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Evidence of economic benefits from marine protected areas

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Summary: Marine protected areas (MPAs) have been used for biodiversity conservation for decades. However, critics argue that evidence of their economic benefits is weak, particularly with regard to fisheries. This continued opposition to MPAs for fisheries slows progress towards conservation targets and undermines the economic and ecological sustainability of the oceans. This paper provides 48 examples of fishery-related and 31 of tourism-related economic benefits in 25 and 24 countries, respectively. There was no evidence of net costs of MPAs to fisheries anywhere. Fishery benefits included increased fish stocks, catch volumes, catch per unit effort, fecundity and larval export, and larger fish and lobsters. Well-designed and enforced MPAs provide sustainable benefits for fishing communities and even sub-optimally designed MPAs can provide economic advantages. MPAs represent one of the best strategies for maintaining the sustainable exploitation of marine resources.

Keywords: marine, conservation, fisheries, reserve, biodiversity, tourism, sustainability, economic.

Evidencia de beneficios económicos de las Áreas Marinas Protegidas

Resumen: Las Áreas Marinas Protegidas (AMP) se han utilizado durante décadas para la conservación de la biodiversidad. Sin embargo, los críticos argumentan que la evidencia de sus beneficios económicos es débil, particularmente en lo que respecta a la pesca. Esta continua oposición a las AMP en pesquerías obstaculiza el progreso hacia los objetivos de las AMP y socava la sostenibilidad económica y ecológica de los océanos. Este documento proporciona 48 ejemplos de pesquería y 31 de beneficios económicos relacionados con el turismo en 24 y 23 países respectivamente. No se detectó evidencia alguna de costos netos de las AMP para las pesquerías en ningún lugar. Los beneficios pesqueros incluyen un incremento del stock de peces, el volumen de capturas, las capturas por unidad de esfuerzo, la fecundidad y la exportación de larvas; y pescados y langostas más grandes. Las AMP bien diseñadas y aplicadas proporcionan beneficios sostenibles para las comunidades pesqueras. Incluso las AMP mal diseñadas pueden proporcionar ventajas económicas. Las AMP representan una de las mejores estrategias para mantener la explotación sostenible de los recursos marinos.

Palabras clave: marino, conservación, pesca, reserva, biodiversidad, turismo, sostenibilidad, económico.

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INTRODUCTION

More than three billion people depend on seafood for almost 20% of their protein and essential nutrients, but two-thirds of fish stocks are in poor biological condition, one-third are overfished, and catch from wild capture fisheries has been steadily declining since 1996 (Costello et al. 2016a, Pauly and Zeller 2016, FAO 2019). With a growing population and increasing anthropogenic pressure on the oceans, future food security for much of the human population is at risk (Worm 2016, Roberts et al. 2017). To avert negative effects on food security, changes in fisheries management practices are needed. Optimizing commercial fisheries for long-term profits, rather than annual maximum sustainable yield, could triple economic benefits from fishing and stabilize 97% of fish stocks by 2050 (Costello et al. 2016a, Worm 2016).

In addition to food insecurity, we are in the midst of a biodiversity crisis (McCauley et al. 2015). The overexploitation of marine wildlife has led to trophic cascades that alter entire ecosystems, and species that were once common are now threatened with extinction (McCauley et al. 2015). This overexploitation of biodiversity destabilizes ecological and economic ecosystem services, hindering sustainable food provisioning, carbon sequestration and fisheries economic benefits (Costello and Baker 2011, McCauley et al. 2015, Epstein et al. 2022). In light of these challenges, marine protected areas (MPAs) have been used to protect and restore ecosystems and their associated habitats, populations and services (Selig and Bruno 2010, Leleu et al. 2012, Krueck et al. 2017). However, there remains scepticism towards using MPAs to achieve economic benefits, specifically regarding fisheries (Fletcher et al. 2015, Hilborn 2017, 2018), as discussed below.

MPAs are widely accepted as the principal tool for protecting biodiversity and conserving threatened species, but their role in fisheries management is debated (Roberts et al. 2017, Pendleton et al. 2018, Kriegl et al. 2021). Critics argue that evidence of fisheries economic benefits resulting from MPAs are too context-dependent to draw robust conclusions about their efficacy as fisheries management tools (Hilborn et al. 2004, Di Franco et al. 2016, Hughes et al. 2016). They argue that there is a lack of evidence that MPAs benefit fisheries, for example, "…the evidence that MRs [Marine Reserves] substantially enhance fishery stocks is weak" (Caveen et al. 2015). Critics also argue that evidence of spillover is "…primarily anecdotal…" (Pantzar et al. 2018), that there is "no equivocal demonstration of spillover in fisheries adjacent to MPA" (Hargreaves-Allen 2020), and that there is only mixed evidence that MPAs enhance larval export or spillover (Caveen et al. 2015). Others argue that fishing effort may increase outside the MPAs due to fishery displacement (Hilborn and Hilborn 2019, McConnaughey et al. 2020), that MPAs provide few if any socio-economic benefits (Caveen et al. 2015) and that gear and catch restrictions provide better biodiversity protection than MPAs (Hilborn and Hilborn 2019, McConnaughey et al. 2020). Such criticisms are frequently used to devalue the use of MPAs as fisheries management tools, without consideration of the factors that result in such outcomes or the success of MPAs in other settings. In all these cases, the examples to the contrary are regarded as exceptional or it is argued that the evidence supporting MPA benefits is not enough.

This opposition causes confusion and conflict between stakeholders, slowing progress towards ocean protection targets (Ballantine 2014, Manson et al. 2021). As economic benefits, food security and other ecosystem services are underpinned by the restoration and bolstering of ecological functions, failure to adequately protect marine biodiversity and important habitats continues to undermine the economic and environmental sustainability of the world's oceans. Here, the evidence for benefits of MPAs to the economic activities of fisheries and tourism are reviewed. Google Scholar was searched using the key words "economic", "value", "MPA", "marine protected area", "marine reserve", "fisheries" and "tourism", and the first 200 records were reviewed to find empirical measurements of economic value to fisheries or tourism.

FISHERIES

Of the 51 MPAs reviewed here: 35% (18) were less than 10 years old and 22% (11) were more than 20 years old. Benefits to adjacent finfish, crustacean and mollusc fisheries were detected in 46 (90%) of the MPAs, including an increased fishery catch (76%) and body size (25%), and detection of spillover (16%) (Table 1). The latter three percentages exceed 100% because some examples showed several effects. Economic benefits to fisheries from MPAs were reported for 25 countries (plus two overseas territories), spanning temperate, sub-tropical and tropical seas in the North Atlantic, North Pacific, South Pacific and Indian Oceans (Fig. 1). The MPAs encompassed a variety of ecosystems, including coral reefs, kelp forests, mangroves, rocky reefs, salt marshes, mudflats and sandy and muddy seabeds. The MPAs employed a variety of protection methods, including multi-use zones, temporary and permanent closures, restrictions on destructive gear types, and bans on boat-based fishing. The use of no-take MPAs, hereafter called marine reserves, consistently showed the largest benefits.

Fisheries close to MPAs had up to 45 times higher catch per unit effort (CPUE) and 40 times higher catch (Table 1). In one study, fish size was on average 34% greater (Beets and Friedlander 1999), and in another, larval export was enhanced, showing no decreasing trend up to 40 km away (Le Port et al. 2017) (Table 1). Another MPA showed increased juvenile recruitment up to the 1000 km^2 limit of the study area (Harrison et al. 2012). Fish behaviour can also change, with reduced flight initiation distance within an MPA, making fish easier to observe (Costello 2014, Januchowski-Hartley et al. 2014). MPAs with varying levels of protection, such as those with partial protection areas and fishery closures, also provided significant advantages for fishermen. Yamasaki et al. (2002) found a nearly four-fold increase in catch volumes, Vandeperre et al. (2011) showed an increase in CPUE of 60%–120% over 30 years, and Kerwath et al. (2013) found that CPUE doubled after 10 years of protection. In total, 32 studies found increased catch since MPA designation.

Some of the studies indicated economic advantages to fisheries due to increases in fish size and consequently fecundity (Table 1), as predicted by modelling (De Leo and Micheli 2015). These outcomes may not directly contribute to catch increases, but they help sustain fisheries adjacent to protected areas within

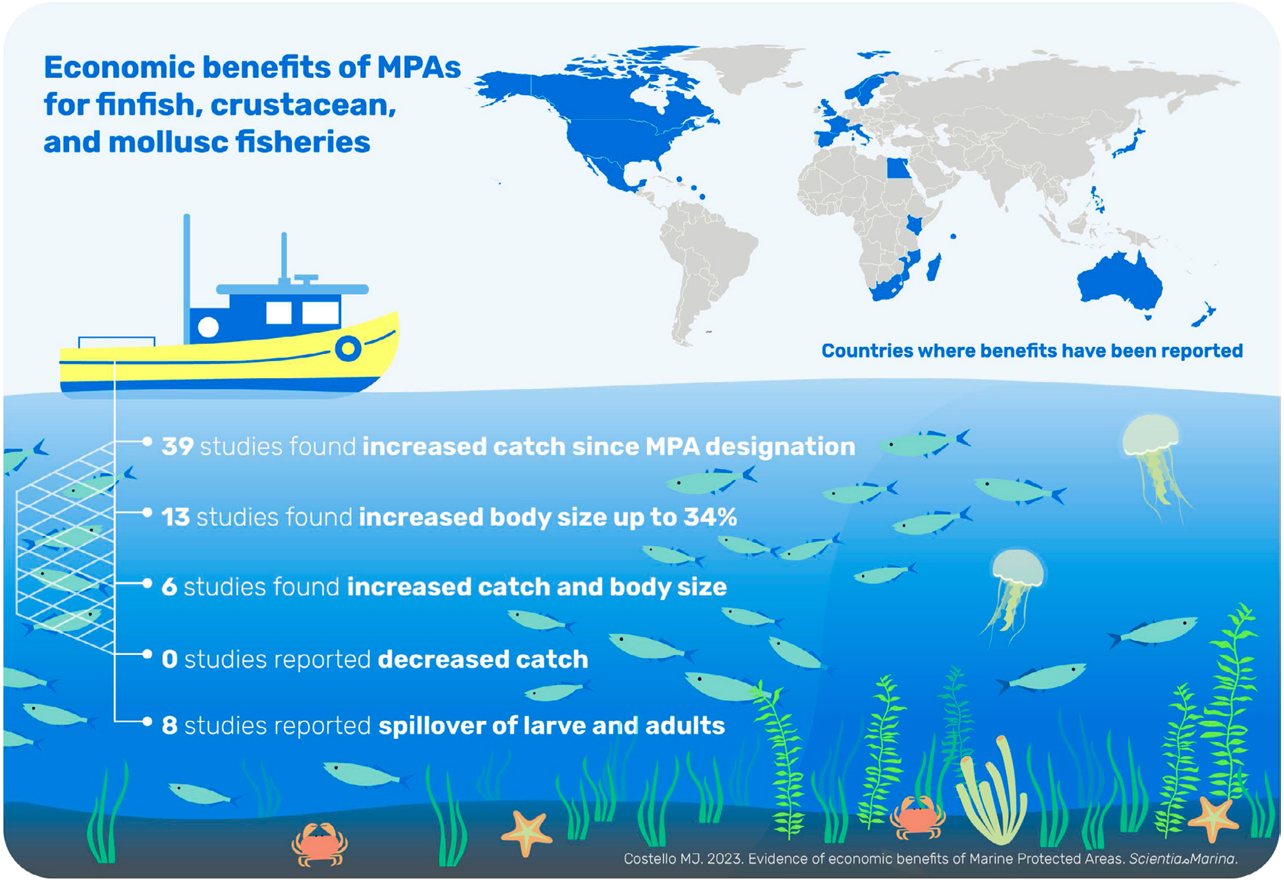

Fig. 1. – Infographic with summarized information of benefits of MPAs for fisheries, as derived from the papers analyzed in this study (Table 1).

larval dispersal ranges through increased recruitment, as, for example, was found by Le Port et al. (2017), Pelc et al. (2009, 2010) and Harrison et al. (2012). Harrison et al. (2012) showed that reserves covering only 28% of the reef area produced half of all juvenile recruitment, and Le Port et al. (2017) found that a small (5.2 km^2) reserve in New Zealand contributed over 10% of juveniles to the surrounding areas. Qu et al. (2021) valued the snapper recruitment effect noted by Le Port et al. (2017) at NZ$5 million (~US$ 3 million) per annum to local commercial fisheries, a considerable economic gain.

