reduction in catch of 50 t a year in overfished bigeye tuna (Thunnus obesus), making little contribution to abatement of the continuous and long-term depletion of the world's major tuna stock.

3.2. Ecosystem benefits of the CSMR

As a result of past mortality through direct interaction with fisheries, in addition to low fecundity rates and other threatening processes, the long-term survival of three groups of non-target species, i.e. seabirds, sea turtles and sharks, are of greatest Australian and global concern [8].

While the Coral Sea Reserve is a very large area, the fishing intensity within it is low relative to that found closer to the Queensland coast in the Great Barrier Reef World Heritage Area (GBRWHA).[1] Moreover the level of fishing in the Coral Sea Fishery has collapsed in recent years to an insignificant level—a mere 4 t in 2009–2010. The benefits of the creation of the CSMR are thus confined almost entirely to the removal of a small part of the ETBF.

As for target species, the assumption here is that the bycatch composition of the 9.6% of ETBF catch removed reflects the overall annual bycatch in the ETBF. On this basis there is a small reduction in catch of sharks of 55 t; likewise the benefit to protected sharks, seabirds, turtles and mammals is minimal. (Catch and bycatch reduction is detailed in Table 2 and protected species in Table 3.)

The removal of the percentage of Queensland fisheries reduces by only 13 t the catch of several target species of unknown status on 2009–2010 catch levels. The impact on discards and other species is unknown (Table 4).

4. Costs of the Coral Sea Marine Reserve

The examination of costs of the Reserve is in terms of the direct costs of establishment together with management. The assessment of opportunity costs is in terms of benefits foregone in management of the marine resources in the Great Barrier Reef World Heritage Area and the Western and Central Pacific Ocean; benefits foregone (opportunity costs) are again classified as anthropocentric and ecocentric.

4.1. Establishment costs

ABARES [6] forecasts average GVP impacts in detail for fisheries affected by the Reserve. In Table 1 these data are augmented by an

Table 2
Fishing effects and the estimation of the removal of a proportion of the Commonwealth's Eastern Tuna and Billfish Fishery from the Coral Sea Marine Reserve: summary of overfished species, shark mortality and species interactions, log book data.
Source: Woodhams et al. [46, Table 22.4].

Species	ETBF mortality 2010 t	Removed t
Overfished		
Bigeye tuna (Thunnus obesus)	518	50
Southern bluefin tuna (Thunnus maccoyii)	148	14
Sharks		
Total	5740	551
Shortfin mako (Isurus oxyrinchus)	51	5
Protected species	ETBF catch 2010 number	Removed number
Turtle spp.	23	2
Seabird spp.	4	0.4
Mammal spp.	4	0.4

Table 3
Fishing effects and estimation of the removal of a proportion of the Commonwealth's Eastern Tuna and Billfish Fishery from the Coral Sea Marine Reserve: summary of protected species mortality, log book data.
Source: [46].

Protected species	ETBF mortality number 2011–2012	Removed number
Shortfin mako (Isurus oxyrinchus)	1682	161
Porbeagle (Lamna nasus)	4	0.4
Longfin mako (Isurus paucus)	2	0.2

estimate of GVP based on the 2009–2010 catches, and totals $3.5 million (all $ are Australian). The cost of establishment in practice will however be largely the sum of compensation payments made to affected individual businesses [6,7]. Compensation payments will be based on present and future profitability of fishing businesses, the value of fisheries assets including entitlements, as well as the impact on fisheries assets and the income and assets of linked land-based businesses. As well as active there are non-active licences that would need to be considered for removal in order to prevent their re-entry in the future.

In the case of the introduction of the Representative Area Programme (RAP) of 2004 which increased the area of no-take zones in the Great Barrier Reef, the impact on annual GVP was estimated at $A43m [9, p. 371]. The compensation costs to the fishing industry and land based businesses were more than five times the GVP, at well over 200 m [10]. If this ratio is maintained in the case of the CSMR (and there is no reason to suppose that it would not, given the highly vertically integrated nature of Queensland fisheries/processing removed [6]) the cost would approach $A20 million.

