A Proposal for Marine Spatial Planning of Ecuador's Exclusive Economic Zone around the Galapagos Marine Reserve

Context

The Galapagos Islands lie approximately one thousand kilometers to the west of mainland Ecuador in the Eastern Tropical Pacific (ETP). Located in the confluence of major oceanic currents, the waters surrounding them are an oasis of marine life and productivity, due to upwelling of deep, cold and nutrient-rich waters that rise to the surface after colliding with the islands and their shallow surrounding waters. The platform upon which the islands lie has an average depth of 200 m, compared to the surrounding ocean floor, which extends to depths greater than 3500 m. The Galapagos Islands function as a natural aggregation spot for marine life, from birds to whales. The surrounding Exclusive Economic Zone (EEZ), extends 200 nautical miles (Nm) from the islands, and contains the Marine Reserve, which extends 40 Nm from a baseline drawn around the coastlines of the major islands. This EEZ provides ecosystem services to several key components of Ecuador's economy, including supporting nature-based tourism at the islands and the fishing industry.

The unique biodiversity of Galapagos and the economic wellbeing of its people are intrinsically dependent upon the ocean. In the 1980s and 1990s, increasing industrial fishing intensity around the islands, rapid population growth on the islands, and concerns about the population status of key coastal species, led Ecuador to show global leadership by creating the Galapagos Marine Reserve (GMR). At the time of its creation in 1998, the GMR, covering an ocean area of 133,000 km^2, was the second largest marine protected area globally (today, it is the 33rd)[1].

Since its establishment, the GMR has contributed to the conservation of species and marine ecosystems throughout the ETP. However, current global changes pose significant conservation challenges, especially those related to the effects of climate change, overfishing and illegal fishing, as well as the survival of threatened and highly migratory marine species. In the light of these challenging and competing conditions, it is crucial to strengthen the protection of the open water ecosystems around the GMR, and to ensure the sustainable use of marine resources throughout the EEZ surrounding the islands.

Photo: Cesar Peñaherrera

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Photo: Sofía Green

Photo: Sofía Green

New marine conservation challenges in the 21st century

Nearly a quarter of a century after the establishment of the GMR, populations of coastal-marine species have benefited from having their key habitats protected from large-scale fishing. Additionally, scientific studies show that the catch of commercially important tuna species per fishing set has nearly doubled in the areas adjacent to the GMR[2]. This phenomenon, also known as the 'spillover' effect, occurs when species located in an area where they are protected for a portion of their life cycle and that has allowed them to grow and/or breed, move to adjacent fishing grounds where they are caught, in larger numbers or larger sizes.

Despite these accomplishments, the current size of the GMR has not been sufficient to provide conservation benefits to highly migratory species and to those that forage outside the protected area, in particular sharks, sea turtles and seabirds. During the establishment of the GMR in the 1990s, knowledge about the biology and movement patterns of several key threatened migratory species was very limited. As illustrated in Table 1 in a list of over 20 threatened migratory species, the conservation status of the majority of these species has worsened since the start of the 21st century, while only one species: the olive ridley sea turtle, has shown signs of recovery.

Table 1

Main migratory marine species of the Eastern Tropical Pacific and changes in their conservation status over the past 20 years. **Red:** species whose status has worsened, **yellow:** species whose status has remained the same, **green:** species whose status has improved, **white:** species at lower risk.

		IUCN Red List Status		
Species	**Common Name**	**1998–2000**	**2020**	**Change**
Carcharhinus falciformis	Silky shark	LR/NT	VU	
Carcharhinus longimanus	Oceanic whitetip shark	LR/NT	CR	
Sphyrna lewini	Scalloped hammerhead shark	LR/NT	CR	
Sphyrna zygaena	Smooth hammerhead shark	LR/NT	VU	
Sphyrna mokarran	Great hammerhead shark	DD	CR	
Alopias pelagicus	Pelagic thresher shark	VU (2009)	EN	
Isurus oxyrinchus	Shortfin mako shark	VU	EN	
Isurus paucus	Longfin mako shark	VU	EN	
Rhincodon typus	Whale shark	VU	EN	
Dermochelys coriacea	Leatherback turtle	EN	CR	
Phoebastria irrorata	Waved albatross	VU	CR	
Zalophus wollebaeki	Galapagos sea lion	VU	EN	
Arctocephalus galapagoensis	Galapagos fur seal	VU	EN	
Mobula birostris	Giant manta	VU (2011)	EN	
Alopias superciliosus	Bigeye thresher shark	VU (2009)	VU	
Chelonia mydas	Green turtle	EN	EN	
Eretmochelys imbricata	Hawksbill turtle	CR	CR	
Pterodroma phaeopygia	Galapagos petrel	CR	CR	
Balaenoptera musculus	Blue whale	EN	EN	
Physeter macrocephalus	Sperm whale	VU	VU	
Lepidochelys olivacea	Olive ridley turtle	EN	VU	
Carcharhinus galapagensis	Galapagos shark	NT	LC	
Carcharhinus limbatus	Blacktip shark	NT	NT	
Galeocerdo cuvier	Tiger shark	NT	NT	
Prionace glauca	Blue shark	NT	NT	
Creagrus furcatus	Swallow-tailed gull	LC	LC	
Fregata menor	Frigatebird	LC	LC	
Sula granti	Nazca booby	LC	LC	
Sula nebouxii	Blue-footed booby	LC	LC	
Sula sula	Red-footed booby	LC	LC	

Critically Endangered **(CR)**	Near Threatened **(NT)**	Status worsened
Endangered **(EN)**	Least Concern **(LC)**	No change
Vulnerable **(VU)**	Data Deficient **(DD)**	Status improved
		Not at risk

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Photo: Jonathan R. Green

Photo: Alex Hearn

Despite belonging to very different taxonomic groups, sharks, sea turtles and seabirds have distinct characteristics in common, such as a long life expectancy, late onset of sexual maturity and low reproductive and natural mortality rates. These traits make these species especially vulnerable to population collapses if their mortality rates increase due to anthropogenic activities, particularly fisheries bycatch and illegal fishing.

Over the past 20 years, scientific knowledge about highly mobile or migratory species in the region has increased significantly. While it is true that the Galapagos Islands are a marine biodiversity hotspot, and that the GMR is crucial for the survival of many species, the current level of protection is insufficient for these wide ranging and migratory species, many of which forage in oceanic ecosystems or migrate to other habitats located over 3000 km away from the islands, in some cases following well-established migratory routes[3,4,5] as illustrated in Table 2.

Table 2 | Examples of some of the most endangered marine migratory species according to the IUCN Red List and their critical habitats outside the GMR.