Two studies did not find unambiguous fishery benefits in terms of gross fish catch. In one case the MPA was only established for 4.5 years and a decline in catch could have been due to one year of poor recruitment of one fish species (Smith et al. 2006), and the same authors subsequently found no decline in catch (Smith et al. 2007). In the second, there was stable or increasing CPUE following closure of 33% of the area to fishing and a 30% decline in effort due to 6 of 13 fisheries having some licences bought out (Fletcher et al. 2015). However, this study did not account for management measures to reduce overfishing and geographic variation in fisheries and environmental factors (e.g. typhoons) (Hughes et al. 2016). Because it was surprising that no studies showed losses to fisheries, we also polled the ~12000 members of the "MPA Help" community (https://octogroup.org/programs/mpa-help/) for evidence of such costs. However, the responses could only provide studies on estimated or modelled costs to fisheries, not demonstrated costs. This indicates that if there are any net losses to any fisheries anywhere due to MPAs, they are not documented and likely rare.

There are many reasons why a fishery may or may not benefit from an MPA, as reviewed by Gaines et al. (2010). Inverted logic often regards MPAs as the "experiment" or "treatment", whereas the MPA is the control or reference for the experiments that study the human activities outside it. Comparisons inside and outside indicate two-thirds of rocky and coral reef fishes have been removed by fishing (Edgar et al. 2014). Assessing the impact of these activities requires not only controls (i.e. marine reserves), but data on their direct effect on target species abundance, body size and age, and associated habitat damage, plus data on the indirect effects on food webs, such as those due to trophic cascades (Costello et al. 2022). The variation associated with fishing effort and gear makes quantifying fishing impact and CPUE difficult (Smith et al. 2006). Furthermore, fishing pressure—be it commercial, recreational, or both—may often continue to increase in the area regardless of the establishment of an MPA (e.g. Nillos Kleiven et al. 2019, Kleiven 2020, LaScala-Gruenewald et al. 2021).

Table 1. – Examples of observed benefits to fisheries due to marine protected areas in order of year of publication. Only real-world, non-theoretical examples were included. + increase, * undocumented, ~ no difference in target species abundance (e.g. fishery catch) before-after or inside-outside MPAs, so protection is without cost, **spillover reported (but may be inferred in other cases). MPA age is years established at the time of the study cited.

Benefits to fisheries	Location	Authors	Age	Catch	Body size
Increased fishery catch and body size					
Fishermen noted increased spillover** up to 2 km from MPA, larger catches and larger fish. Increased CPUE and catch per unit area (CPUA).	Kenya	McClanahan and Mangi 2000	9	+	+
After 3 years, 5-fold increase in kaikoso clams (*Andarra* spp.) in adjacent fished areas and a 200% increase in CPUE. After 5 years, 7-fold increase.	Fiji	Tawake et al. 2001	4	+	+
CPUE of all fish and CPUE and length of common pandora, *Pagellus erythrinus*, and red mullet, *Mullus surmuletus*, increased close to the reserve boundary.	Spain	Stelzenmüller et al. 2007	24	+	+
Despite high fishing effort, fish yields within 500 m of the MPA increased continuously during the study period. Increased fish size in areas between the reserve and fished zones.	Spain	Stobart et al. 2009	19	+	+
Mean annual net benefit of 10% of the catch in weight for lobster *Palinurus elephas,* despite reserve protection.	Spain	Goñi et al. 2010	20	+	+
Increased CPUE inside the periodical closures. Fish larger in catches from closures and Acanthuridae were significantly more abundant. Fish flight initiation distance decreased.	Vanuatu	Januchowski-Hartley et al. 2014	6	+	+
Recovery of cod stock following MPA and reduction of fishing effort in wider area.	Kattegat, Sweden	Bergström et al. 2022	12	+	+
Increased abundance and size of groupers outside MPA.	Mediterranean, Israel	Frid et al. 2022	4	+	+
Increased fishery catch only					
Both U.S. National Monuments in the Pacific show that catch and CPUE are higher for longline fisheries.	Hawai'i	Lynham et al. 2020	14	+	~
35% reduction in fishing area compensated by a 225% increase in total catch for spiny lobster (*Panulirus interruptus*) after 6 years.	NE Pacific, USA	Lenihan et al. 2021	9	+	~
Spillover** was detected up to 1 km beyond the reserve for small herbivorous fishes (Acanthuridae and Scaridae). Despite concentrated fishing pressure, fish abundance outside the reserve showed no decrease.	Mozambique	da Silva et al. 2015	9	+	*
Fishermen claim higher catch in fishing grounds adjacent to the MPA and fish close to the MPA boundary. Increased CPUE on nearby fishing grounds.	Isle of Man	Bradshaw et al. 1999	10	+	*
Increase in target fish in adjacent fishing grounds. Increase in catch rates.	Madagascar	Grandcourt et al. 2001	12	+	*
In adjacent areas after 5 years catches increased by 46% - 90%, depending on fishing gear, and biomass of commercial reef fish doubled.	Saint Lucia	Roberts et al. 2001	6	+	*

Benefits to fisheries	Location	Authors	Age	Catch	Body size
Two-thirds increase in CPUE in adjacent fishery grounds, fishery now sustainable.	Red Sea, Egypt,	Galal et al. 2002	7	+	*
Landing volumes of snow crabs (*Chionoecetes opilio*) increased from 59 t in 1980 to 196 t in 1999. CPUE increased more than 4-fold.	Japan	Yamasaki 2002	19	+	*
Increased CPUE for hogfish (*Lachnolaimus maximus)* related to decreasing distance from the reserve.	Turks and Caicos Islands	Tupper and Rudd 2002	10	+	*
Ten-fold increase in fish catch by weight and ten-fold increase in CPUE for line fishing since reserve creation.	Philippines	Maypa et al. 2002	20	+	*
Catch rates of trammel netters were 33% - 50% higher inside the trawl exclusion area than outside.	Italy	Whitmarsh et al. 2002	12	+	*
Increased catch after 5 years for commercial species. Increased CPUE and double total catch for cod (*Gadus morhua*). Increased larval export from scallops (*Placopecten magellanicus*).	Atlantic USA	Gell and Roberts 2003	9	+	*
Biomass of bignose unicorn fish (*Naso vlamingii*) increased by a factor of 40 outside the reserve (200 - 250 m). Hook-and-line CPUE for *N. vlamingii* 45 times higher within 200 m of the reserve.	Philippines	Russ et al. 2003	20	+	*
Increasing CPUE near the MPA for 4 km, declining as increasing distance from the MPA, including spillover**.	Atlantic USA	Murawski et al. 2004, 2005	10	+	*
Catches increased by 27% outside the Sumolin reserve and 41% outside the Apo reserve. Total fishery catch either sustained or enhanced.	Philippines	Alcala et al. 2005	31	+	*
Increasing lobster CPUE and CPUA within 2 km of MPA.	Spain	Goñi et al. 2006	16	+	*
Catch rates higher near the reserve by a factor of 1.1 - 2.0.	Philippines	Abesamis et al. 2006	23	+	*
Increased spillover** beyond MPA boundaries for 2.5 km.	France, Spain	Goñi et al. 2008	8	+	*
A general pattern of decreasing fish biomass from within MPA to fished areas consistent with biomass spillover.	France, Spain	Harmelin-Vivien et al. 2008	34	+	*
Increased CPUE and IPUE (income per unit effort) close to the MPA border. Increased resilience of fish assemblages against fishing and human impacts within 2 km.	Spain	Stelzenmüller et al. 2008	34	+	*
Three-fold increase in the density of mollusc juveniles, black murex snail (*Hexaplex nigritus*), found in fished areas at the downstream edge of the reserve.	Mexico	Cudney-Bueno et al. 2009	7	+	*
Five-fold increase in yellow tang (*Zebrasoma flavescens*) within MPAs. Density in boundary sites less than 1 km from the nearest MPA nearly as high as within the MPA.	Hawai'i	Williams et al. 2009	10	+	*
Higher fishery yields within 500 m of the MPA than in areas more than 1 km away.	France, Spain	Forcada et al. 2009	20	+	*
CPUE of target species and marketable catch increased by 2% – 4% per year, over at least 30 years.	Southern Europe	Vandeperre et al. 2011	37	+	*

Benefits to fisheries	Location	Authors	Age	Catch	Body size
Reserves covering 28% of the local reef area produced half of all juvenile recruitment to fished reefs within 30 km.	Australia	Harrison et al. 2012	19	+	*
Reduced fish flight initiation distance, increased CPUE.	Philippines	Januchowski-Hartley et al. 2013	29	+	*
CPUE in the MPA vicinity immediately increased. This continued after 5 years, doubling pre-MPA CPUE after 10 years.	South Africa	Kerwath et al. 2013	23	+	*
Density of adult king scallops (*Pecten maximus*) declined three-fold with increasing distance from the reserve boundary.	U.K.	Howarth et al. 2015	7	+	*
Adult snapper (*Pagrus auratus*) within the MPA contributed 11% of juveniles to surrounding areas with no decreasing trend up to 40 km away.	New Zealand	Le Port et al. 2017	37	+	*
Relative abundance of snapper (*Pagrus auratus*) increased within the MPA despite increased fishing effort.	Australia	Harasti et al. 2018	13	+	*
Increased diversity of rockfish larvae in plankton.	California, USA	Freeman et al. 2022	12	+	*
Increased body size only					
Larger spiny lobsters (*Jasus edwardsii*) were caught adjacent to the reserve.	New Zealand	Kelly et al. 2002	27	~	+
Lobsters spillover** from MPAs were larger	North Sea, Norway	Thorbjørnsen et al. 2018	9	~	+
Average size of red hind grouper (*Epinephelus guttatus*) increased by 34%. Sex ratio decreased to 4 females per male.	Virgin Islands USA	Beets and Friedlander 1999	9	*	+
Record-size catches of red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*) and spotted sea trout (*Cynoscion nebulosus*) in adjacent areas to the reserve.	Atlantic USA	Roberts et al. 2001	41	*	+
Spillover**, density and modal size of *N. vlamingii* increased outside the reserve within 200 – 300 m.	Philippines	Abesamis and Russ 2005	22	*	+
Spillover reported only					
Spillover** of finfish species between the closed area and fished area with time lags ranging from 1 – 3 years.	Atlantic Canada	Fisher and Frank 2002	15	*	*
Larval export** from the mussel, *Perna perna,* increased from reserves, enhancing recruitment in nearby fished areas within several km.	South Africa	Pelc et al. 2009	34	*	*
Uncertain effect on fisheries					
Fishing activity decreased by 82% in the MPA without any negative effect on the industrial pelagic fishery catch in the region.	Mexican Pacific	Favoretto et al. 2023	5	~	~
36% decline in catch after closure of 33% of the area to fishing but no decline in CPUE.	Great Barrier Reef, Australia	Fletcher et al. 2015	9	~	*
The majority of fishermen (85%) perceived no effect of marine reserves on their catch.	Seychelles	Cinner et al. 2014	46	*	*
Since MPA designation, 23% of recreational fishermen felt the number of fish caught had improved, 32% considered it the same, 17% felt it had declined and 28% could not say.	Australia	Martin et al. 2016	9	*	*
Initial analysis of a decline of fish catch of 14% not supported by second analysis.	Gulf of Mexico, USA	Smith et al. 2006, 2007	4.5	-	*