4.2. Management costs

Economies of size have been found to influence the management costs of MPAs; variable and fixed costs per unit of area fall with an increase in area [11,12]. Ban et al. [12] surveyed experts in management who took account not only of the size and remoteness of the area but also the complementarity of the Reserve with the management of the GBR in making an assessment of marginal costs. The experts suggested an annual management cost of $A13.4 million when zoning is not uniform, which is the case with the CSMR; something of the complexity of zoning of the area is illustrated in Fig. 2.

Table 4
Fishing effects of Queensland's Deep Water Fin Fish Fishery in 2009–2010 and estimates of the removal of 25.9% of the fishery from the Coral Sea Marine Reserve, observer data.
Sources: [49,50].

Target species	DWFFF catch 2009–2010 t	Removed t
Bar cod (Epinephalus ergastularius) Blue eye trevalla (Hyperoglyphe antarctica) Rosy jobfish (Pristipomoides filamentosus) Bass groper (Polyprion americanus)	}50	}13
All spp.	Discards 2009–2010 Unknown	Unknown
Protected species Turtle spp. Seabird spp. Mammal spp. Other	Interactions 2009–2010 }Unknown	}Unknown

4.3. Opportunity costs

4.3.1. Management failure in the tuna fisheries of the Western and Central Pacific Ocean

The Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific came into force in 2004 (Fig. 3). The aim of the convention, to which Australia is a signatory, is to ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the WCPO.

The catch of bigeye continues at a high level in 2011: in the Pacific Ocean as a whole at 2.34 million t and in the Western and Central Pacific Convention Area (WCPCA) at 1.52 million t [13, pp. ii, 39], despite the stocks being overfished and subject to overfishing for over a decade [14,15]. The seriousness of the depletion is emphasised by Davies et al. [16 pp. 35, 36] in a report to the Western and Central Pacific Fisheries Commission (WCPFC) that estimates that bigeye tuna biomass for the WCPO is about half the level of the mid-1970s.

There are also issues of depletion of major shark species. Overfished and subject to overfishing are silky shark (Carcharhinus falciformis) and oceanic white tip (Carcharhinus longimanus) [17,18]; moreover the former is listed as near threatened, and the latter vulnerable, by the IUCN [19] (Table 5).

The depletion of important WCPO fish stocks and the continual overfishing on these stocks is a consequence of the failure of initiatives for cooperative management for the sustainable use of tuna and other fish resources, as recognized in reports of the regional management body [14,20].

An examination of the impacts on non-target species completes this section. Most bycatch and even the targeted species in the WCPCA have received limited attention to date. It is possible to provide an assessment of the impact of the fishery for a few species only because in the longline fishery the discarded by catch is not recorded by fishers and there is a low level of observer coverage [21].

An earlier analysis by Lewes [22] of bycatch in the longline fishery of the WCPO tuna fishery (1992–1997) reported a shark catch rate of 13,260 t and of other species 44,390 t. He

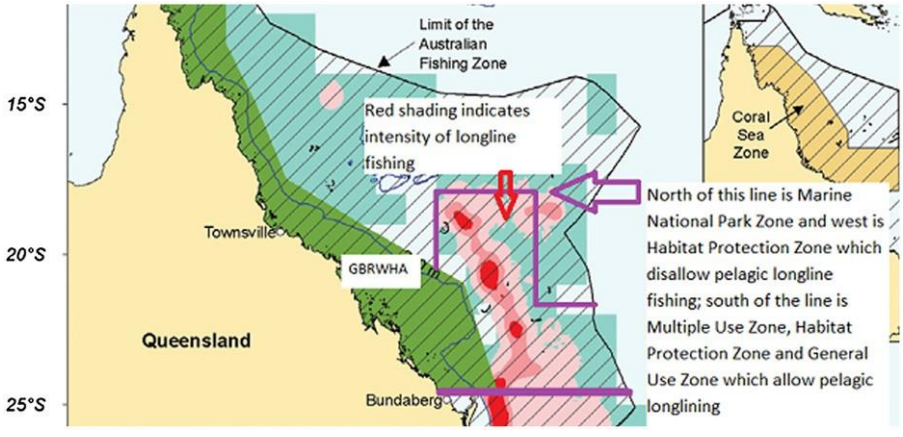

Fig. 2. Accommodation of pelagic longline fishing in Australia's Coral Sea Marine Reserve by zoning. Sources: [46, Fig. 22.1; 50].