Species	Current IUCN Conservation Status	Important zones outside the GMR	Population Status
Scalloped Hammerhead Shark	Critically Endangered (2019)	They forage at seamounts outside the GMR and migrate along the Cocos Ridge to the Cocos Island National Park (Costa Rica).	Since the 1990s, the East Tropical Pacific population has decreased by 50%[6].
Whale Shark	Endangered (2016)	The aggregations of adult females that visit the GMR, migrate along the Equatorial Front in international waters as well as between Galapagos and the Ecuadorian coast.	The Indo-Pacific population is estimated to have decreased by 63% over the last three generations (75 years)[7].
Waved Albatross	Critically Endangered (2018)	Over 99% of the population nests on Española Island in Galapagos. Their foraging behavior changes as the reproductive season progresses. They utilize areas southeast of the GMR, extending to the coasts of Peru and mainland Ecuador.	It is estimated that the population has decreased by 12% since 2001, and by 30-49% in the last three generations[8].
Leatherback Turtle	Critically Endangered (2013), East Pacific population	After nesting primarily on beaches in Costa Rica, they migrate along the Cocos Ridge to the Galapagos Islands. Then, they disperse throughout the Central Pacific.	This population has decreased by 97% over the last three generations[9].
Green Turtle	Endangered (2004)	They migrate between the Galapagos Islands, which is their most important nesting site in the entire East Pacific, and other foraging grounds such as Cocos Island and mainland Ecuador.	Studies between 1976-2001 suggest that the population is stable, but there is uncertainty regarding its current status[10].


Photo: Alex Hearn


Photo: Julio Vizuete


Photo: Alex Hearn


Photo: Jonathan R. Green

In recent years, marine conservation has placed greater emphasis on oceanic ecosystems and their associated geological features. For example, seamounts are important aggregation sites and may be used as navigational waypoints by both endangered and commercially important species. There are two main seamount chains associated with Galapagos: the Carnegie Ridge which physically connects Galapagos with mainland Ecuador, and the Cocos Ridge that connects Galapagos with Cocos Island and Costa Rica. The regional connectivity that these ridges provide is crucial to generating resilience and maintaining genetic diversity among migratory marine species. Conservation and spatial management strategies that focus on including key seamount areas have a high potential of maintaining the ecosystem services they provide.

Beyond the conservation of endangered migratory marine species and key oceanic ecosystems, ensuring the sustainability of marine resources in the ETP region has become increasingly challenging. According to the 2019 annual report of the Inter-American Tropical Tuna Commission (IATTC), there are warning signs for the populations of commercially important tuna species such as bigeye tuna, yellowfin tuna and skipjack tuna, which form the basis of Ecuador's industrial tuna fishery[11]. It is crucial to maintain the populations of these species in good condition to guarantee the economic benefits for the fishing industry and long-term food security for the people of Galapagos and mainland Ecuador.

Significant current threats

Illegal Fishing and Unsustainable Fishing Practices

Present-day threats to fisheries are very different from those of the 1990s. Currently, one of the main problems is illegal fishing by national, Ecuadorian vessels that enter the protected waters of the GMR. According to statistics from the Galapagos Park Directorate, between 2018 and 2020, 136 fishing vessels were intercepted inside the GMR[12]. Local fishermen have expressed their concern regarding the presence of smaller longline fishing vessels (which do not carry tracking devices) inside fishing zones within the GMR that are intended to support local economies. Likewise, illegal fishing by international vessels is another major concern for all countries in the ETP. According to data from Global Fishing Watch, between 2012-2018, vessels from at least 13 countries carried out fishing operations inside the Ecuadorian EEZ around Galapagos[13].

Since the mid-1990s, the national fleet has significantly increased its fishing capacity and intensity in the waters surrounding the GMR. In 2000, the IATTC established a regional maximum capacity of 158,000 m^3 for the purse-seine fishery. However, the current capacity is 253,000 m^3. Nationally, the industrial fishing fleet has grown from 47 vessels in 1997 to 116 vessels in 2019[14,15]. Likewise, tuna catches within the Galapagos EEZ have doubled since the start of the 21st century. The semi-industrial longline fleet has the capacity for 'mother ships' to tow up to 12 smaller vessels to Galapagos and beyond, in search of tuna, billfish and sharks[16]. Furthermore, reports show that foreign vessels are fishing intensively in those international waters around the EEZ. This increase in fishing effort could negatively affect the sustainability of national marine resources today and in the future.

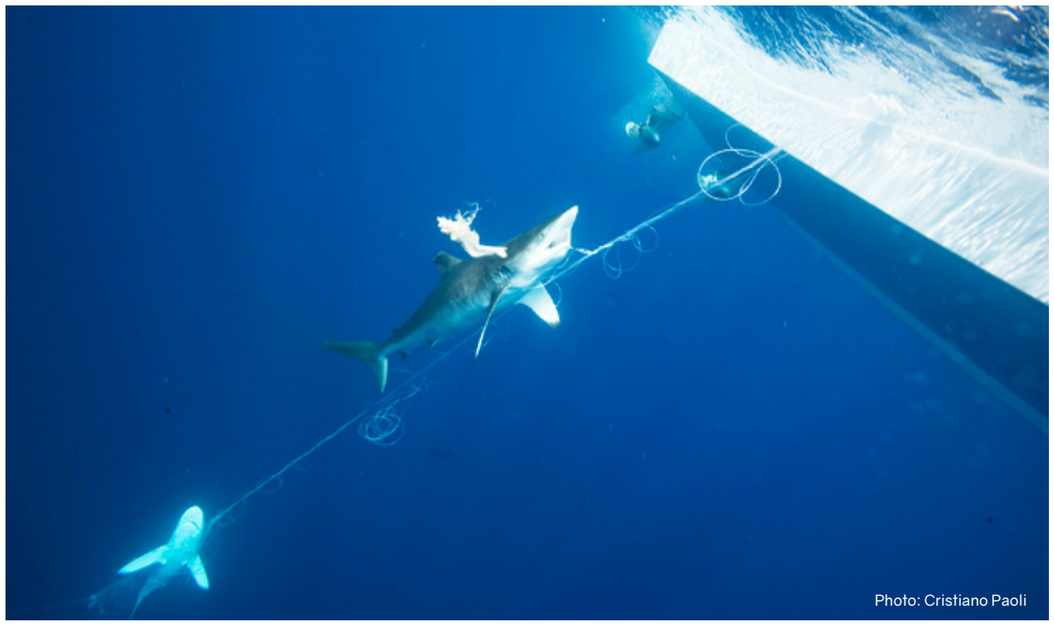

Photo: Cristiano Paoli

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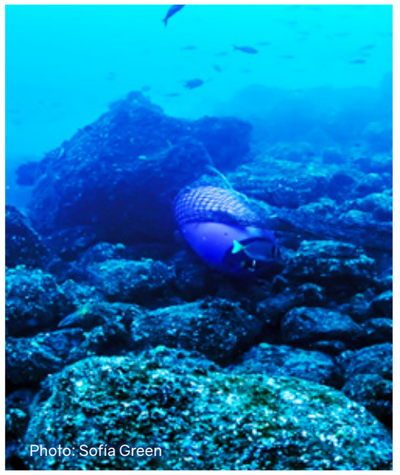

Photo: Sofia Green

Photo: Sofia Green

The use of Fish Aggregation Devices (FADs) in the ETP region has become widespread since the 1990s. FADs attract and aggregate commercially important fish species such as tuna as well as protected species such as silky sharks. In general, FADs do not increase productivity, but rather concentrate fish and intensify their capture. Because of this, if not used responsibly, FADs can lead to overfishing. In the early 1990s, less than 5% of purse-seine sets used FADs while currently, around 70% of sets employ FADs[17]. The Ecuadorian tuna fishing fleet is one of the fleets that use the most FADs in the region. Although the percentage of bycatch obtained by fisheries using FADs has decreased from 15-20% in the 1990s to 2-3% at present[18], the volume of by-catch is still significant given the large and targeted fishing effort that FADs facilitate. In other words, percentage of by-catch is not an appropriate indicator of the impact of fishing on a species or group of species, because the impact will depend rather on the proportion of the population of each species caught. This applies to several endangered species of sharks such as silky and hammerhead sharks.