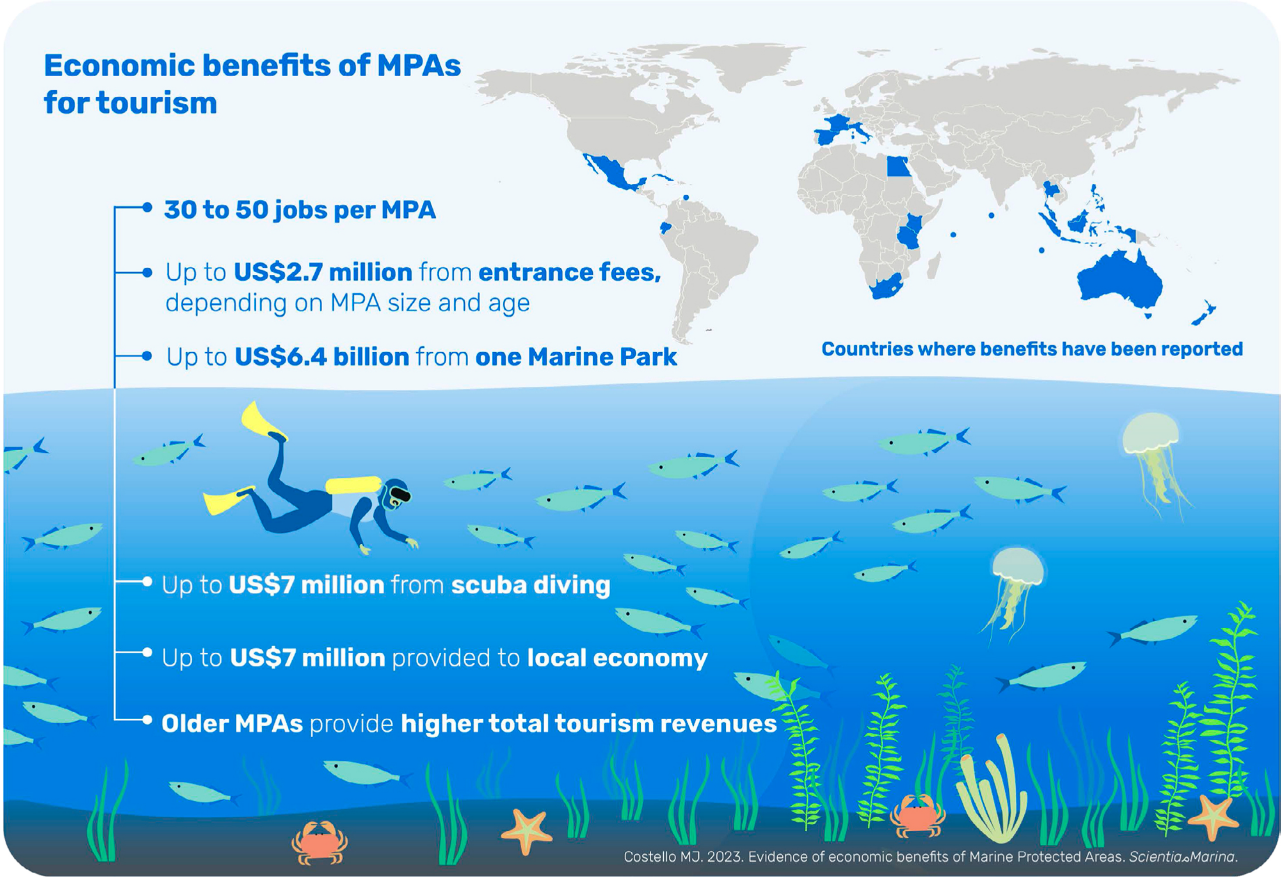

Fig. 2. – Infographic with summarized highlights of economic benefits of MPAs for tourism, as derived from the papers analyzed in this study (Table 2).

TOURISM

Examples of economic benefits from tourism were found in 24 countries, of which the majority were in tropical and sub-tropical locations, with four examples from temperate regions (France, Spain, Italy and New Zealand) (Fig. 2, Table 2). MPAs were located in the Indian, North Atlantic, North Pacific and South Pacific Oceans. The MPAs which showed benefits to tourism covered a range of ecosystems, including rocky reefs, kelp forests and sandy and muddy bottoms, but were dominated by coral reefs, mangroves and seagrass ecosystems. These 31 examples (Table 2) reported benefits to local communities, private companies, NGOs and state departments directly through user fees and indirectly through related expenses such as transport, accommodation, food, goods and other services. Shark diving contributes about $18 million a year to the economy of Palau, whereas shark fishing would contribute only $10800 (Vianna et al. 2012).

Individual MPAs have generated millions to billions of dollars in tourism revenue per year (Table 2). The Great Barrier Reef Marine Park, Australia, generated US$6.4 billion, and others generate hundreds of millions, such as the Galápagos Marine Reserve, Ecuador; Mu Ko Phi Phi Marine National Park, Thailand; and Ras Mohammed National Park, Red Sea, Egypt (Table 2). Some MPAs obtained millions of dollars from user fees (including fines), including Bonaire National Marine Park, Ras Mohammed National Park and the Wadi El Gemal–Hamata Protected Area. However, many MPAs, such as in New Zealand, do not charge visitor fees. In general, older, more established MPAs provided higher total tourism revenues, as shown by the Great Barrier Reef Marine Park, Mu Ko Phi Phi Marine National Park, Ras Mohammed National Park and the Bahamas Shark Sanctuary (Fig. 3).

REBUTTAL OF CRITICISMS

Any sample of the literature will be biased by what research was conducted and published. However, the present sample provides no indications of significant costs to fisheries from establishment of MPAs. Indeed, there were 77 examples of evidence that MPAs can provide economic benefits through fisheries (n=46) and tourism (n=31) (Tables 1, 2). Evidently, MPAs can provide a rare win-win strategy for ocean management, enabling conservation and long-term economic goals to be achieved simultaneously.

Contrary to Caveen et al. (2015), MPAs are shown to substantially increase fish stocks and catch, and can provide sometimes lucrative socio-economic benefits (Tables 1, 2, Fig. 3). Another criticism of MPAs is that there is little or only anecdotal evidence of spillover from MPAs to fished areas (Caveen et al. 2015, Pantzar et al. 2018, Hargreaves-Allen 2020). However, the majority of examples of fisheries benefits from MPAs refer to the spillover of target species.

It may seem counter-intuitive that restricting fishing in an area will result in more fish elsewhere. Yet, this happens because marine life disperses from its safe haven (the MPA), which acts like a reservoir to replenish adjacent fisheries. In financial terms, the capital is invested and people benefit from the interest on the investment. To count MPAs as a cost to fisheries is analogous to claiming that interest earned on money is a cost. The evidence of this benefit is unequivocal (Table 1).

The fact that there were only four examples of larval export from MPAs reflects the practical challenges in distinguishing eggs and larvae from MPA vs non-MPA parents. Nevertheless, rather than there being mixed evidence of enhanced larval export (as suggested by Caveen et al. 2015), the evidence collected to date supports predictions that MPAs contribute disproportionately to larval dispersal (Pelc et al. 2010, Freeman et al. 2022) and subsequent fisheries recruitment, further enhancing their worth as fisheries management tools (Hastings and Botsford 1999, De Leo and Micheli 2015, Kough et al. 2019).

Recent research has elaborated further on the fisheries benefits of protected areas arising from the increased size and fecundity of fish within MPA boundaries (Barneche et al. 2019, Marshall et al. 2021). As protected areas increase fish size by an average of 28% (Lester et al. 2009), and the reproductive output of fish increases disproportionately with size and weight, the reproductive contribution of fish within protected areas has been systematically underestimated (Marshall et al. 2019). Consequently, establishing protected reservoirs of Big Old Fat Fecund Female Fish (BOFFFFs) can lead to increased larvae diversity in the plankton (Freeman et al. 2022) and enhance fishery yields (Marshall et al. 2019). This highlights the importance of keeping BOFFFFs within breeding populations and also shows that a failure to consider reproductive hyper-allometry overestimates the effectiveness of traditional fisheries management (Marshall et al. 2021). These important findings further strengthen the use of protected areas as fisheries management tools. Were fishermen given custodianship of fish stocks, then, like farmers, they might favour strict protection of broodstock in no-take MPAs.

Some authors have speculated that the implementation of MPAs reduces access to fisheries, resulting in lower catches and revenues for fishermen (e.g. Fletcher et al. 2015 and Chan 2020). Such studies are sometimes cited as examples of MPAs displacing fishing and negatively impacting resource users. However, the findings of the former have been brought into question by Pecl et al. (2010) and Hughes et al. (2016), and the latter has been disproved by research using empirical rather than modelled results, showing that catch and CPUE increased following MPA expansion (Lynham et al. 2020). Hilborn and Hilborn (2019) and McConnaughey et al. (2020) contended that MPAs displace fishing effort, and that this displaced fishing effort then drives down abundance in neighbouring areas, but without evidence of such effects. Indeed, depending on fishery management policies, fishing effort may be displaced, but we found no evidence of any consequent declines in fish abundance or catch outside MPAs. This may be because:

- the MPA was so small that the fishing effort effect was undetectable,
- the fishermen previously active in the MPA discontinued fishing through being compensated (e.g. quotas bought out) and/or changed employment (e.g. to tourism or aquaculture),
- there were no data on fishing inside or outside the MPA before or after MPA creation,
- some fishing was still allowed in the MPA, as

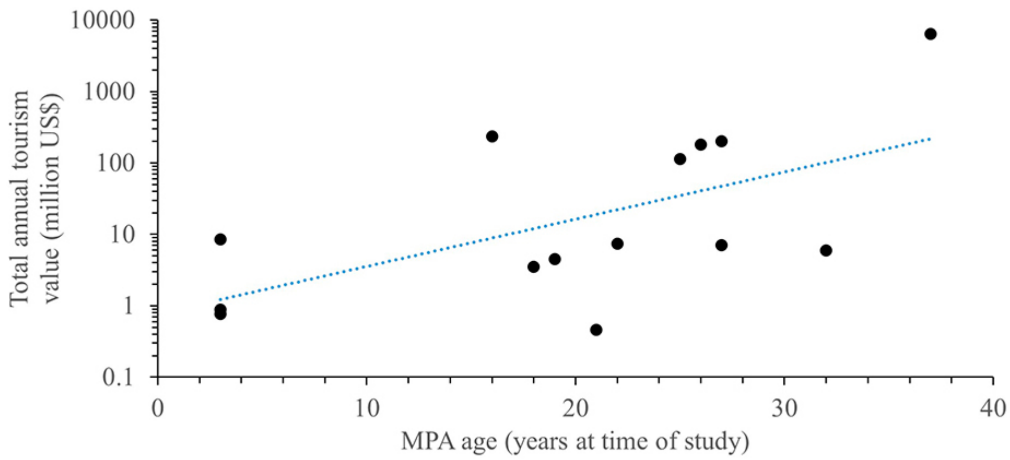

Fig. 3. – MPAs with known value of combined indirect and direct tourism (US$ on a log10 scale) and their age (Rank Spearman correlation coefficient 0.47, without highest value is 0.33; Pearson Product moment correlation coefficient R2=78). Where an MPA value was estimated as a range between two numbers (e.g. Ras Mohammed National Park, US$153-205 million per annum), the mean of those numbers was used.