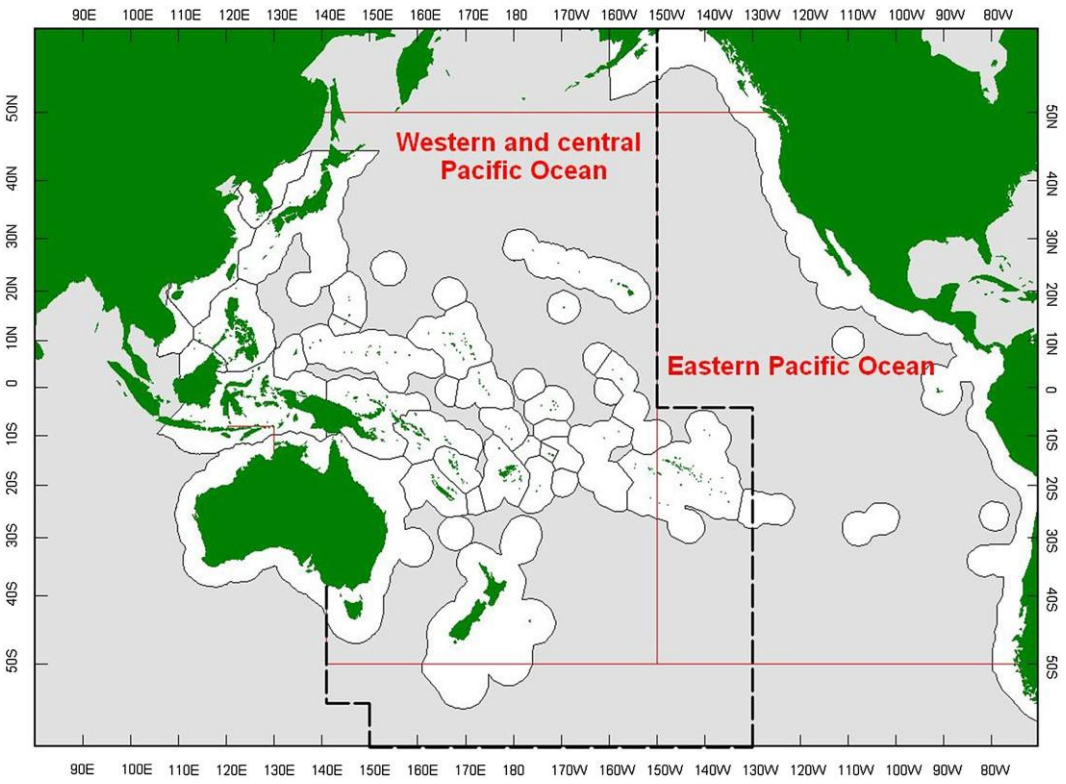

Fig. 3. Western and Central Pacific Fisheries Convention Area. The WCPO Commission was established in 2004 under the Convention. Its aim is to ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the WCPO. Its members are Australia, China, Canada, Cook Islands, European Union, Federated States of Micronesia, Fiji, France, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America, Vanuatu; for participating territories and cooperating non-members see Appendix C.

Table 5
Catch of silky and oceanic white tip sharks in the WCPO, 2009, extrapolated observer data.
Source: [51, Table 2].