The Galapagos artisanal fishing sector is concerned about the increased use of FADs around the GMR. They are also concerned that FADs are also starting to be deployed in areas east of the GMR boundary, allowing them to drift with the South Equatorial Current across the reserve, essentially expanding the scale of fisheries capture for the schools of fish attracted to the FADs which subsequently drift outside the reserve. This practice could be negatively affecting the catches of locally important species such as wahoo and yellowfin tuna. Additionally, it could affect resident populations of threatened sharks that associate with FADs. Finally, FADs may pose a collision risk to Galapagos fishers, especially when operating at night.

Significant current threats

Climate Change

According to the projections of the Intergovernmental Panel on Climate Change (IPCC), within the ETP region, fisheries productivity in the EEZ around Galapagos may be less affected than coastal areas, particularly the upwelling sites influenced by the Humboldt and Cromwell cold currents[19]. This will likely result in increased fishing pressure in the waters around Galapagos by vessels that, until now, have fished elsewhere. This pattern is already occurring on both national and international levels, as shown by the growing scale and presence of foreign vessels along the borders of the Galapagos EEZ in recent years.

Thus, it will be imperative to safeguard national interests against this situation. For this reason, the IPCC identifies the ETP as an area that is at risk of facing complex fishing governance challenges.

Although at a regional scale the temperature of the ETP has increased by 0.4-0.8 °C in the last 40 years, there is no clear trend regarding the surface sea temperature in the waters surrounding Galapagos over the past 100 years[20]. However, the expected oceanographic changes in the EEZ around Galapagos throughout this century are:


Photo: Sofía Green


Photo: Alex Heaarn


Photo: Julio Vizuete


Photo: Alex Hearn

- Sea surface temperature rise
- Increased intensity and frequency of El Niño and La Niña events
- Sea level rise (several centimeters)
- Increased precipitation
- Increased ocean acidification
- Reduced upwelling

Based on the observed behaviors in the past El Niño events, the foraging areas of endemic species (fur sea lions, sea lions, flightless cormorants, among others) are expected to expand as sea surface temperature rises and marine productivity decreases[21]. Similarly, the reproductive rates of these species could also decline, and the distributions of other oceanic species may shift over time.

Goals for Spatial Planning of the EEZ around Galapagos

The following goals should be considered during discussions on strategies to strengthen protection of open waters around the Galapagos Marine Reserve:

- Implement ecosystem-based management through marine spatial planning of the entire EEZ surrounding Galapagos, to ecologically connect and maintain the benefits of oceanic ecosystems and the services they provide.
- Ensure, through the creation of responsible fishing zones and control of illegal fishing, that national fleets have exclusive access to spillover effects arising from increased protection.
- Protect the current GMR from illegal fishing.
- Support measures to build economic and ecological resilience to mitigate the impacts of climate change on species of both commercial and conservation interests.
- Protect highly productive areas and cold-water refugia: upwelling events related to seamounts and persistent frontal zones.
- Maintain and protect the unique genetic resources of the GMR (for example, endemic species which may forage outside the current reserve) and maintain genetic diversity of highly migratory species.
- Protect migratory routes to maintain and strengthen connectivity of threatened marine species between biologically important areas (for example the Coco-Galapagos Swimway) across the ETP region.
- Support measures to reverse the declining population trends of migratory species and of species that forage in open waters around the GMR.
- Support Sustainable Development Goal 14 and its targets aimed to protect and sustainably utilize the oceans and marine resources in order to maintain ecosystem services and economic benefits in the long term.

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Photo: Alex Hearn

Photo: Anonymous

Building the Proposal

The construction of this proposal is based on a technical-scientific process, using an ecosystem-based and precautionary approach. This work brings together the experience and knowledge of an interdisciplinary team comprised of national and international researchers with extensive experience in different fields such as conservation and management of oceanic ecosystems, open water species and habitats (particularly those surrounding the Galapagos), climate change and its impacts on marine environments, and management of fisheries resources and fisheries economics. Several scenarios were considered and compared (see Annex 1 for details). The key inputs for the scientific and technical analysis of this proposal and the comparison with other alternative scenarios, included provision of:

- Spatially explicit information for 54 conservation targets (see Annex 2 for details) that include ecological processes, seamounts as critical oceanic habitats as well as the distribution and, where available, foraging areas and/or migratory routes of threatened marine species; and catches of commercial species.
- Data on bycatch intensity of the longline fishing fleet outside the GMR.
- Oceanographic modeling to estimate the effects of FADs in the EEZ surrounding Galapagos.
- Knowledge from local fishers about key areas in Galapagos for artisanal fishing that attract illegal fishing.
- Information generated by other existing regional marine conservation initiatives.

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A Holistic Ecosystem-Based Proposal

This proposal to strengthen protection of oceanic environments around the GMR is based on an integrated ecosystem-based management approach of the entire EEZ surrounding Galapagos. As such, it envisages the creation of different zones:

1. **A new marine reserve** extending over 445,953 km^2, where extractive activities are not permitted and that protects critical oceanic ecosystems as well as migratory routes and foraging areas of endangered marine species.
2. **Two Responsible Fishing Zones (RFZs),** available to user groups through exclusive access-type agreements (such as territorial user rights), to be discussed and defined with user groups. It cannot be affirmed that current fishing levels in these zones are sustainable, however, there are significant levels of by-catch, so careful management and effective monitoring will be required in the RFZs. In both zones, there should be a commitment to move towards 100% observer coverage (either physical or through technology), to release all bycatch species, and to contemplate the use of catch quotas. The vision for these two RFZs is to transition towards sustainable, certified fisheries, and to encourage exploration of bycatch reduction techniques, and includes:

   2a. Responsible fishing zone of 195,849 km^2 located west of the current GMR that includes the most important fishing areas for the purse-seine tuna fishing fleet and the semi-industrial longline fleet, as well as two spillover areas towards the north and south of the main fishing grounds.

   2b. Responsible fishing zone free of FADs that extends over 29,534 km^2. Scientific studies show that FADs placed east of the Galapagos have a high probability of entering the marine reserve, thus negatively affecting biodiversity and artisanal fishing operating inside the GMR.