Table 2. – Examples of the economic benefits of marine protected areas from tourism. Only real-world, non-theoretical examples were included. MPA age is years at the time of the study cited.

Location	Author(s)	Benefits from tourism	Age
Cuba	González-Sansón et al. 2002	Punta Frances MPA generates US$200000 per year from SCUBA diving and cruise ship tourism.	23
Belize	Young and Bilgre 2002	From 1995 to 1999, the Hol Chan Marine Reserve generated almost US$500000 from ticket sales.	15
Seychelles	Mathieu et al. 2003	Seychelles MPAs provide direct revenue of US$135324, providing 31 jobs, 13 trainee positions and an operating profit of over US$8000.	≥ 6
Philippines	Tongson and Dygico 2004	Tubbataha Reefs Natural Marine Park introduced a fee collection and permit system raising over US$30000 per annum.	16
Canary Islands, Spain	Roncin et al. 2008	La Restinga MPA generates US$739200 from diving-related tourism alone.	12
France, Mediterranean	Roncin et al. 2008	Bonifacio generates US$1137600 from diving-related tourism alone.	9
Thailand	Asafu-Adjaye and Tapsuwan 2008	Mu Ko Similan Marine National Park generates US$457389 annually through entrance fees, service charges and accommodation.	26
Sabah, Malaysia	Teh et al. 2008	Sugud Islands Marine Conservation Area generated US$26900 in 2004 from conservation and user fees.	7
South Africa	Dicken and Hosking 2009	Annual value of tiger shark diving to the Aliwal Shoal region was US$885000 per annum.	18
Kenya	Hicks et al. 2009	Mombasa Marine National Park valued solely for recreation (tourism) at US$3.5 million/km/year.	18
Spain	Merino et al. 2009	Medes Islands Marine Reserve generates US$7.4 million annually through non-extractive tourism.	19
Australia, Indian Ocean	Catlin et al. 2010	Annual expenditure of US$4.5 million from whale shark tour participants in the Ningaloo Marine Park.	23
Fiji	Brunnschweiler 2010	Marine park levy from tourism paid annually to each village for not fishing the reserve: US$20000.	7
South Africa	Dicken 2010	Pondoland MPA has a direct value of tourism estimated at US$765800.	6
Bonaire, Caribbean	Uyarra et al. 2010	User fees for access to Bonaire National Marine Park generated US$1039597 in 2008 alone.	29
Mexico, Gulf of California	Aburto-Oropeza et al. 2011	Small-scale tourism operators (less than 30 people) in Cabo Pulmo National Park generated US$538800 in 2006.	16
Egypt, Red Sea	Samy and Lizaso 2011	Ras Mohammed National Park generates US$2635200 per year from user fees. Recreational value of the MPA’s coral reefs is between US$153 and US$205 million annually.	28
Egypt, Red Sea	Samy and Lizaso 2011	Wadi El Gemal–Hamata MPA provides 50 jobs and generates US$3995453 per year from fees, penalties and sanctions.	8
Fiji	Vianna, et al. 2011	MPAs generate US$650000 annually from dive tourism by businesses operating at shark diving sites.	14
Cocos Island, Costa Rica	Friedlander et al. 2012	At full occupancy, 5 diving liveaboards at Isla del Coco National Park bring over US$7 million to the local economy.	34

Location	Author(s)	Benefits from tourism	Age
Australia, Coral Sea	Deloitte Access Economics 2013	Value of tourism at the Great Barrier Reef Marine Park estimated at US$6.4 billion annually.	38
Zanzibar, Tanzania	Nordlund et al. 2013	The Chumbe Island Coral Park provides 43 jobs and generates an annual revenue of around US$500000.	22
Kenya	Job and Paesler 2013	Kisite Marine National Park earns annual revenue of US$80000, 7 times its operating costs, and provides 40 jobs.	40
Maldives	Cagua et al. 2014	Annual expenditure of US$7.6 - 9.4 million from whale shark-related tourism.	5
New Zealand	Costello 2014	Ecotourism from Leigh Marine Reserve (Cape Rodney-Okakari Point Marine Reserve) valued at US$5.9 million annually.	39
Galápagos	Lynham et al. 2015	Marine-based tourism at the Galápagos Marine Reserve contributes US$236 million annually.	17
Thailand	Seenprachawong 2016	Mu Ko Phi Phi Marine National Park generates large ecotourism benefits representing an annual value in excess of US$200 million.	33
Raja Ampat, Indonesia	Atmodjo et al. 2017	Tourism pays for the costs of managing the Raja Ampat MPA network and provides US$127500 per year to a community fund.	13
Bahamas	Haas et al. 2017	Shark-diving industry contributes US$113.8 million annually to the Bahamian economy in direct and value added expenditures.	6
Italy	Lucrezi et al. 2017	Dive operators in Portofino MPA contribute over US$100000 in tax annually.	18
Moalboal, Philippines	Cusack et al. 2021	Annual revenues directly related to marine reserve visitation estimated at US$4.68 million.	34

over 94% of MPAs allow fishing (Costello and Ballantine 2015),
- fishing was already ecologically sustainable, negligible or absent in the MPA area prior to establishment (many MPA boundaries are placed to avoid areas important for fishing) or
- protection in the MPA counteracted this effect through spillover and larval export.

It is a credit to how MPAs have been designed and implemented that MPAs have generally benefited fisheries.

Yet, many MPAs are poorly funded to properly manage and enforce full protection of biodiversity; i.e. too many are “paper parks” (Relano and Pauly 2023). Were more MPAs better planned, funded and consequently managed, we would likely see more widespread benefits to biodiversity, including fisheries and people (Fig. 4). The examples in this paper (Table 1, 2) should inspire improved management. The emerging benefits to society will in turn inspire local communities to establish more marine reserves.

Several studies estimated negligible fishery losses from the creation of MPAs. For example, the likely costs to fisheries of expanding MPAs in Northern Ireland ranged from £0 to £6000 per annum per proposed MPA (Department of Agriculture, Environment and Rural Affairs of Northern Ireland 2020); up to 3.8% loss of income was reported from new MPAs in the Oregon Territorial Sea (The Research Group LLC 2021); and it was reported that MPA expansion to 30% of the Seychelles EEZ would have a negligible impact on the tuna fishery because the areas only contributed 4% of the catch (Chassot et al. 2018). If fisheries are already operating in an ecologically sustainable manner, with negligible effect on biodiversity, then creating MPAs may confirm this, and no fishery benefits would be evident, as suggested in a study on the Great Barrier Reef fisheries (Fletcher et al. 2015).

Regardless of the reason, not only do claims of fishery displacement effects not seem to have impacted fisheries, but the evidence shows that MPAs sustain or increase catch in adjacent areas (Table 1). Rather than negatively affecting fish catch through the displacement of fishing effort, ‘fishing-the-line’, where commercial and recreational fishermen concentrate fishing effort along MPA boundaries, has been shown to increase yield and provide greater catches of larger individuals, and is a well-known practice among fishermen (Kelly et al. 2002, Goñi et al. 2006, Boerder et al. 2017, personal observation). A metanalysis found fish abun-

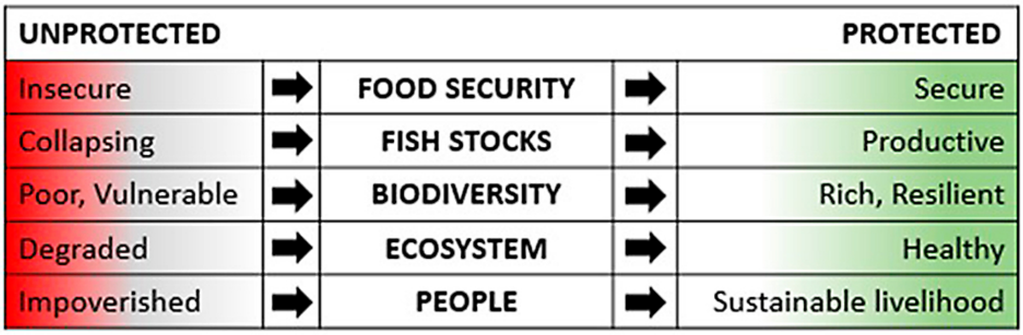

Fig. 4. – A diagram indicating how protection of marine biodiversity can benefit people and nature.

dance and biomass increase by 33% and 54%, respectively, immediately outside 23 MPAs (Di Lorenzo et al. 2016). MPAs increase resilience to fishing, as shown by their ability to sustain consistent catches while subject to intense fishing pressure along their boundaries (Stelzenmüller et al. 2008, Stobart et al. 2009, da Silva et al. 2015, Harasti et al. 2018). This displacement of fishing effort to reserve boundaries and neighbouring areas may also enhance fish stock availability and stabilize local catches, depending on the relative size of the MPA, as shown for far-ranging pelagic species such as tuna (Boerder et al. 2017).

Gear and catch restrictions can reduce impacts on biodiversity, but Hilborn's (2016) claim that these fishery regulations offer more protection than MPAs is only true when compared with partly protected areas which still allow fishing. Furthermore, most commercial and recreational fishing methods, including hook and line and pots, can kill species of seabirds, mammals, turtles and fish which are already threatened with extinction. Although changes in fishing gear can be successful at reducing bycatch, they do not eliminate it, and technological advances in fishing gear that may reduce bycatch have been slow to be adopted. Furthermore, contrary to assertions by McConnaughey et al. (2020), limiting (but not banning) trawl fishing effort cannot have more positive effects on benthic biota than the implementation of MPAs, because bottom trawls destroy biogenic habitats, some created by species with life spans of centuries (Hiddink et al. 2017). In contrast, MPAs enable the natural recovery of benthic habitats and commercial species (Gell and Roberts 2003, Stewart et al. 2020).

The economic benefits of MPAs can be numerous (Tables 1, 2). However, stakeholder negotiation during the design process can lead to MPAs being placed in areas where there is little fishing and low biodiversity, as well as to reductions in protected area size, shape and the level of protection provided (Helson et al. 2010, Magris and Pressey 2018, Kuempel et al. 2019). Sometimes, due to anticipated opposition, MPA boundaries and locations are not designed to maximize benefits to biodiversity and fisheries, but instead are based on political processes that prioritize public acceptance or logistics, ignoring or downgrading ecological and biological aims (Devillers et al. 2015, Lubchenco and Grorud-Colvert 2015). This reduces the potential benefits of MPAs, as all outcomes ultimately depend on ecological recovery. MPA design, attributes and stakeholder support play a large part in determining any benefits to fisheries and tourism (Di Franco et al. 2016), and poorly designed or enforced MPAs may not reap economic benefits (Campbell et al. 2012). Were more MPAs selected to maximize fishery benefits, economic benefits might be even greater than those found here (Table 1). The evidence here strengthens arguments to design both partial-take MPAs and marine reserves to benefit both biodiversity and fisheries rather than shrink them into residual locations. Considering that many, perhaps most, MPAs are not established to benefit fisheries, it is noteworthy that so many show fishery benefits (Table 1).

There do not appear to be any studies demonstrating a clear economic cost to fisheries after the establishment of an MPA, only benefits. Balmford et al. (2004) estimated that a global MPA network may create 1 million jobs, and its \$5-19 billion cost was less than the government subsidies to industrial fisheries, which only serve to postpone the eventual collapse of otherwise unsustainable fisheries and associated employment. They did not provide data on the costs of existing fisheries management, which are likely to be greater than the cost of MPA management (Anonymous 2023), or estimate the benefits to fisheries. Similarly, a global analysis on the cost-benefits of expanding protected areas on land and sea found that the economic revenue would be \$64 to £454 billion greater than that of not expanding them by 2050, and would avoid losses of \$179 to £534 billion (Waldron et al. 2020). Consequently, the expansion of MPAs, which promote sustainable management, could save money when compared with current fisheries management practices, particularly if the costs of existing fisheries management and subsidies are redistributed. Because of the simplicity of the management, marine reserves have lower management costs than partly protected MPAs and fishery areas (Anonymous 2023). Other studies have also estimated the varying costs of establishing and maintaining protected areas, but similarly do not place this in the context of existing costs in marine spatial management, or consider the costs of continuing the status quo (Jantke et al. 2018). Estimating the cost-benefits of MPAs to fisheries is complicated, but Brander et al (2020) conclude that expanding the global MPA network will reap benefits 1.4 to 2.7 times the costs.