Method	Silky number	Oceanic whitetip number
Longline	390,000	98,000
Purse seine	100,000	5000
Total	490,000	103,000

commented then on the paucity of information on bycatch and its implications in the fishery as follows:

> ybecause of poor reporting of the catch of NAD [non-target associated and dependent] species by logbook (which realistically is unlikely to improve, even in the long term), and the relatively low observer coverage, the total catch of the range of species can only be estimated, with considerable uncertainty surrounding existing estimates. They do however give an indication of the relative importance of bycatch by fishery, and identify the species involved. Given some assumptions concerning stability of per-hook impacts over time, any ecological impacts of longlining on bycatch species are likely to be of long standing, and may be difficult to detect retrospectively even if time series catch/effort data were available [22, p. 1].

[1] The Great Barrier Reef Marine Park differs from the Great Barrier Reef World Heritage Area in that the Park's boundary skirts inshore areas while the WHA's boundary is mainly at low water mark. Both are managed by the Commonwealth's Great Barrier Reef Marine Park Authority.

The tuna fishery of the WCPO continues to be managed on a single species stock assessments and a paucity of data on bycatch in the longline fishery of the WCPO suggests that there has not been a material improvement in data collection and dissemination since Lewis made his comments. Limited observer coverage suggests the longline bycatch continues to claim a wide range of species, protected and unprotected [21,23], supporting the claim that sustainable management requires more data on bycatch and threatened species.

The1995 FAO Code of Conduct for Responsible Fisheries states that fisheries management should ensure the conservation not only of target species but also sympatric non-target species. To this end a reference framework for principles and goals has been developed [24]. The FAO code is now explicit in most Regional Fisheries Management Organisation conventions, including the Western and Central Pacific Fisheries Commission (WCPFC).

Some member countries have recently expressed their concerns on ecological risks and the sustainability of target species. For example, the Federated States of Micronesia and Republic of the Marshall Islands [25, p. 1] who licence 134 longline vessels to fish in their waters, and are signatories to the Western and Central Commission Convention comment

> ythat due to limited monitoring and inadequate data collection protocols, basic information to determine with certainty the ecological risks posed by these longline fisheries is largely unavailable. The stock of bigeye tuna taken in these fisheries is overexploited, and it is unclear at this stage if regional management measures are adequate to correct this.

4.3.2. Erosion of values of the Great Barrier Reef World Heritage Area

In this section, the focus is on the increase in management intensity needed to improve the resilience of the GBRWHA whose ecological values are suffering serious erosion and threats. An overview of the threats is presented followed by an analysis of one major threat: the extraction of top predators.

Coral cover across the Great Barrier Reef has suffered a large reduction to 14%, a loss of 51% of initial cover since 1985 [26]; and a critical review of environmental management of the Great Barrier Reef is another jolt to perceptions that all is well [27]. The stressors most responsible are terrestrial pollution, climate change and fishing impacts. The management response since 1975 has not concentrated on these issues. There was no significant action on fishing until demersal trawling management in year 2000 and rezoning to increase no take zones from 4% to 33% in 2004. Effective action on terrestrial pollution through the Reef Plan did not begin until 2008; and effective action on climate change has yet commenced nationally or globally. Brody and Waterhouse [27] conclude that while it may still be credibly claimed that the GBR is the best managed coral reef system in the world, this is a relative assessment against other reef systems and not an absolute claim for effective management.

A UNESCO mission report on the GBR [28] found that the property is indeed affected by a number of current and potential impacts requiring decisive and immediate action to secure the GBR's outstanding universal values over the long-term. Climate change, catchment runoff, coastal development, ports and shipping and direct extractive use, pose the biggest threats to the long-term conservation of the property. (Appendix A contains a fuller summary of the mission report.)

At its 36th session the World Heritage Committee [29]endorsed its mission's report without amendment. UNESCO requested an updated report from Australia on the state of conservation of the property, including on the implementation of actions recommended, for consideration by the World Heritage Committee at its 37th session in 2013 ''ywith a view to consider, in the absence of substantial progress, the possible inscription of the property on the List of World Heritage in Danger'' [29, p. 27].