3. **El Niño Buffer Zone** is an area of 33,852 km^2 that is included in responsible fishing zone 2a, but during years where an El Niño event is declared, this will be a de facto No-Take Area here as a precautionary measure for endemic species that would not normally leave the GMR, but whose foraging ranges expand during these seasonal events.

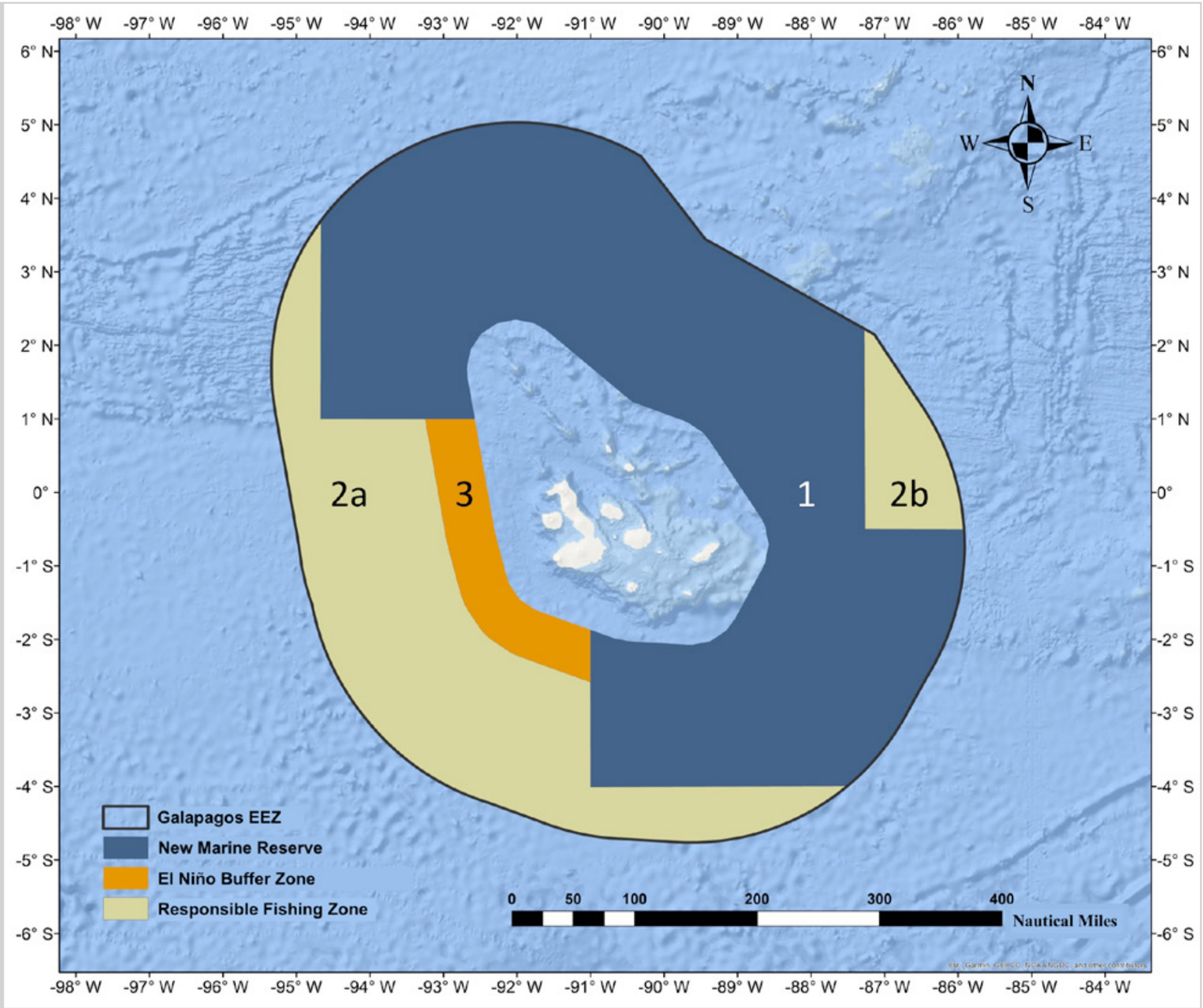

Figure 1. Proposal for integrated management of the entire Galapagos (Ecuador) EEZ. The proposal contemplates the creation of a marine reserve area (**Zone 1, in blue**), where extractive activities are not permitted; and the creation of two Responsible Fishing Zones (**Zone 2, in green**), where fishing is permitted under certain conditions to manage activities sustainably. FADs would not be permitted in Zone 2b. **Zone 3 (in orange)** would be managed under the same conditions as Zone 2a, except during El Niño events, when it would become a temporary no-take zone.

Enhancing Conservation Goals, Coverage and Targets

The 445,953 km² of new marine protection will contribute to the conservation of oceanic ecosystems outside the GMR on three key ecosystem elements: ecosystem processes, seamounts as critical habitats and threatened migratory species. 53 out of 54 layers that represent these elements would be covered by the proposed protection in 50% or more of their distribution ranges. In terms of ecological processes, the upwelling events that occur west of the GMR are mostly protected by the current reserve. However, specific protection through the El Niño buffer zone is proposed for the years where upwelling weakens.
The Cocos and Carnegie ridges, which are important to guarantee connectivity of oceanic environments, are integrated into the new protection zone. Regarding the conservation benefits to threatened migratory species, the new protection zone would for example, cover 90% and 76% of the migratory routes of hammerhead shark and whale shark respectively; 91% of the foraging area of the waved albatross at the southeast of the Galapagos EEZ; and 77% of the leatherback turtle's critical habitat. In summary, the additional protection will encompass the most important zones already identified by several conservation initiatives in the ETP to ensure the health of oceanic ecosystems and to improve the survival probabilities of endangered species.

Photo: Jonathan R. Green

Photo: Sofia Green

Conservation Objectives

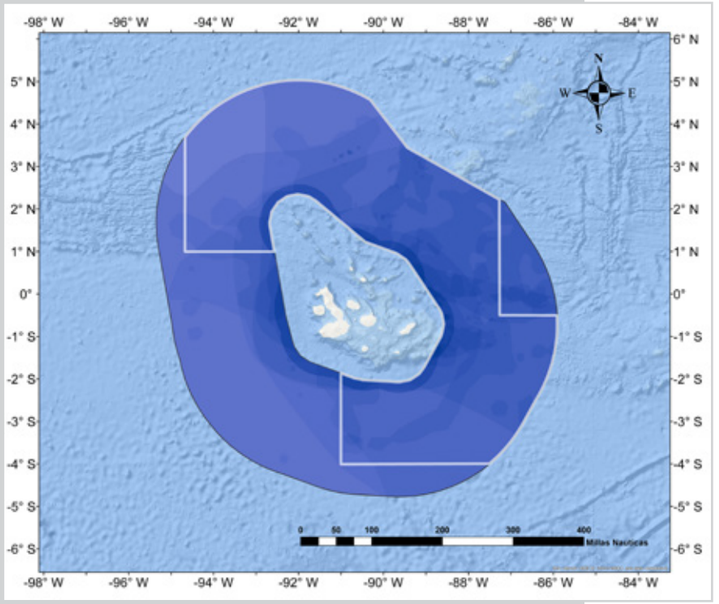

Figure 2. Conservation objectives achieved by the area proposed as a new marine reserve. We overlaid 54 geo-referenced conservation objective layers (for details see Annex 2), including distributions and migratory routes / foraging grounds for key species. The intensity of the blue within the Galapagos EEZ reflects the number of overlapping layers for each 4km² pixel.