In contrast to land-based agriculture and forestry, fisheries make no investment in habitat or broodstock management. The sea is a public not a private resource, and stakeholders include not only commercial fishermen but also people involved in subsistence and recreational fishing, sport, tourism, education, research, conservation, mining, mariculture and transport. Despite this, the financial costs of MPAs are frequently estimated prior to implementation. Thereafter, the level of protection and the area protected are often reduced, or a financial package is determined, to assuage the temporary loss of resource access to one group of stakeholders (Olsson et al. 2008, Clifton 2013). These measures are based on the assumption that wildlife within protected areas belongs to those who exploited it, whereas it is a public resource which the exploiters have not invested in. In fact, protected areas are a method of investing in ecosystem restoration and sustainability, which are the foundations of productive, profitable fisheries and a resource for present and future generations.

In addition to the lack of research on existing fisheries management costs, the environmental costs of fishing, from carbon emissions to the loss of biodiversity, are seldom found within the literature. In the few studies to estimate environmental costs, the release of greenhouse gases from seabed sediments by bottom trawling is significant (Sala et al. 2021, Atwood et al. 2023). Conversely, using protected areas provides a management strategy that benefits biodiversity, which can in turn result in increased carbon capture and storage (Mariani et al. 2020, Luisetti et al. 2020, Hutto et al. 2021, Epstein and Roberts 2022).

MPAs can also increase the resilience of biodiversity to climate change through harbouring more abundant and genetically diverse populations (Costello 2021). For example, studies on abalone in Baja California found that marine reserves enhance resilience to climate impacts in abalone populations, because unfished populations had a larger body size and greater egg production (Micheli et al. 2012, Munguía-Vega et al. 2015). More comprehensive economic studies could show additional positive economic benefits of MPAs because of their benefits to fisheries, carbon storage, reducing greenhouse gas emissions, and in some cases, tourism. Further research to address these knowledge gaps is needed.

CONCLUSIONS

Given recent criticism of MPAs, the challenges faced during their design and designation, and their frequent small size and sub-optimal location, one would expect their economic benefits to be hard to detect or negligible. But the evidence in the scientific literature is that they can provide economic benefits for fisheries and tourism (Tables 1, 2, Figs 1-3). The generality of these benefits across oceans, continents, countries and a diversity of habitats and ecosystems is clear. While such benefits may seem surprising because fishing has been reduced in an area, it is also common sense that unfished stocks will increase in abundance and spread to adjacent areas as adults, juveniles, larvae or eggs. Thus, sweeping dismissals of MPA economic benefits are unfounded.

Fisheries management already restricts fishing, sometimes with complete bans for years, so it partly already implements no-take MPAs without calling them MPAs. In some areas, widespread fishery controls, such as quota and gear restrictions, already restrict fishing more than MPAs, especially when most MPAs still allow some fishing. An analysis of marine reserves in Sweden found they complemented fishery management measures, but when reopened to fisheries even temporarily the benefits were promptly lost (Bergström et al. 2022).

MPAs represent a viable, low-tech, cost-effective strategy that can be used effectively for small to large areas (Roberts et al. 2017). As such, they have proven highly successful, both for safeguarding marine biodiversity and ecosystem functioning, and more pertinently, for reversing fishery declines, securing food provisions and ecosystem services and enabling the sustainable exploitation of fisheries resources (Pitchford et al. 2007, Jones et al. 2017, Ortiz-Lozano et al. 2017) (Table 1). Consequently, a review of 118 studies found that no-take, well enforced and older MPAs benefited human well-being (Ban et al. 2019). MPAs that are accessible to the public and harbour biodiverse habitats and mega-fauna have been shown to generate huge incomes from tourism, providing increased revenue and improved living standards, while contributing significantly to national GDP (Vianna et al. 2012, Sala et al. 2013) (Table 2). There is also a need to shift the conventional management of fisheries from commercial to include the wider socio-economic benefits to coastal communities (Pitcher and Lam 2015).

The literature shows that the largest benefits to fisheries (Table 1) and biodiversity come from the designation of marine reserves from which no marine life or materials can be removed (Lester and Halpern 2017, Friedlander et al. 2017, Sala and Giakoumi 2017). This "Ballantine's Law" after the "father of marine reserves" who championed the then radical idea that MPAs should be completely no-take and permanent following his leading the establishment of the first MPA in New Zealand (which now hosts 44 marine reserves) (Ballantine and Gordon 1979, Ballantine 2014, Walls and Gordon 2017). Costello and Ballantine (2015) found that 76% of coastal countries had not even one marine reserve, and today they occupy only ~3% of the global ocean (see http://www.mpatlas.org and https://navigatormap.org).

The fishing industry and fishing communities have much to gain from MPAs, but misconceptions perpetuated in the scientific literature are serving as barriers to their efficacy and implementation. Global analyses have prioritized where to locate MPAs to meet the calls by the Convention on Biological Diversity, the UN Convention on the Law of the Sea, and the International Union for Conservation of Nature for at least 30% of ocean habitats to be fully protected by 2030 (Zhao et al. 2020). To achieve this, fishery scientists need to promote the use of MPAs as a strategy to support biodiversity, including "ecosystem-based management" of fisheries, and work with conservation scientists in order to realize the true capacity of MPAs for economic success (Costello et al. 2016b, Bergström et al. 2022) (Fig. 4). MPAs are our best strategy for reversing declining biodiversity and unsustainable fisheries, because business as usual for global fisheries is unsustainable.

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REFERENCES

Abesamis R.A., Russ G.R. 2005. Density-dependent spillover from a marine reserve: long-term evidence. Ecol. Appl. 15: 1798-1812
https://doi.org/10.1890/05-0174

Abesamis R.A., Alcala A.C., Russ G.R. 2006. How much does the fishery at Apo Island benefit from spillover of adult fish from the adjacent marine reserve? Fish. Bull. 104: 360-375.

Aburto-Oropeza O., Erisman B., Galland G.R., et al. 2011. Large recovery of fish biomass in a no-take marine reserve. PLoS ONE 6: e23601.
https://doi.org/10.1371/journal.pone.0023601

Alcala A.C. Russ G.R., Maypa A.P.et al. 2005. A long-term, spatially replicated experimental test of the effect of marine reserves on local fish yields. Can. J. Fish. Aq. Sci. 62: 98-108.
https://doi.org/10.1139/f04-176

Anonymous. 2023. Sustainably financing Ireland's Marine Protected Area Network. FairSeas, Cork, 88 pp.
Accessed at https://fairseas.ie/wp-content/uploads/2023/06/Fair-Seas-Sustainably-Financing-Irelands-Marine-Protected-Area-Network.pdf

Asafu-Adjaye J., Tapsuwan, S. 2008. A contingent valuation study of scuba diving benefits: Case study in Mu Ko Similan Marine National Park, Thailand. Tourism Manag. 29: 1122-1130.
https://doi.org/10.1016/j.tourman.2008.02.005

Atmodjo E., Lamers M., Mol A. 2017. Financing marine conservation tourism: Governing entrance fees in Raja Ampat, Indonesia. Mar. Pol. 78: 181-188.
https://doi.org/10.1016/j.marpol.2017.01.023

Atwood T.B., Sala E., Mayorga J., et al. 2023. Reply to: Quantifying the carbon benefits of ending bottom trawling. Nature 617 (7960): E3-E5.
https://doi.org/10.1038/s41586-023-06015-6

Ballantine B. 2014. Fifty years on: lessons from marine reserves in New Zealand and principles for a worldwide network. Biol. Conserv. 176: 297-307.
https://doi.org/10.1016/j.biocon.2014.01.014

Ballantine W.J., Gordon D.P. 1979. New Zealand's first marine reserve, Cape Rodney to Okakari point, Leigh. Biol. Conserv. 15: 273-280.
https://doi.org/10.1016/0006-3207(79)90048-X

Balmford A., Gravestock P., Hockley N., et al. 2004. The worldwide costs of marine protected areas. Proc. Nat. Acad. Sci. 101: 9694-9697.
https://doi.org/10.1073/pnas.0403239101

Ban N.C., Gurney G.G., Marshall N.A., et al. 2019. Well-being outcomes of marine protected areas. Nature Sustain. 2 (6): 524-532.
https://doi.org/10.1038/s41893-019-0306-2

Barneche D.R., Rezende E.L., Parravicini V., et al. 2019. Body size, reef area and temperature predict global reef-fish species richness across spatial scales. Global Ecol. Biogeog. 28: 315-327.
https://doi.org/10.1111/geb.12851

Beets J., Friedlander A. 1999. Evaluation of a conservation strategy: a spawning aggregation closure for red hind, Epinephelus guttatus, in the US Virgin Islands. Environ. Biol. Fish. 55: 91-98.
https://doi.org/10.1023/A:1007404421518

Bergström U., Berkström C., Sköld M., et al. 2022. Long-term effects of no-take zones in Swedish waters. Aqua reports 2022:20. Swedish University of Agricultural Sciences, Lysekil, Sweden, 289 pp.

Boerder K., Bryndum-Buchholz A., Worm B. 2017- Interactions of tuna fisheries with the Galápagos marine reserve. Mar. Ecol. Progr. Ser. 585: 1-15.
https://doi.org/10.3354/meps12399

Bradshaw C., Veale L.O., Hill A.S. et al. 1999. The effect of scallop dredging on Irish Sea benthos: experiments using a closed area. J. Shellfish Res. 18: 709.

Brander L.M., Van Beukering, P., Nijsten, L., et al. 2020. The global costs and benefits of expanding Marine Protected Areas. Mar. Pol. 116: 103953.
https://doi.org/10.1016/j.marpol.2020.103953

Brunnschweiler J.M. 2010. The Shark Reef Marine Reserve: a marine tourism project in Fiji involving local communities. J. Sust. Tourism 18: 29-42.
https://doi.org/10.1080/09669580903071987

Cagua E.F., Collins N., Hancock J., et al. 2014. Whale shark economics: a valuation of wildlife tourism in South Ari Atoll, Maldives. PeerJ. 2: e515.
https://doi.org/10.7717/peerj.515

Campbell S.J., Hoey A.S., Maynard J., et al. 2012. Weak compliance undermines the success of no-take zones in a large government-controlled marine protected area. PLoS ONE 7: e50074.
https://doi.org/10.1371/journal.pone.0050074

Catlin J., Jones T., Norman B., et al. 2010. Consolidation in a wildlife tourism industry: the changing impact of whale shark tourist expenditure in the Ningaloo coast region. Inter. J. Tourism Res. 12: 134-148.
https://doi.org/10.1002/jtr.742

Caveen A., Polunin N., Gray T., et al. 2015. Critique of the scientific evidence for fisheries benefits of MRs. In: The controversy over marine protected areas: pp. 51-80, Springer, Cham.
https://doi.org/10.1007/978-3-319-10957-2_5

Chan H. 2020. Economic impacts of Papahānaumokuākea Marine National Monument expansion on the Hawaii longline fishery. Mar. Pol. 115: 103869.
https://doi.org/10.1016/j.marpol.2020.103869

Chassot E., Guillotreau P., Gastineau B. 2018. Economic value assessment of Seychelles tuna fisheries. Publication prepared for The Nature Conservancy. Submitted to the Seychelles Marine Spatial Plan Initiative and Government of Seychelles. University of Nantes and Capacités, France, 57 pp.