A recent report of the Commonwealth of Australia [30] to the World Heritage Committee of UNESCO highlighted the problems of extraction of top order predators, death of bycatch species and the incidental catch of protected species. (Appendix B is the full extract of the Commonwealth's concerns about fishing in the GBR.) The next section reviews one of the major threats to the Reef identified by the Commonwealth: the removal of top predators.

4.3.2.1. Removal of top predators from the GBRWHA.

Seventy percent of interactions reported in the Queensland administered East Coast Inshore Fin Fish Fishery took place in fishery north of Gladstone and South of Bundaberg [30, Fig. 1]; this northern sector is almost entirely within the GBRWHA. The percentage of the number of sharks and rays retained and released alive have been recorded, enabling the annual mortality in terms of numbers to be estimated.

Whaler sharks (Carcharhinus obscurus), grey mackerel (Scomberomorus semifasciatu) and barramundi (Lates calcarifer) were the main predator species caught. Interactions were observed and recorded with a total 42 species of shark and rays [3, Table 2]. The annual mortality of the large predator scalloped hammerhead (Sphyrna lewini) approached 2000 in number (Table 6).

More detail on the derivation of benefits and opportunity costs can be found in Appendix D.

Table 6
Estimated annual mortality of sharks in the Queensland administered East Coast Inshore Fin Fish Fishery in the Great Barrier Reef World Heritage Area, 2009–2011, extrapolated observer data.
Source: [31].

Species	Mortality (number) '000
All shark spp.	16,527
Scalloped hammerhead (Sphyrna lewini)[a]	1839

[a] The scalloped hammerhead is listed as endangered globally by the IUCN [18].

5. Discussion

The results identified the benefits of the Coral Sea MPA in terms of reduction in overfishing–anthropocentric benefit– and in the reduction in the removal of top predators and protected species-ecocentric benefit. The benefits were shown to be modest due to the low level of fishing generally, together with a zoning strategy that accommodates the fishery with the heaviest impact. Nevertheless, establishment costs of the Reserve could still total $A20 million, with on-going management costs of some $A13 million per annum.

The conservation effectiveness of MPAs in general has been queried in the literature. For example, Pitchford et al. [32] emphasise that for migratory species, very large MPAs are needed to be effective, i.e. much larger even than the Coral Sea MPA. Kearney et al. [33] are critics of MPAs in Australia because they do not address the major threats to the marine environment and, moreover, are not subject to cost–benefit analysis. MPA creation simply provides political comfort to the government in assuaging public anxiety about failed fisheries management. And Agardy et al. [34] argue that MPA creation can divert attention and resources away from addressing the real issues in areas more highly threatened and more difficult to tackle.[2]

A consensus of 300 scientists from 21 countries was highly critical of an earlier Coral Sea MPA proposal, in particular the failure to protect reefs and the concessions made to pelagic longline fishing [36]. Their submission called for the whole Reserve to be no-take zoned. In its final zoning, the Commonwealth did move to protect all reefs; but on the other hand, it actually increased the area in which pelagic longlining is allowed [6] (Fig. 2).

Removal of pelagic longlining, which is demonstrably incompatible with the Reserve's values, would increase establishment costs through higher compensation payments. But simplified zoning and the consequent reduction in annual surveillance costs would offset this increase.

The results showed that the Coral Sea proposal generates limited benefits but substantial opportunity costs. Urgent investment is required elsewhere. There is a depletion of major fish stocks and threats to the ecosystems of the WCPO, in which Australia has a management responsibility. The GBR is at a crossroads; survival by addressing major threats or a continuous decline.

It is important to note that tuna and billfish are the main asset and at the same time a major food source of many Pacific islands [41] with most Pacific island communities largely dependent on fish for protein [37]. The conservation and sustainable exploitation of these stocks is vital not only in terms of food security for the islands but also globally, given that the tuna fishery of the WCPO is the largest fishery in the world providing 55 per cent of global tuna supplies.