Regional Conservation Initiatives

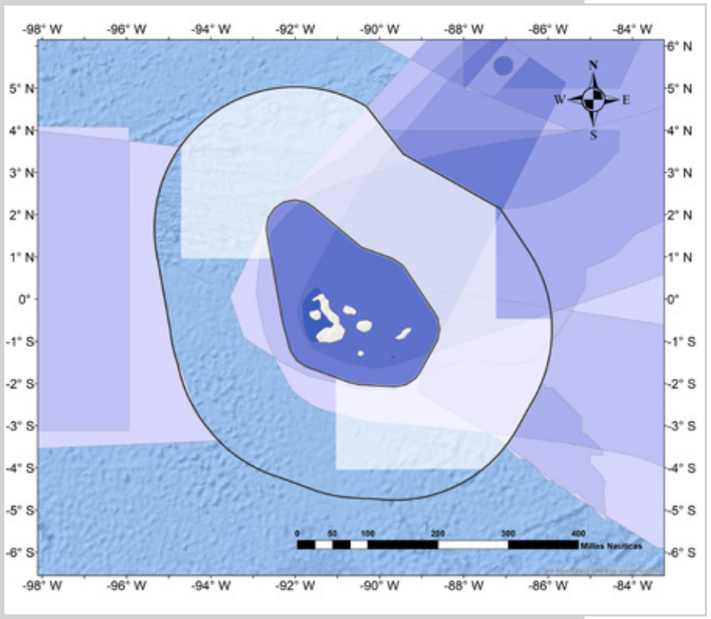

Figure 3. Overlay of 12 regional conservation initiatives for the Eastern Tropical Pacific (for details see Annex 2). The intensity of the blue reflects the number of overlapping layers for each 4km² pixel.

Ocean Productivity

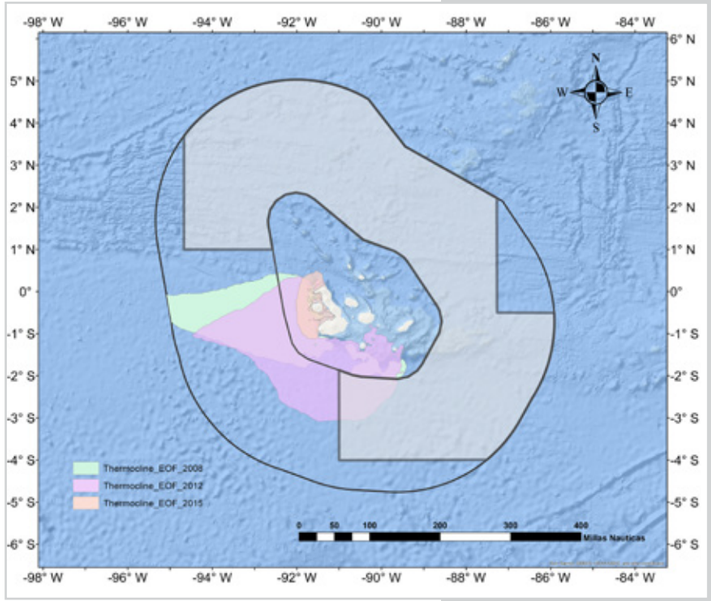

Figure 4. Ocean productivity layers, based on a biogeochemical oceanographic model developed by Southampton Oceanography Centre, for a neutral year (2012), en El Niño year (2015) and a La Niña year (2008).

Seamounts

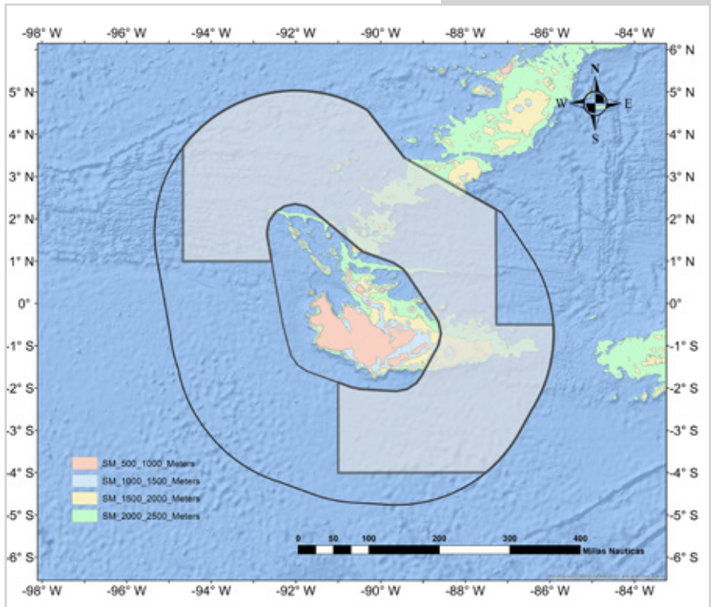

Figure 5. Location of seamounts. Using a 2019 bathymetric dataset, we created 500m-section depth layers to map the location of seamounts, from 0-1000m, 1000-1500m, 1500-2000m and from 2000-2500m.

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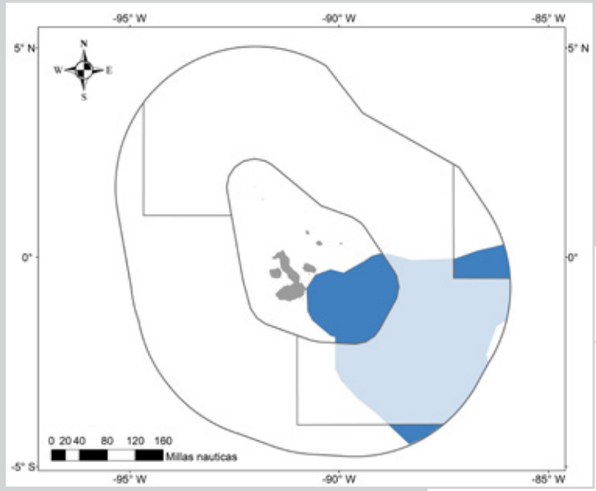