Cinner J.E., Daw T., Huchery C., et al. 2014. Winners and losers in marine conservation: fishers' displacement and livelihood benefits from marine reserves. Soc. Nat. Res. 27: 994-1005.
https://doi.org/10.1080/08941920.2014.918229

Clifton J. 2013. Compensation, conservation and communities: an analysis of direct payments initiatives within an Indonesian marine protected area. Environ. Conserv. 40: 287-295.
https://doi.org/10.1017/S0376892913000076

Costello C., Ovando D., Clavelle T., et al. 2016a. Global fishery prospects under contrasting management regimes. Proc. Nat. Acad. Sci. 113: 5125-5129.
https://doi.org/10.1073/pnas.1520420113

Costello M.J. 2014. Long live Marine Reserves: A review of experiences and benefits. Biol. Conserv. 176: 289-296. https://doi.org/10.1016/j.biocon.2014.04.023

Costello M.J., Salmond A., Hikuroa D., et al. 2016b. Marine reserves: Sustainable fisheries need reserves. Nature 540 (7633): 341. https://doi.org/10.1038/540341e

Costello M.J. 2021. Biodiversity conservation through protected areas supports healthy ecosystems and resilience to climate change and other disturbances. In: Goldstein M.I., DellaSala, D.A. (Eds), Imperiled: The Encyclopedia of Conservation. Reference Module in Earth Systems and Environmental Sciences, Elsevier, ISBN 9780124095489, in press. https://doi.org/10.1016/B978-0-12-821139-7.00164-1

Costello M.J., Baker C.S. 2011. Who eats sea meat? Expanding human consumption of marine mammals. Biol. Conserv. 12: 2745-2746. https://doi.org/10.1016/j.biocon.2011.10.015

Costello M.J., Ballantine B. 2015. Biodiversity conservation should focus on no-take Marine Reserves: 94% of Marine Protected Areas allow fishing. Trends Ecol. Evol. 30: 507-509. https://doi.org/10.1016/j.tree.2015.06.011

Costello M.J. Gordó-Vilaseca C., Coll M. 2022. Trophic Cascades and Marine Reserves: dual indicators of fishery and climate change disruption in pelagic and benthic ecosystems. In: Imperiled: The Encyclopedia of Conservation, Elsevier, 903-911. https://doi.org/10.1016/B978-0-12-821139-7.00234-8

Cudney-Bueno R., Lavín M.F., Marinone S.G., et al. 2009. Rapid effects of marine reserves via larval dispersal. PloS ONE 4: e4140. https://doi.org/10.1371/journal.pone.0004140

Cusack C., Sethi S.A., Rice A.N., et al. 2021. Marine ecotourism for small pelagics as a source of alternative income generating activities to fisheries in a tropical community. Biol. Conserv. 261, 109242. https://doi.org/10.1016/j.biocon.2021.109242

da Silva I. M., Hill N., Shimadzu H., et al. 2015. Spillover effects of a community-managed marine reserve. PLoS ONE 10, e0111774. https://doi.org/10.1371/journal.pone.0111774

De Leo G.A., Micheli F. 2015. The good: the bad and the ugly of marine reserves for fishery yields. Phil. Trans. R. Soc. B: Biol. Sci. 370 (1681): 20140276. https://doi.org/10.1098/rstb.2014.0276

Deloitte Access Economics. 2013. Economic contribution of the Great Barrier Reef. Great Barrier Reef Marine Park Authority Townsville. Report to the Great Barrier Reef Marine Park Authority. http://elibrary.gbrmpa.gov.au/jspui/handle/11017/2996

Department of Agriculture, Environment and Rural Affairs of Northern Ireland. 2020. Consultation on the development of fisheries management measures for Marine Protected Areas and establishment of Scallop enhancement sites in the Northern Ireland inshore region. November 2020. Accessed https://www.daera-ni.gov.uk/consultations/consultation-development-fisheries-management-measures-marine--protected-areas-MPA-and-establishment on 30 July 2023.

Devillers R., Pressey R.L., Grech A., et al. 2015. Reinventing residual reserves in the sea: are we favouring ease of establishment over need for protection? Aquat. Conserv. Mar. Freshwat. Ecosys. 25: 480-504. https://doi.org/10.1002/aqc.2445

Di Franco A., Thiriet P., Di Carlo G., et al. 2016. Five key attributes can increase Marine Protected Areas performance for small-scale fisheries management. Sci. Rep 6: 38135. https://doi.org/10.1038/srep38135

Di Lorenzo M., Claudet J., Guidetti P. 2016. Spillover from Marine Protected Areas to adjacent fisheries has an ecological and a fishery component. J. Nat. Conserv. 32: 62-66. https://doi.org/10.1016/j.jnc.2016.04.004

Dicken M.L. 2010. Socio-economic aspects of boat-based ecotourism during the sardine run within the Pondoland Marine Protected Area, South Africa. African J. Mar. Sci. 32: 405-411. https://doi.org/10.2989/1814232X.2010.502642

Dicken M.L., Hosking S.G. 2009. Socio-economic aspects of the tiger shark diving industry within the Aliwal Shoal Marine Protected Area, South Africa. African J. Mar. Sci. 31: 227-232. https://doi.org/10.2989/AJMS.2009.31.2.10.882

Edgar G.J., Stuart-Smith R.D., Willis T.J., et al. 2014. Global conservation outcomes depend on Marine Protected Areas with five key features. Nature 506 (7487): 216-220. https://doi.org/10.1038/nature13022

Epstein G., Middelburg J.J., Hawkins J.P., et al. 2022. The impact of mobile demersal fishing on carbon storage in seabed sediments. Global Change Biol. 28: 2875-2894. https://doi.org/10.1111/gcb.16105

Epstein G., Roberts C.M. 2022. Identifying priority areas to manage mobile bottom fishing on seabed carbon in the UK. PLoS Climate 1: e0000059. https://doi.org/10.1371/journal.pclm.0000059

FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017. Rome. Accessed 18/06/20. http://www.fao.org/3/ca5495t/CA5495T.pdf

Favoretto F., López-Sagástegui C., Sala E., et al. 2023. The largest fully protected marine area in North America does not harm industrial fishing. Sci. Adv. 9: eadg0709. https://doi.org/10.1126/sciadv.adg0709

Fisher J.A., Frank, K.T. 2002 Changes in finfish community structure associated with an offshore fishery closed area on the Scotian Shelf. Mar. Ecol. Progr. Ser. 240: 249-265. https://doi.org/10.3354/meps240249

Fletcher W.J., Kearney R.E., Wise B.S., et al. 2015. Large-scale expansion of no-take closures within the Great Barrier Reef has not enhanced fishery production. Ecol. Appl. 25: 1187-1196. https://doi.org/10.1890/14-1427.1

Forcada A., Valle C., Bonhomme P., et al. 2009. Effects of habitat on spillover from Marine Protected Areas to artisanal fisheries. Mar. Ecol. Progr. Ser. 379: 197-211. https://doi.org/10.3354/meps07892

Freeman J.B., Semmens, B.X., Thompson A.R. 2022. Impacts of Marine Protected Areas and the environment on larval rockfish species richness and assemblage structure in the Southern California Bight. Mar. Ecol. Progr. Ser. 698: 125-137. https://doi.org/10.3354/meps14161

Frid O., Lazarus M., Malamud S., et al. 2022. Effects of Marine Protected Areas on fish communities in a hotspot of climate change and invasion. Medit. Mar. Sci. 23: 157-190. https://doi.org/10.12681/mms.26423

Friedlander A.M., Zgliczynski B.J., Ballesteros E., et al. 2012. The shallow-water fish assemblage of Isla del Coco National Park, Costa Rica: structure and patterns in an isolated, predator-dominated ecosystem. Rev. Biol. Trop. 60 S3: 321-338. 60(S3): 321-338. https://doi.org/10.15517/rbt.v60i3.28407

Friedlander A.M., Golbuu Y., Ballesteros E., et al. 2017. Size, age, and habitat determine effectiveness of Palau's Marine Protected Areas. PloS ONE. 12: e0174787. https://doi.org/10.1371/journal.pone.0174787

Gaines S.D., White C., Carr M.H., et al. 2010. Designing marine reserve networks for both conservation and fisheries management. Proc. Nat. Acad. Sci. 107: 18286-18293. https://doi.org/10.1073/pnas.0906473107

Galal N., Ormond R.F.G., Hassan O. 2002. Effect of a network of no-take reserves in increasing catch per unit effort and stocks of exploited reef fish at Nabq, South Sinai, Egypt. Mar. Freshwat. Res. 53: 199-205. https://doi.org/10.1071/MF01158

Gell F.R., Roberts C.M. 2003. Benefits beyond boundaries: the fishery effects of marine reserves. Trends Ecol. Evol. 18: 448-455. https://doi.org/10.1016/S0169-5347(03)00189-7

Goñi R., Quetglas A., Reñones O. 2006. Spillover of spiny lobsters Palinurus elephas from a marine reserve to an adjoining fishery. Mar. Ecol. Progr. Ser. 308: 207-219. https://doi.org/10.3354/meps308207

Goñi R., Adlerstein S., Alvarez-Berastegui D., et al. 2008. Spillover from six western Mediterranean Marine Protected Areas: evidence from artisanal fisheries. Mar. Ecol. Progr. Ser. 366: 159-174. https://doi.org/10.3354/meps07532

Goñi R., Hilborn R., Díaz D., et al. 2010. Net contribution of spillover from a marine reserve to fishery catches. Mar. Ecol. Progr. Ser. 400: 233-243. https://doi.org/10.3354/meps08419

González-Sansón G., Angulo J., Borrego R., et al. 2002. Investigación orientada al establecimiento de un plan de manejo en el Parque Nacional Marino de Punta Francés, Cuba. In: Angulo-Valdés J.A. and Hatcher B.G (2010) A new typol-