It was foreseen that the deficiencies apparent in fisheries management systems elsewhere would likely be exacerbated in

[2] Westhead et al. [35] welcome the critical assessment of MPAs by Agardy et al. [34] but repudiate the latter's criticism of the Gully MPA in Nova Scotia.

the South Pacific [38]. Then, two decades ago, it was hoped that the newly formed convention on the conservation and management of tuna in the WCPO would successfully introduce measures to limit tuna catches [39]. Yet the depletion of bigeye tuna stock continues in the vacuum that is effective tuna management. An agreed new strategy is all the more urgent if this vital and valuable stock is not to be further eroded and if yellowfin tuna (Thunnus albacares), which is subject to ever-increasing catches, is to continue be sustainably exploited. Kompass et al. [40] found that maximum economic yield would be achieved by a reduction in catches and a rebuilding of tuna stocks, not only for bigeye, but for yellowfin and the abundant skipjack (Katsuwonus pelamis). Thus conservation and economic objectives would go hand in hand.

The introduction of effective management measures in the WCPO tuna fisheries will not be easy given the fishery is based on migratory, multi-species stocks, fished by many nations. These characteristics lead to such practical difficulties as:

- unwillingness of countries to limit fishing mortality on bigeye and yellowfin when this might negatively impact their catches of skipjack, the main target of the fishery and a species not under threat;
- unwillingness of countries involved in bigeye-targeted long-line fishing to reduce their catches when they perceive excessive catches of juvenile fish by purse seine to be the main cause of the problem;
- difficulties in the Philippines and Indonesia in implementing any effective regulation of their domestic tuna fisheries, which are predominantly artisanal [41].

At the same time there is continual pressure to increase fishing effort to meet the legitimate economic aspirations of SPC members, to provide access for new entrants to the fishery from Europe and Latin America and to meet the established distant-water fishing nations wish to maintain their historical share of the fishery [41]. Nevertheless, as a country with a strong interest in ensuring economic welfare of Pacific island countries but with only a small stake itself in the WCPO tuna fisheries, Australia is in a position to take a leadership role in promoting and investing in cooperative solutions. Australia is one of the wealthiest members of the WCPFC and should be making available adequate resources for greater observer coverage and analysis and dissemination of information that would move the Commission towards its international obligations to manage fish stocks sustainably and limit bycatch. The contribution that Australia can make to leadership and development of management solutions is demonstrated by Hanich [42], whose proposition is an equitable and transparent framework for distributing the burden of conservation in the WCPFC.

The Results section included a summary of the severe challenges facing the Australian government and its management arm the Great Barrier Reef Marine Park Authority (GBRMPA) in maintaining the values of the GBR. An example is given in the results of just one of the threats to the ecological integrity of the Reef: the removal of top predators.

If progress in addressing the threats is deemed unsatisfactory, then the GBR could be downgraded to the status of ‘‘world heritage in danger’’ by the World Heritage Committee. The GBR has iconic status in Australia and globally. The economic (tourism) and political (iconic status with Australian population) implications of such a relegation could be severe.

That there is an opportunity cost in investment by the Australian government in the Coral Sea MPA is confirmed by the reduction in the budget of the Great Barrier Reef Marine Park Authority (GBRMPA) in the face of the demonstrated need for increased levels of management. GBRMPA's programme expenses are set to decline by $A6 million or 12% in 2012–13 compared with 2010–2011 [43, Table 1.1]. The completion of Reef Plan funding by June 2013 contributes to a reduction in programme expenses. The UNESCO mission [28] pointedly complained that continuation of the Reef Plan initiatives and associated regulatory and incentives packages is essential to reach the targets set for 2020 and the overall long-term conservation of the Great Barrier Reef, and will need to be maintained beyond 2013.

6. Conclusions

The cuts to the budget for managing the Great Barrier Reef may well reflect the fact that the Australian government is under severe budgetary constraints. The scarcity of government funds for discretionary spending should, however, result in a strict prioritisation of investment benefits.

Analysis suggests that there is no justification for funding the Coral Sea Reserve initiative ahead of much higher priority investments that would address the urgent and wide ranging issues of management in the largest tuna fishery in the world and in the Great Barrier Reef.