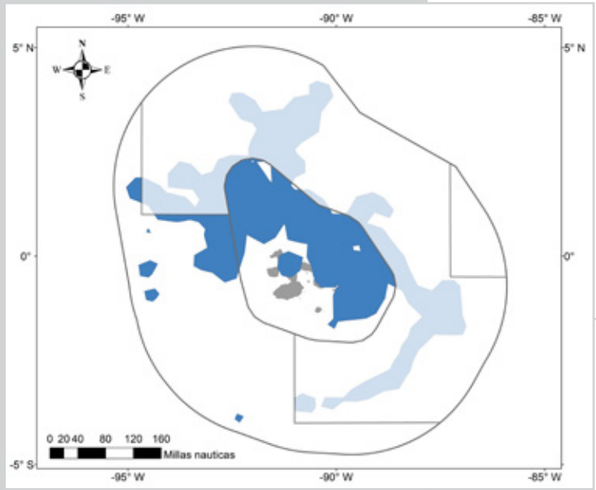

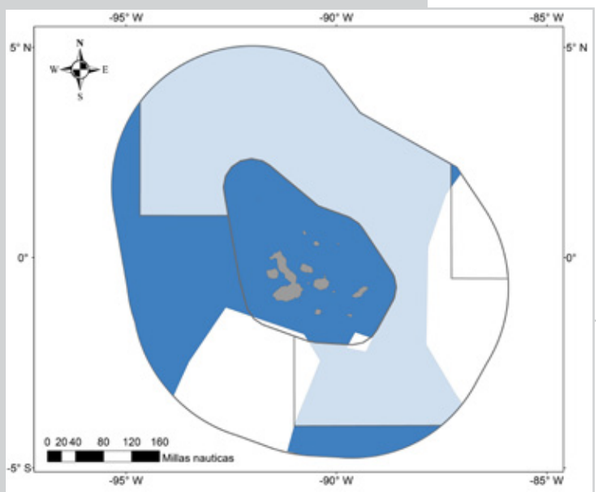

Figure 6. Key foraging grounds and/or migratory routes (in blue) for examples of Critically Endangered marine species, with new marine reserve area overlaid, to indicate its contribution towards the protection for each species.

Waved Albatross.

Under the proposed scenario, 91% of its foraging grounds to the southeast of the Galapagos EEZ would be protected.

Scalloped Hammerhead Shark

Under the proposed scenario. 90% of its migratory pathways and known foraging areas in the Galapagos EEZ would be protected.

Leatherback Turtle

Under the proposed scenario. 77% of its movement pathways in the Galapagos EEZ would be protected.

Responsible Fishing and Climate Resilience Zones

Fishery resources in the open waters around the GMR are important for national fleets. However, their exploitation involves significant levels of by-catch. The aim of this proposal is that the investment made in the form of creation of the no-take area should in the medium term help these fleets safeguard their livelihood, as occurred with the creation of the GMR in 1998. The contribution to the value of the total catch obtained in these oceanic ecosystems is not uniform throughout the Galapagos EEZ. In fact, the area in the southwestern part of the Galapagos EEZ is one of the most important zones for Ecuadorian fisheries as it represents 71% and 82% of the total value of catch from the EEZ around Galapagos. These zones would be open to fishing activities under a territorial user-rights, responsible management approach that is also adaptive to climate change. Under this approach, the proposal contemplates the creation of an El Niño buffer zone, which would come into effect during El Niño events to provide extra protection for fish stocks and potential expansion of foraging areas for endemic species. In these responsible fishing zones, the national fleets would have an exclusive benefit to any spillover effect caused by the new protected area.

Photo: Frida Lara

Photo: Frida Lara

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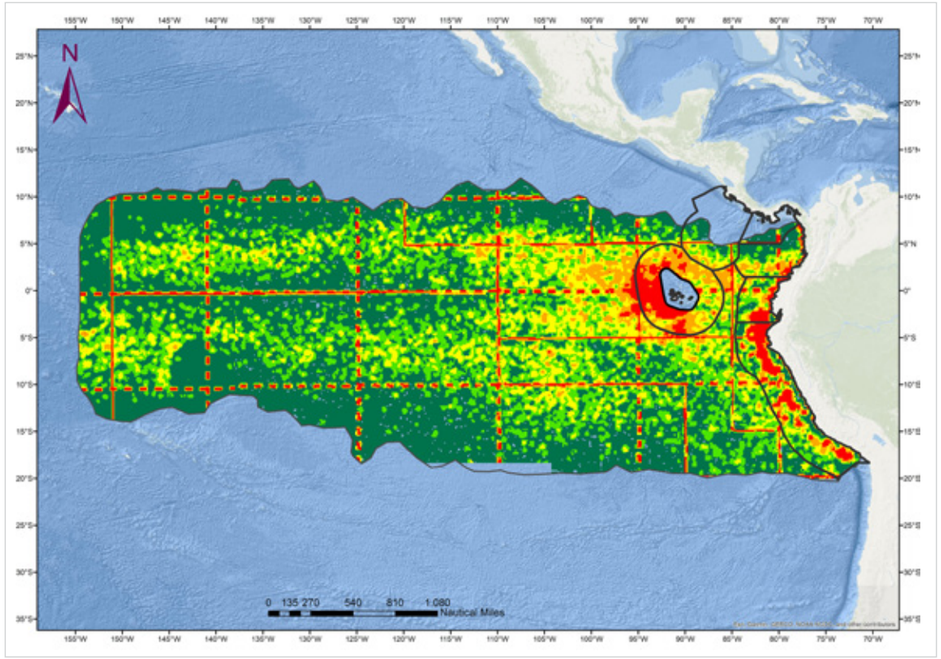
Photo: Sofía Green

Photo: Anonymous

It should be noted that with this additional protection, if exploited in a sustainable fashion, Ecuadorian vessels with access rights to these zones would not lose their catch from these areas because their target species are migratory and would be captured outside the reserve, in line with the same spillover effect that occurred after the establishment of the original GMR. Likewise, the fishery areas that generate 93.6% and 95.8% of the total catch value would remain accessible for the purse-seine tuna fishing fleet and the longline artisanal fishing fleet respectively (Figures 7 and 8).