ogy of benefits derived from marine protected areas. Mar. Pol. 34: 635-644.
https://doi.org/10.1016/j.marpol.2009.12.002
Grandcourt E., Andrianarivo, C., Rene de Roland, L., et al. 2001. Status and management of the marine protected areas of Madagascar. International Coral Reef Action Network, East African Component. (ICRAN project UNEP/FAO) MT/1100-99-70. In: Gell F.R. and Roberts C.M. (2003) Benefits beyond boundaries: the fishery effects of marine reserves. Trends Ecol. Evol. 18: 448-455.
https://doi.org/10.1016/S0169-5347(03)00189-7
Haas A.R. et al. 2017. The contemporary economic value of elasmobranchs in The Bahamas: Reaping the rewards of 25 years of stewardship and conservation. Biol. Conserv. 207: 55-63.
https://doi.org/10.1016/j.biocon.2017.01.007
Harasti D., Fedler T., Brooks E.J. 2018. Increase in relative abundance and size of snapper Chrysophrys auratus within partially-protected and no-take areas in a temperate marine protected area. Front. Mar. Sci. 5: 208.
https://doi.org/10.3389/fmars.2018.00208
Hargreaves-Allen V.A. 2020. The economics of marine reserves. Oxford Research Encyclopedia of Environmental Science.
https://doi.org/10.1093/acrefore/9780199389414.013.438
Harmelin-Vivien M., Le Diréach L., Bayle-Sempere J. et al. 2008. Gradients of abundance and biomass across reserve boundaries in six Mediterranean marine protected areas: Evidence of fish spillover? Biol. Conserv. 141: 1829-1839.
https://doi.org/10.1016/j.biocon.2008.04.029
Harrison H.B., Williamson D.H., Evans R.D., et al. 2012. Larval export from marine reserves and the recruitment benefit for fish and fisheries. Curr. Biol. 22: 1023-1028.
https://doi.org/10.1016/j.cub.2012.04.008
Hastings A., Botsford L.W. 1999. Equivalence in yield from marine reserves and traditional fisheries management. Science 284 (5419): 1537-1538.
https://doi.org/10.1126/science.284.5419.1537
Helson J., Leslie S., Clement G. et al. 2010. Private rights, public benefits: Industry-driven seabed protection. Mar. Pol. 34: 557-566.
https://doi.org/10.1016/j.marpol.2009.11.002
Hicks C.C., McClanahan T.R., Cinner J.E., et al. 2009. Trade-offs in values assigned to ecological goods and services associated with different coral reef management strategies. Ecol. Soc. 14.
https://doi.org/10.5751/ES-02712-140110
Hiddink J.G., Jennings S., Sciberras M. et al. 2017. Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance. Proc. Nat. Acad. Sci. 114: 8301-8306.
https://doi.org/10.1073/pnas.1618858114
Hilborn R. 2016. Policy: Marine biodiversity needs more than protection. Nature 535: 224-226.
https://doi.org/10.1038/535224a
Hilborn R. 2017. Traditional fisheries management is the best way to manage weak stocks. Proc. Nat. Acad. Sci. 114: E10610-E10610.
https://doi.org/10.1073/pnas.1715680114
Hilborn R. 2018. Are MPA effective? ICES J. Mar. Sci. 75: 1160-1162.
https://doi.org/10.1093/icesjms/fsx068
Hilborn R., Hilborn U. 2019. Ocean Recovery: A sustainable future for global fisheries? Oxford University Press.
https://doi.org/10.1093/oso/9780198839767.001.0001
Hilborn R., Stokes K., Maguire J.J., et al. 2004. When can marine reserves improve fisheries management? Ocean & Coast. Manag. 47: 197-205.
https://doi.org/10.1016/j.ocecoaman.2004.04.001
Howarth L.M., Roberts C.M., Hawkins J.P., et al. 2015. Effects of ecosystem protection on scallop populations within a community-led temperate marine reserve. Mar. Biol. 162: 823-840.
https://doi.org/10.1007/s00227-015-2627-7
Hughes T., Cameron D.S., Chin A., et al. 2016. A critique of claims for negative impacts of Marine Protected Areas on fisheries. Ecol. Appl. 26: 637-641.
https://doi.org/10.1890/15-0457
Hutto S.H., Brown M., Francis E. 2021. Blue carbon in Marine Protected Areas: Part 1; A guide to understanding and increasing protection of blue carbon. National Marine Sanctuaries Conservation Science Series ONMS-21-07. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries. Available at: sanctuaries.noaa.gov.
Jantke K., Jones K.R., Allan J.R., et al. 2018. Poor ecological representation by an expensive reserve system: evaluating 35 years of marine protected area expansion. Conserv. Lett. 11: e12584.
https://doi.org/10.1111/conl.12584
Januchowski-Hartley F.A., Graham N.A., Cinner J.E. et al. 2013. Spillover of fish naïveté from marine reserves. Ecol. Lett. 16: 191-197.
https://doi.org/10.1111/ele.12028
Januchowski-Hartley F.A. et al. 2014. Fishery benefits from behavioural modification of fishes in periodically harvested fisheries closures. Aquat. Conserv.: Mar. Freshwat. Ecosys. 24: 777-790.
https://doi.org/10.1002/aqc.2388
Job H., Paesler F. 2013. Links between nature-based tourism, protected areas, poverty alleviation and crises-The example of Wasini Island (Kenya). J. Outdoor Recreat. Tourism. 1: 18-28.
https://doi.org/10.1016/j.jort.2013.04.004
Jones E.V., Macintosh D., Stead S. et al. 2017. How effective are MPA in conserving crab stocks? A comparison of fisheries and conservation objectives in three coastal MPA in Thailand. Ocean Coast. Manag. 149: 186-197.
https://doi.org/10.1016/j.ocecoaman.2017.09.012
Kelly S., Scott D., MacDiarmid A.B. 2002. The value of a spillover fishery for spiny lobsters around a marine reserve in northern New Zealand. Coast. Manag. 30: 153-166.
https://doi.org/10.1080/089207502753504689
Kerwath S.E., Winker H., Götz A. et al. 2013. Marine Protected Area improves yield without disadvantaging fishers. Nature Comm. 4: 1-6.
https://doi.org/10.1038/ncomms3347
Kleiven A.R., Moland, E., Sumaila U.R. 2020. No fear of bankruptcy: the innate self-subsidizing forces in recreational fishing. ICES J. Mar. Sci. 77: 2304-2307.
https://doi.org/10.1093/icesjms/fsz128
Kough A.S., Belak C.A., Paris C.B. et al. 2019. Ecological spillover from a Marine Protected Area replenishes an over-exploited population across an island chain. Conserv. Sci. Pract. 1: e17.
https://doi.org/10.1111/csp2.17
Kriegl M., Elías Ilosvay X.E., von Dorrien C. et al. 2021. Marine Protected Areas: At the crossroads of nature conservation and fisheries management. Front. Mar. Sci. 8: 676264.
https://doi.org/10.3389/fmars.2021.676264
Krueck N.C., Ahmadia G.N., Possingham H.P. et al. 2017. Marine reserve targets to sustain and rebuild unregulated fisheries. PLoS Biol. 15.
https://doi.org/10.1371/journal.pbio.2000537
Kuempel C.D., Jones K.R., Watson J.E. et al. 2019. Quantifying biases in marine-protected-area placement relative to abatable threats. Conserv. Biol. 33: 1350-1359.
https://doi.org/10.1111/cobi.13340
LaScala-Gruenewald D.E., Grace R.V., Haggitt T.R., et al. 2021. Small marine reserves do not provide a safeguard against overfishing. Conserv. Sci. Pract. 3: e362.
https://doi.org/10.1111/csp2.362
Le Port A., Montgomery J.C., Smith A.N.H. et al. 2017. Temperate Marine Protected Area provides recruitment subsidies to local fisheries. Proc. R. Soc. B: Biol. Sci. 284 (1865): 20171300.
https://doi.org/10.1098/rspb.2017.1300
Leleu K., Remy-Zephir B., Grace R. et al. 2012. Mapping habitats in a marine reserve showed how a 30-year trophic cascade altered ecosystem structure. Biol. Conserv. 155: 193-201.
https://doi.org/10.1016/j.biocon.2012.05.009
Lenihan H., Gallagher J.P., Peters J.R. et al. 2021. Evidence that spillover from Marine Protected Areas benefits the spiny lobster (Panulirus interruptus) fishery in southern California. Sci. Rep. 11: 1-9.
https://doi.org/10.1038/s41598-021-82371-5
Lester S.E., Halpern B.S. 2009. Biological responses in marine no-take reserves versus partially protected areas. Mar. Ecol. Progr. Ser. 367: 49-56.
https://doi.org/10.3354/meps07599
Lester S.E., Halpern B.S., Grorud-Colvert K., et al. 2009. Biological effects within no-take marine reserves: a global synthesis. Mar. Ecol. Progr. Ser. 384: 33-46.
https://doi.org/10.3354/meps08029
Lubchenco J., Grorud-Colvert K. 2015. Making waves: The science and politics of ocean protection. Science 350 (6259): 382-383.
https://doi.org/10.1126/science.aad5443

Lucrezi S., Milanese M., Markantonatou V., et al. 2017. Scuba diving tourism systems and sustainability: Perceptions by the scuba diving industry in two Marine Protected Areas. Tourism Manag. 59: 385-403. https://doi.org/10.1016/j.tourman.2016.09.004

Luisetti T., Ferrini S., Grilli G. et al. 2020. Climate action requires new accounting guidance and governance frameworks to manage carbon in shelf seas. Nature Comm. 11: 1-10. https://doi.org/10.1038/s41467-020-18242-w

Lynham J. et al. 2015. Economic valuation of marine-and shark-based tourism in the Galápagos Islands. National Geographic Pristine Seas. 44. https://media.nationalgeographic.org/assets/file/Galapagos-EconReport_Nov15.pdf

Lynham J., Costello C., Gaines S.D. et al. 2020. Impact of two of the world's largest protected areas on longline fishery catch rates. Nature Comm. 11: 1-9. https://doi.org/10.1038/s41467-020-14588-3

Magris R.A., Pressey R.L. 2018. Marine Protected Areas: Just for show? Science 360 (6390): 723-724. https://doi.org/10.1126/science.aat6215

Manson P., Nielsen-Pincus M., Granek E.F. et al. 2021. Public perceptions of ocean health and marine protection: Drivers of support for Oregon's marine reserves. Ocean Coast. Manag. 201: 105480. https://doi.org/10.1016/j.ocecoaman.2020.105480

Mariani G., Cheung W.W., Lyet A. et al. 2020. Let more big fish sink: Fisheries prevent blue carbon sequestration-half in unprofitable areas. Sci. Adv. 6 (44): eabb4848. https://doi.org/10.1126/sciadv.abb4848

Marshall D.J., Gaines S., Warner R,, et al. 2019. Underestimating the benefits of Marine Protected Areas for the replenishment of fished populations. Front. Ecol. Environ. 17: 407-413. https://doi.org/10.1002/fee.2075

Marshall D.J., Bode M., Mangel M., et al. 2021. Reproductive hyperallometry and managing the world's fisheries. Proc. Nat. Acad. Sci. 118 (34): e2100695118. https://doi.org/10.1073/pnas.2100695118

Martin C.L., Momtaz S., Jordan A. et al. 2016. Exploring recreational fishers' perceptions, attitudes, and support towards a multiple-use Marine Protected Area six years after implementation. Mar. Pol. 73: 138-145. https://doi.org/10.1016/j.marpol.2016.08.002

Mathieu L.F., Langford I.H., Kenyon W. 2003. Valuing marine parks in a developing country: a case study of the Seychelles. Environ. Devel. Econ. 8: 373-390. https://doi.org/10.1017/S1355770X0300196

Maypa A.P., Russ G.R., Alcala A.C. et al. 2002. Long-term trends in yield and catch rates of the coral reef fishery at Apo Island, central Philippines. Mar. Freshwat. Res. 53: 207-213. https://doi.org/10.1071/MF01134

McCauley D.J., Pinsky M.L., Palumbi S.R. et al. 2015. Marine defaunation: animal loss in the global ocean. Science 347 (6219): 1255641. https://doi.org/10.1126/science.1255641

McClanahan T.R., Mangi S. 2000. Spillover of exploitable fishes from a marine park and its effect on the adjacent fishery. Ecol. Appl. 10: 1792-1805. https://doi.org/10.1890/1051-0761(2000)010[1792:SOEFFA]2.0.CO;2

McConnaughey R.A., Hiddink J.G., Jennings S. et al. 2020. Choosing best practices for managing impacts of trawl fishing on seabed habitats and biota. Fish Fish. 21: 319-337. https://doi.org/10.1111/faf.12431

Merino G., Maynou F., Boncoeur J. 2009. Bioeconomic model for a three-zone Marine Protected Area: a case study of Medes Islands (northwest Mediterranean). ICES J. Mar. Sci. 66: 147-154. https://doi.org/10.1093/icesjms/fsn200

Micheli F., Saenz-Arroyo A., Greenley A., et al. 2012. Evidence that marine reserves enhance resilience to climatic impacts. PLoS ONE 7: e40832. https://doi.org/10.1371/journal.pone.0040832

Munguía-Vega A., Sáenz-Arroyo A., Greenley A.P., et al. 2015. Marine reserves help preserve genetic diversity after impacts derived from climate variability: Lessons from the pink abalone in Baja California. Global Ecol. Conserv. 4: 264-276. https://doi.org/10.1016/j.gecco.2015.07.005

Murawski S., Rago P., Fogarty M. 2004. Spillover effects from temperate Marine Protected Areas. Amer. Fish. Soc. Symp. 42: 167-84.