Following through with management solutions in these cases will be challenging and will not carry the political kudos of new MPA creation. But good public policy dictates that Australian government spending should be subject to cost–benefit analysis, and MPA creation is no exception.

Appendix A. Extracts from the World Heritage Committee report on its mission to Australia

The future conservation of the Great Barrier Reef World Heritage area is at a cross roads and decisions that will be taken in the immediate future will be decisive for the long-term health of the property as a whole. The mission concludes that the property is affected by a number of current and potential threats and that decisive and immediate action is required to secure its Outstanding Universal Value over the long-term. Climate change, catchment runoff, coastal development, ports and shipping and direct extractive use pose the most important threats to the long-term conservation of the property. Considering the rapid increase of coastal developments, including ports infrastructure, and the fact that circa 35 new development proposals are awaiting determination by 2013, including in highly sensitive or already pressured areas, the mission concludes that this is of high concern to the conservation of the OUV for which the property is inscribed on the World Heritage List. The property further lacks an overall plan for the future sustainable development of the reef that will protect its OUV and ensure its ecological integrity while simultaneously achieving sustainable economic and social goals. The continuation of investments for improving water quality beyond 2013 also requires confirmation. The overall outcome of the management of the property should result in a net-benefit for the long-term health of the property as a whole [28, p. 4].

Emerging issues since the 2009 Outlook Report include proposed port expansions, increases in shipping activity, coastal development and intensification and changes in land use within the GBR catchment; population growth; the impacts from marine debris; illegal activities; and extreme weather events including floods and cyclones. Further building the resilience of the GBR by improving water quality, reducing the loss of coastal habitats and increasing knowledge about fishing and its effects and encouraging modified practices, will give the GBR its best chance of adapting to and recovering from the threats ahead, including the impacts of a changing climate [28, p. 89].

Appendix B. Extract from Commonwealth of Australia report to UNESCO on the Great Barrier Reef

The high level risks identified (for the GBR) include extraction of top order predators, for example sharks, incidental catch of protected species and other species of conservation concern, illegal fishing (foreign and domestic) and death of discarded (bycatch) species. The limited information that is available also means that the ecosystem level impacts of fishing are not well understood.

Serious illegal activity continues to be a concern, undermining strategies aimed at building the resilience of the GBR. The types of illegal fishing incidents detected on the GBR include fishing in zones closed to fishing and use of fishing equipment or methods in zones where they are not permitted.

Recreational fishing in no-fishing zones continues to be the most frequent offence type, particularly in areas near to large population centres, and has been increasing since the rezoning of the marine parks in 2004. This in large part reflects the very high, and growing, number of people who fish recreationally in the marine parks.

Incidents of illegal take of threatened dugongs and turtles by Indigenous persons who do not have local native title rights and/or have been using illegal fishing nets remain a key issue drawing on-going media attention and community criticism. As well as undertaking increased patrolling in identified high risk areas, the field management programme provides training and other assistance to communities and Indigenous rangers to sustainably manage traditional fishing and hunting [30, p. 68].

Appendix C. Members of the Western and Central Pacific Fisheries Commission

Members

Australia, China, Canada, Cook Islands, European Union, Federated States of Micronesia, Fiji, France, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America, Vanuatu.

Participating territories

American Samoa, Commonwealth of the Northern Mariana Islands, French Polynesia, Guam, New Caledonia, Tokelau, Wallis and Futuna

Cooperating non-members

Belize, Democratic Peoples' Republic of Korea, Ecuador, El Salvador, Indonesia, Mexico, Senegal, St Kitts and Nevis, Panama, Thailand, Vietnam [44] p.1.