Value of Industrial Tuna Fleet Catches



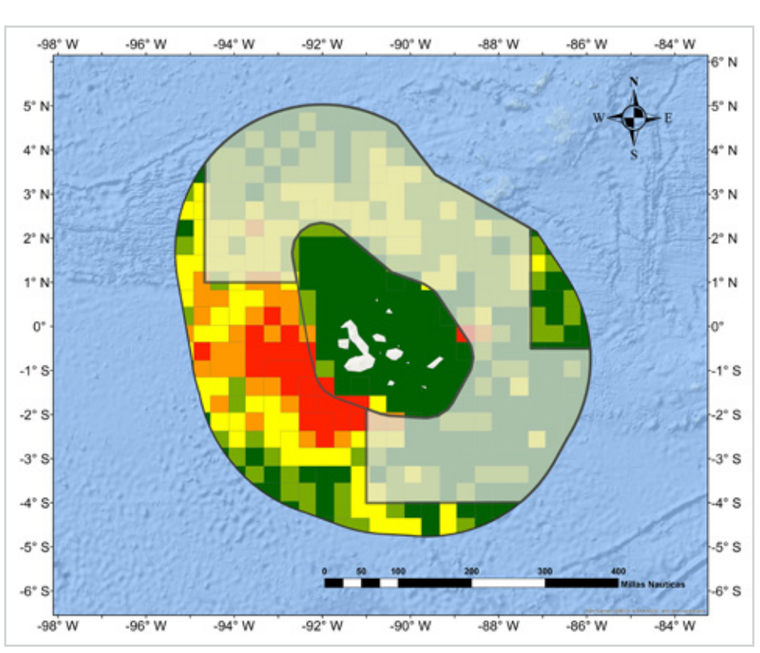
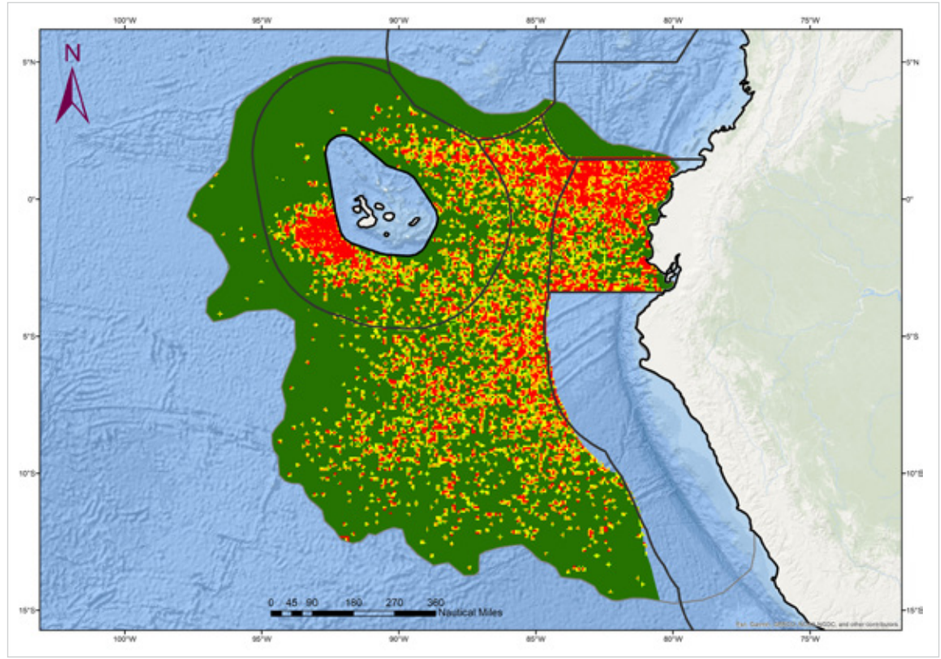


Figure 7. Spatial distribution of catch value for Ecuador's tuna purse seine fleet. **Above:** Total area of operation of the purse seine fleet (approx. 17.2 million km²). We mapped the value of the catch obtained for each 4km² pixel, on a scale of low (green) to high value (red). **Below:** Relative value for each 4km² pixel within the Galapagos EEZ on a scale of 0 (green) to 10 (red), with proposed new marine reserve overlaid.

Value of national longline fleet catches



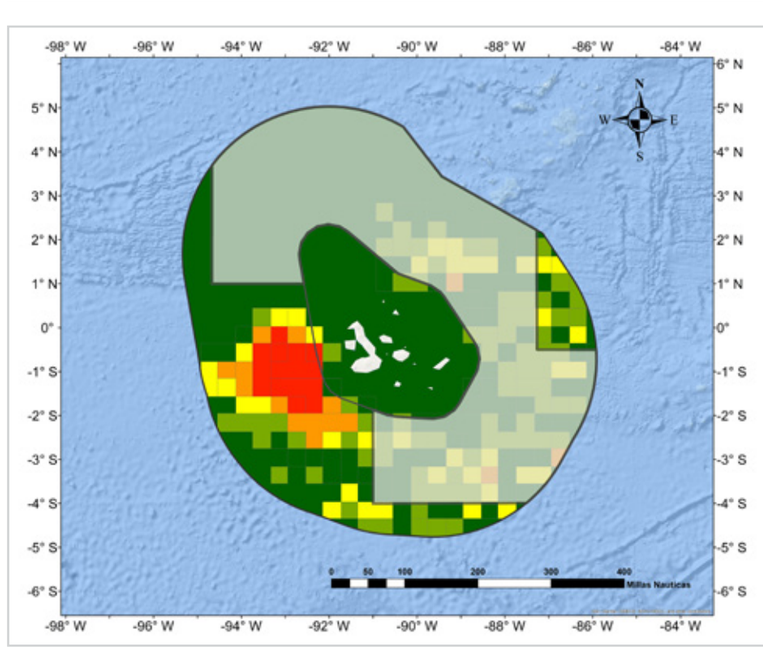


Figure 8. Spatial distribution of catch value for Ecuador's national longline fleet. **Above:** Total area of operation of the longline fleet (approx. 3.3 million km²). We mapped the value of the catch obtained for each 4km² pixel, on a scale of low (green) to high value (red). **Below:** Relative value for each 4km² pixel within the Galapagos EEZ on a scale of 0 (green) to 10 (red), with proposed new marine reserve overlaid.

Implementation: Key Steps

Successful implementation of this marine spatial planning proposal for the EEZ surrounding the Galapagos Islands will require additional steps to ensure that environmental, social and economic objectives are met.

These include:

Active stakeholder participation

There should be a nationwide analysis and discussion of this proposal including participation of relevant authorities and stakeholders, including the national fishing sector, civil organizations and non-profit groups.

Design and implementation of management strategies

Appropriate co-management of the EEZ surrounding Galapagos will require a clearly defined strategy and regulations. In particular, to ensure application and compliance of regulatory measures in the RFZs (such as territorial user rights mechanisms, bycatch mitigation techniques, catch quotas, eliminating the use of FADs in Zone 2b, moving towards 100% observer coverage, among others) both fishery and environmental authorities will need to work closely with the fishing sector to construct a sound governance structure. Furthermore, as the capacity for spatially and temporally explicit resource monitoring and control is improved, components of dynamic spatial management could be incorporated in these zones.

Photo: WildAid


Photo: WildAid

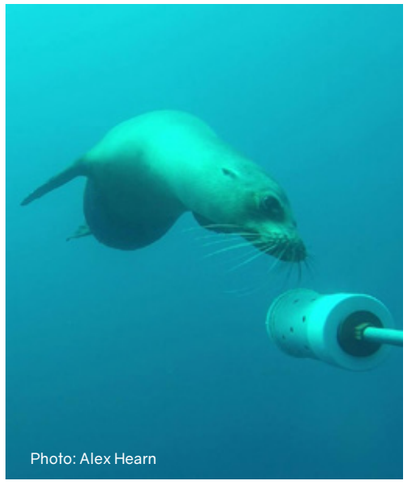


Photo: Alex Hearn


Photo: Alex Hearn

Control and enforcement mechanisms

There will be a need to develop an integrated control and enforcement strategy for both the new protected area and the RFZs, and this may incorporate new tracking technologies. A study is currently underway to analyze the costs that would be incurred, and thus help to inform the decision-making process.

Sustainable financing mechanisms

A sustainable financing mechanism is key to the successful implementation of this proposal. Several initiatives to create Trust Funds or similar structures are currently being explored. Coordination and integration of these different initiatives will facilitate the development of a solid long-term financial base.