Murawski S.A., Wigley S.E., Fogarty M.J., et al. 2005. Effort distribution and catch patterns adjacent to temperate MPA. ICES J. Mar. Sci. 62: 1150-1167. https://doi.org/10.1016/j.icesjms.2005.04.005

Nillos Kleiven P.J., Espeland S.H., Olsen E.M., et al. 2019. Fishing pressure impacts the abundance gradient of European lobsters across the borders of a newly established Marine Protected Area. Proc. R. Soc. B 286 (1894): 20182455. https://doi.org/10.1098/rspb.2018.2455

Nordlund L.M., Kloiber U., Carter E. et al. 2013. Chumbe Island Coral Park-governance analysis. Mar. Pol. 41: 110-117. https://doi.org/10.1016/j.marpol.2012.12.018

Olsson P., Folke C., Hughes T.P. 2008. Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. Proc. Nat. Acad. Sci. 105: 9489-9494. https://doi.org/10.1073/pnas.0706905105

Ortiz-Lozano L., Olivera-Vázquez L., Espejel I. 2017. Legal protection of ecosystem services provided by Marine Protected Areas in Mexico. Ocean Coast. Manag. 138: 101-110. https://doi.org/10.1016/j.ocecoaman.2017.01.017

Pantzar M., Russi D., Hooper T. et al. 2018. Study on the Economic Benefits of Marine Protected Areas. Literature review analysis. Report to the European Commission. Europe: Executive Agency for Small and Medium-sized Enterprises (EASME).

Pauly D., Zeller D. 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Nature Comm. 7: 10244. https://doi.org/10.1038/ncomms10244

Pelc R.A., Baskett M.L., Tanci T., et al. 2009. Quantifying larval export from South African marine reserves. Mar. Ecol. Progr. Ser. 394: 65-78. https://doi.org/10.3354/meps08326

Pelc R.A., Warner R.R., Gaines S.D. et al. 2010. Detecting larval export from marine reserves. Proc. Nat. Acad. Sci. 107 (43): 18266-18271. https://doi.org/10.1073/pnas.0907368107

Pendleton L.H., Ahmadia G.N., Browman H.I., et al. 2018. Debating the effectiveness of marine protected areas. ICES J. Mar. Sci. 75: 1156-1159. https://doi.org/10.1093/icesjms/fsx154

Pitcher T.J., Lam M.E. 2015. Fish commoditization and the historical origins of catching fish for profit. Marit. Stud. 14, 1-19. https://doi.org/10.1186/s40152-014-0014-5

Pitchford J.W., Codling E.A., Psarra D. 2007. Uncertainty and sustainability in fisheries and the benefit of marine protected areas. Ecol. Model. 207: 286-292. https://doi.org/10.1016/j.ecolmodel.2007.05.006

Qu Z., Thrush S., Parsons D. et al. 2021. Economic valuation of the snapper recruitment effect from a well-established temperate no-take marine reserve on adjacent fisheries. Mar. Pol. 134: 104792. https://doi.org/10.1016/j.marpol.2021.104792

Relano V, Pauly D. 2023. The 'Paper Park Index': Evaluating Marine Protected Area effectiveness through a global study of stakeholder perceptions. Mar. Pol. 151: 105571. https://doi.org/10.1016/j.marpol.2023.105571

Roberts C.M., Bohnsack J.A., Gell F., et al. 2001. Effects of marine reserves on adjacent fisheries. Science 294 (5548): 1920-1923. https://doi.org/10.1126/science.294.5548.1920

Roberts C.M., Hawkins J.P., Gell F.R. 2005. The role of marine reserves in achieving sustainable fisheries. Phil. Trans. R. Soc. B: Biol. Sci. 360 (1453): 123-132. https://doi.org/10.1098/rstb.2004.1578

Roberts C.M., O'Leary B.C., McCauley D.J. et al. 2017. Marine reserves can mitigate and promote adaptation to climate change. Proc. Nat. Acad. Sci. 114: 6167-6175. https://doi.org/10.1073/pnas.1701262114

Roncin N., Alban F., Charbonnel E., et al. 2008. Uses of ecosystem services provided by MPA: How much do they impact the local economy? A southern Europe perspective. J. Nat. Conserv. 16: 256-270. https://doi.org/10.1016/j.jnc.2008.09.006

Russ G.R., Alcala, A.C., Maypa A.P. et al. 2003. Spillover from marine reserves: the case of Naso vlamingii at Apo Island, the Philippines. Mar. Ecol. Progr. Ser. 264: 15-20. https://doi.org/10.3354/meps264015

Sala E., Giakoumi S. 2017. No-take marine reserves are the most effective protected areas in the ocean. ICES J. Mar. Sci. 75: 1166-1168. https://doi.org/10.1093/icesjms/fsx059
Sala E., Costello C., Dougherty D., et al. 2013. A general business model for marine reserves. PLoS ONE 8: e58799. https://doi.org/10.1371/journal.pone.0058799
Sala E., Mayorga J., Bradley D., et al. 2021. Protecting the global ocean for biodiversity, food and climate. Nature 592 (7854): 397-402. https://doi.org/10.1038/s41586-021-03371-z
Samy M., Lizaso J.S. 2011. Status of marine protected areas in Egypt. Anim. Biodiv. Conserv. 34: 165-177. https://doi.org/10.32800/abc.2011.34.0165
Seenprachawong U. 2016. An economic analysis of coral reefs in the Andaman Sea of Thailand. In: Olewiler et al. (Eds), Marine and Coastal Ecosystem Valuation, Institutions, and Policy in Southeast Asia, pp. 31-45, Springer, Singapore. https://doi.org/10.1007/978-981-10-0141-3_3
Selig E.R., Bruno J.F., 2010. A global analysis of the effectiveness of marine protected areas in preventing coral loss. PLoS ONE 5: e9278. https://doi.org/10.1371/journal.pone.0009278
Smith M.D., Zhang J., Coleman F.C. 2006. Effectiveness of marine reserves for large-scale fisheries management. Can. J. Fish. Aquat. Sci. 63: 153-164. https://doi.org/10.1139/f05-205
Smith M.D., Zhang J., Coleman F.C. 2007. Structural modeling of marine reserves with Bayesian estimation. Mar. Res. Econ. 22: 121-136. https://doi.org/10.1086/mre.22.2.42629548
Stelzenmüller V., Maynou F., Martín P. 2007. Spatial assessment of benefits of a coastal Mediterranean Marine Protected Area. Biol. Conserv. 136: 571-583. https://doi.org/10.1016/j.biocon.2007.01.002
Stelzenmüller V., Maynou F., Bernard G., et al. 2008. Spatial assessment of fishing effort around European marine reserves: implications for successful fisheries management. Mar. Poll. Bull. 56: 2018-2026. https://doi.org/10.1016/j.marpolbul.2008.08.006
Stobart B., Warwick R., González C., et al. 2009. Long-term and spillover effects of a Marine Protected Area on an exploited fish community. Mar. Ecol. Progr. Ser. 384: 47-60. https://doi.org/10.3354/meps08007
Tawake A., Parks J., Radikedike P. et al. 2001. Harvesting clams and data involving local communities in monitoring can lead to conservation success in all sorts of unanticipated ways: a case in Fiji. Conserv. Practice 2: 32-35. https://doi.org/10.1111/j.1526-4629.2001.tb00020.x
Teh L.C., Teh L.S., Chung F.C. 2008. A private management approach to coral reef conservation in Sabah, Malaysia. Biodiv. Conserv. 17: 3061-3077. https://doi.org/10.1007/s10531-007-9266-3
The Research Group LLC. 2021. Interactive model user guide for the broadscale spatial analysis of Oregon nearshore fisheries. Update 2017-2019 Base Period. Prepared for the Marine Reserve Program and Marine Resources Program, Oregon Department of Fish and Wildlife. 53 pp.
Thorbjørnsen S.H., Moland E., Huserbråten M.B.O., et al. 2018. Replicated marine protected areas (MPA) support movement of larger, but not more, European lobsters to neighbouring fished areas. Mar. Ecol. Progr. Ser. 595: 123-133. https://doi.org/10.3354/meps12546
Tongson E., Dygico M. 2004. User fee system for marine ecotourism: The Tubbataha Reef experience. Coast. Manag. 32: 17-23. https://doi.org/10.1080/08920750490247463
Tupper M., Rudd M.A. 2002. Species-specific impacts of a small marine reserve on reef fish production and fishing productivity in the Turks and Caicos Islands. Environ. Conserv. 29: 484-492. https://doi.org/10.1017/S0376892902000346
Uyarra M.C., Gill J.A., Côté I.M. 2010. Charging for nature: marine park fees and management from a user perspective. Ambio 39: 515-523. https://doi.org/10.1007/s13280-010-0078-4
Vandeperre F., Higgins R.M., Sánchez-Meca J. et al. 2011. Effects of no-take area size and age of marine protected areas on fisheries yields: a meta-analytical approach. Fish Fish. 12: 412-426. https://doi.org/10.1111/j.1467-2979.2010.00401.x
Vianna G.M.S., Meeuwig J.J., Pannell D., et al. 2011. The socio-economic value of the shark-diving industry in Fiji. Australian Institute of Marine Science. Perth: University of Western Australia, 26 pp.
Vianna G.M.S., Meekan M.G., Pannell D.J., et al. 2012. Socio-economic value and community benefits from shark-diving tourism in Palau: a sustainable use of reef shark populations. Biol. Conserv. 145: 267-277. https://doi.org/10.1016/j.biocon.2011.11.022
Waldron A., Adams V., Allan J. et al. 2020. Protecting 30% of the planet for nature: costs, benefits, and economic implications: Working paper analysing the economic implications of the proposed 30% target for areal protection in the draft post-2020 Global Biodiversity Framework. Campaign for Nature, Conservation Science Group, University of Cambridge, UK, 58 pp.
Walls K., Gordon D.P. 2017. Bill Ballantine (1937-2015), a father of marine reserves. Biol. Conserv. 211: 189-192. https://doi.org/10.1016/j.biocon.2017.04.012
Whitmarsh D., James C., Pickering H., et al. 2002. Economic effects of fisheries exclusion zones: a Sicilian case study. Mar. Res. Econ. 17: 239-250. https://doi.org/10.1086/mre.17.3.42629366
Williams I.D., Walsh W.J., Claisse J.T., et al. 2009. Impacts of a Hawaiian Marine Protected Area network on the abundance and fishery sustainability of the yellow tang, Zebrasoma flavescens. Biol. Conserv. 142: 1066-1073. https://doi.org/10.1016/j.biocon.2008.12.029
Worm B. 2016. Averting a global fisheries disaster. Proc. Nat. Acad. Sci. 113 (18): 4895-4897. https://doi.org/10.1073/pnas.1604008113
Yamasaki A. 2002. Establishment of preserved area for snow crab Chionoecetes opilio and consequent recovery of the crab resources. Fish. Sci. 68: 1699-1702. https://doi.org/10.2331/fishsci.68.sup2_1699
Young E., Bilgre B. 2002. Hoi Chan Marine Reserve Management Plan. San Jose, Costa Rica: World Conservation Union, Pizarro F. Ed., IUCN. https://portals.iucn.org/library/sites/library/files/documents/2002-015.pdf
Zhao Q., Stephenson F., Lundquist C., et al. 2020. Where Marine Protected Areas would best represent 30% of ocean biodiversity. Biol. Conserv. 244: 108536. https://doi.org/10.1016/j.biocon.2020.108536