Appendix D. Derivation of benefits and opportunity costs

Benefits of removal of fisheries from the Coral Sea Marine Reserve

It could be argued that given the likelihood of a continuation of high fuel process and a high Australian dollar, which will continue to depress the Commonwealth's Demersal Trawl and Demersal Longline Fisheries, there is limited ecological value in the removal of fishing licences to the Coral Sea Reserve. Over the longer term, however, economic conditions may change and there could be an unrestrained return to higher level of fishing. The removal of all permits in these fisheries, involving some 16 permits, would guarantee the long-term protection from removal of ecologically important species and the protection of deep-water tropical habitats from bottom trawling [45] and a reduction in the establishment of permanent anchorages on reefs [46] while, at the same time, removing uncertainties surrounding the future of the fisheries. Catches are small in the fisheries Dropline and Handline/rod & Trap & troll and Dropline, at 6.0 and 12.1 t, respectively, in the 10 year average, and may be easily accommodated in the other zones in the Reserve still open to them (Table 1).

The largest removal is 9.6% of the Eastern Tuna and Billfish Fishery (ETBF). One business with four vessels is responsible for most of the pelagic longlining that occurs in the CSMR and there are other vessels affected with a total catch equivalent to one average vessel.

A sole operator with four vessels mainly fishes in the Coral Sea Zone (Fig. 2), which will be closed to pelagic longlining as it will become Habitat Protection Zone. Zoning has accommodated most of ETBF pelagic longline fishing outside the Coral Sea Zone and only a small portion of this fishing is displaced, as illustrated in Fig. 2. This marginal displacement is equivalent to the catch of one average operator in the fishery but appears to effect four operators.

There is a very small reduction in overfished species bigeye tuna and southern bluefin tuna and in the shark catch by the removal of a small proportion of the ETBF. Shark discards are high in the fishery (Table 2) but the ecological benefit of this reduction depends on the survival rate of sharks discarded. If this is high, as some reports suggest, then the benefit will be reduced accordingly. In 2010 catch data the majority of shortfin makos (Isurus oxyrinchus) hooked, 1867 out of 2191, or 85% were dead [46]. Recent data [47] suggest a similar level of short fin mako mortality at 1682 out of 2022 hooked, a rate of 83% (Table 3).

It should be noted that Tables 2 and 3 data are derived from log books; actual mortality of sharks and protected species in the ETBF may be greater, given that observed catches in 2006 were found by Phillips et al. [6] to be in excess of logbook catches. Moreover, Phillips' data suggest relatively high rates of interaction with albatross, turtles and shortfin mako in the fishery (Table 4). The lower rates of interactions reported in log books compared with observer data may be due partly to recent measures taken in the fishery to reduce bycatch. These are, in the case of sea birds, the carrying of tori lines and avoiding offal discharge during setting and hauling; and in the case of turtles, baiting and hook use strategies [48].

Bycatch in the Western and Central Pacific Ocean (WCPO)

There is considerable concern over the future of the stock of the oceanic white tip sharks. The Western and Central Pacific Fisheries Commission adopted a Conservation and Management Plan (CMM201104) that bans the retaining on board, transshipping, storing and landing of oceanic white tip sharks and requires this species to be released in a manner that results in as little harm to the shark as possible (Table 5). It is not clear, however, if this will be effective and an examination of existing observer data is recommended to see if further direct mitigation measures can be identified [17].

The purse seine bycatch is minor compared with that of the longline fishery. But there is a considerable level of interaction with and mortality of baleen whales, whale sharks and toothed cetaceans in the WCPFC tropical purse seine fishery [52, Table 2a].

Sharks catch in Queensland's Inshore Fin Fish Fishery (ECIFFF)

The removal of sharks from the Great Barrier Reef World Heritage Area is mainly by the Queensland government administered ECIFFF

(Table 6), a pelagic longline fishery. A shark observer programme [31] involved 233 observer days over 2 years (1/7/2009–30/6/2011) and 44 fishers that was a representative sample of the 150 licenced shark fishers in ECIFFF. The coverage of 233 days and 42 vessels represents 9.4% of the total fishing effort in the fishery given the number of fishing days in total was 730 and the number of licensed vessels 150. The fishing days observed appear to be reasonably representative of those undertaken by the commercial fleet as a whole [31].

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