Long term monitoring and research

Effective implementation of this proposal requires the design and implementation of a long-term research and monitoring program. This should encompass both the new marine reserve and the RFZs, to establish whether the management practices adopted are securing increases in fish stocks and recovery of endangered species, and if these gains continue as climate change progresses.

Long-Term Benefits for all Stakeholders

The marine spatial planning proposal for the EEZ surrounding Galapagos presented here is an investment that includes a combination of marine conservation, fishing and climate resilience strategies to provide benefits for all sectors with an integrative long-term perspective.

- **The national fishing fleets,** as the main user group of the Galapagos EEZ, will maintain access to their key fishing grounds in the most productive zones, and will be permitted to carry out their activities here under a responsible management approach that fosters long-term sustainable catches. Additionally, these fishing areas should benefit from enhanced levels of productivity through spillover effects caused by the new oceanic protected area, as occurred with the GMR.

- **The Galapagos artisanal fishery** will benefit from the reduction of illegal fishing inside the GMR, from the elimination of the risks posed by banning the use of FADs in the responsible fishing area to the east of the GMR, and by the spill-in effect of commercial species from the new no-take area into the GMR.

- **Conservation** of open water ecosystems encompassed by the proposed area will contribute to improving the protection of key oceanic habitats such as seamounts, of ecological processes such as upwelling that increase marine productivity and of endangered highly migratory species. All of these ecosystem elements will benefit from a new extension of protected critical habitats that will facilitate connectivity and recruitment between protected areas in the region and will generate resilience in the face of a highly changing environment.

- **Tourism** in marine protected areas of the Eastern Tropical Pacific, including Galapagos, is largely dependent on marine biodiversity, with highly mobile megafauna often the main attraction. By strengthening the protection of oceanic ecosystems and key migration routes for these species, their populations will be healthier and more abundant, indirectly benefiting the tourism activities in the Galapagos, and potentially throughout the region.

- **Civil society**, in general, will benefit through the conservation of biodiversity and marine habitats, as well as from the management of marine resources that ensure healthier and sustainable ecosystems in the region. These oceanic ecosystems around the Galapagos will contribute to food security and will provide various benefits to future generations, not only in Ecuador but also at regional and global scales.

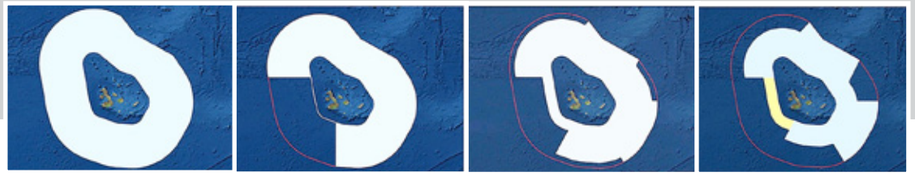
A Proposal for Marine Spatial Planning of Ecuador's Exclusive Economic Zone around the Galapagos Marine Reserve

Photo: Jonathan R. Green

Spatial management of the Galapagos EEZ through the creation of different zones will provide a significant contribution to the achievement of national, regional and global Sustainable Development Goals, through the protection and responsible management of marine resources. However, in order to ensure its successful implementation, it is vital to have tangible support from stakeholders, and the financial and management structure and capacity for adequate monitoring and enforcement.

A Proposal for Marine Spatial Planning of Ecuador's Exclusive Economic Zone around the Galapagos Marine Reserve

Annex 1: Comparison of different Galapagos EEZ spatial management scenarios evaluated.



Conservation				
Area of new marine reserve (km^2)	**445,953**	705,187	516,377	518,900	379,243
% Galapagos EEZ	**63%**	100%	73%	74%	54%
Conservation Objectives met (total: 54)	**53**	54	51	54	53
% Seamounts	**100%**	100%	100%	100%	100%
% Upwelling, neutral year	**52%**	100%	48%	78%	57%
% Leatherback turtle	**77%**	100%	27%	80%	67%
% Green turtle	**95%**	100%	97%	95%	93%
% Waved albatross	**91%**	100%	100%	98%	90%
% Hammerhead shark	**90%**	100%	91%	97%	86%
% Whale shark	**76%**	100%	85%	88%	74%

Fishing				
Responsible Fishing Zones (km^2)	**259,234**	0	188,810	186,287	325,944
% Value of purse seine catch in Galapagos EEZ	**71%**	0%	63%	25%	71%
% Value of longline catch in Galapagos EEZ	**82%**	0%	76%	27%	82%
% Total value of purse seine catch not in new reserve	**94%**	78%	92%	84%	94%
% Total value of longline catch not in new reserve	**96%**	77%	94%	83%	96%

Note: For conservation objectives, the values represent the percentage of each layer within the EEZ that would be protected by each no-take scenario.

Annex 2: Description of datasets used in analyses

Processes and Habitats
High productivity areas 2008 (La Niña)
High productivity areas 2012 (neutral)
High productivity areas 2015 (El Niño)
Seamounts<1000m
Seamounts 1000-1500m
Seamounts 1500-2000m
Seamounts 2000-2500m

Species Tracks
Silky shark
Blacktip shark
Galapagos shark
Blue shark
Whale shark
Tiger shark
Scalloped hammerhead shark
Green turtle
Leatherback turtle
Hawksbill turtle
Frigatebird
Waved albatross
Swallow-tailed gull
Galapagos petrel
Blue-footed booby
Galapagos sea lion

General Distributions
Pelagic thresher shark
Pelagic thresher shark
Galapagos shark
Oceanic whitetip shark
Shortfin mako shark
Longfin mako shark
Great hammerhead shark
Scalloped hammerhead shark
Smooth hammerhead shark
Silky shark
Blacktip shark
Tiger shark
Blue shark
Whale shark
Giant manta
Olive ridley turtle
Green turtle
Leatherback turtle
Hawksbill turtle
Swallow-tailed gull
Frigatebird
Waved albatross
Galapagos petrel
Blue-footed booby
Red-footed booby
Nazca booby
Galapagos fur seal
Galapagos sea lion
Sperm whale
Blue whale

A Proposal for Marine Spatial Planning of Ecuador's Exclusive Economic Zone around the Galapagos Marine Reserve

Existing Conservation Initiatives	
Government/Regional	**NGO**
CMAR- Eastern Tropical Pacific Marine Corridor	Alliance for Zero Extinction (AZE)
Ecologically or Biologically Significant Marine Areas (EBSA)	Swimways Initiative
Particularly Sensitive Sea Areas (PSSA)	Mission Blue Hope Spots
UNESCO Natural World Heritage Sites	Biodiversity Hotspots, Conservation International
Marine Protected Areas	Important Birdlife and Biodiversity Areas (IBA)
Spatial fishery measures	WWF Priority Marine Conservation Areas
Purse Seine Exclusion Zone "El Corralito" (IATTC)	
Costa Rica offshore purse seine exclusion zone	

Photo: Peter Winch

Photo: Jonathan R. Green

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