A Survey of Fishing Activity in 19 Marine Protected Areas

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Executive Summary

People around the world depend on healthy and abundant oceans for subsistence, recreation, and livelihoods. Yet our oceans are under threat from climate change, overfishing, illegal fishing, oil and gas drilling, and other destructive practices. To help protect our oceans, governments can establish marine protected areas (MPAs) in both coastal waters and far from shore and on the high seas for various reasons, from safeguarding valuable fisheries to protecting important habitats. MPAs serve a critical role in the ocean ecosystem by providing marine species a place to rebuild and flourish. Each protected area is unique and designed to safeguard the specific ocean wildlife and marine habitats within their boundaries, and each MPA has varying levels of protections from complete closures of the region to allowing certain types of fishing or other activities. Oceana investigated whether fishing boats and other vessels were following protection measures by identifying 19 protected areas around the world to take a deeper look **(Fig. 1)**. MPAs were selected to represent a variety of sizes, ages, habitats protected, protection measures, and geographies **(Appendix 1).** Using Global Fishing Watch (GFW),* we tracked vessel movement in and around these MPAs from January 2017 to December 2020.

Highlights include:

- Instances where fishing appeared to occur in protected areas and instances where vessels appeared to disable their electronic tracking systems, also called gap events, near the protected area's boundaries; o In 2020, a U.S.-flagged trawler appeared to turn off its electronic tracking system (also known as an automatic identification system, or AIS) for about 29 hours
  (over a day) on the eastern side of the Dry Tortugas Ecological Reserve **(Fig. 5).**
  - o There were 1,375 apparent gap events that occurred from 38 vessels within the Canal de Menorca Natura 2000 site in Spain from 2017 to 2020. This site appeared to have the most disappearances in AIS transmissions from a smaller number of fishing vessels present in the area. Trawlers were the most common type of vessels that appeared to turn off their AIS. They accounted for over half of all apparent AIS gap events in this study.
  - o There were seven apparent gaps in AIS transmission around the Huon Commonwealth Marine Reserve in Australia from 2017 through 2020. Five of these apparent gaps in AIS transmission were by the same Australian-flagged trawler.

- Protected areas that have been designated but have no management plans or official restrictions in place;
- Canal de Menorca Natura 2000 site in Spain still has no management plan in place, although it was established in 2014.
    - Fishing pressure within Canal de Menorca increased in 2018 and 2020 since it was proposed as a protected area.
    - All but two of the trawlers that fished in and around the Canal de Menorca site had at least one apparent gap in their AIS data.
- Clear violations of MPA restrictions on both fishing and shipping activities;
- The Cetáceos da Madeira Natura 2000 site in Portugal had one of the largest quantities of apparent fishing activity. Vessels within this site appeared to fish for a total of 18,873 hours. From 2017 to 2020, 859 tankers flagged to 39 countries came within the prohibited 30 nautical miles (NM) of the Aldabra Atoll World Heritage Site in Seychelles. Six cargo ships also passed through this site, violating the site's management plan.
- There were five sites that had more fishing within the boundaries of the protected area than within a 30 NM zone outside of the MPA.

Marine protected areas must be more than symbolic. These critical areas need management plans, monitoring, and enforcement to ensure that the wildlife, fisheries, and important habitat are protected. Expanding transparency of fishing can provide governments and fisheries managers with more tools to manage MPAs whether they are close to shore or on the high seas. Governments should:

- **Mandate transparency by requiring Automatic Identification System (AIS) use**: Governments and regional fishery management organizations should require the constant use of tamper-resistant AIS devices on all fishing vessels. These tracking systems are essential for transparency and public accountability of global fishing operations. In addition, they improve maritime safety, help combat illegal fishing, and increase compliance with laws and regulations.
- **Publicly release vessel monitoring system (VMS) data:** Governments should release VMS data to complement the AIS data and improve the surveillance of boats in areas where AIS reception varies. These are two distinct systems that are best used with one another.
- **Improve monitoring and enforcement**: Governments should monitor and enforce relevant fishing regulations for their fleets worldwide. Coastal states should monitor and control foreign vessels that are allowed to fish in their national waters.
- **Require management plans**: Governments must adopt clearly defined management plans soon after MPA designation and provide the management plans to the public. Precautionary restrictions on most harmful activities should apply as soon as sites are designated.

*= **Note**: Global Fishing Watch, a provider of open data for use in this report, is an international nonprofit organization dedicated to advancing ocean governance through increased transparency of human activity at sea. The views and opinions expressed in this report are those of the authors, which are not connected with or sponsored, endorsed, or granted official status by Global Fishing Watch. By creating and publicly sharing map visualizations, data, and analysis tools, Global Fishing Watch aims to enable scientific research and transform the way our ocean is managed. Global Fishing Watch's public data was used in the production of this publication.

Introduction

Healthy and abundant oceans are vital to the communities that depend on them for subsistence and survival. Fish and seafood products are key sources of animal protein for an estimated 3.1 billion people around the world and the primary source of animal protein for another 1 billion.[4] Fish and seafood are important sources of vitamins and nutrients like long-chain omega-3 fatty acids, iodine, vitamin D, and calcium. However, our oceans are threatened by overfishing, destructive fishing practices that destroy important habitat areas, illegal fishing that ignores the rules, and oil and gas drilling, among other threats. Protecting areas of the ocean is essential to combat this overexploitation by reducing fishing pressure and allowing fish and wildlife to recover.[1]

Marine protected areas (MPA) are places that are identified by governments and other management bodies as regions that need protection. With respect to fishing, these protections can range from no-take marine reserves to restrictions on certain types of fishing gear used or species targeted. Constraints may also include restrictions on recreational activity, dumping, transiting, oil and gas exploration, or vessel anchorage.[2] Protected areas can shelter endangered species, conserve biodiversity, and give marine wildlife a place to live, grow, and reproduce.[1] By creating MPAs, countries can safeguard and restore valuable marine resources to ensure future generations have access to a sustainable food supply and healthy oceans.[2]

MPAs vary greatly on their effectiveness of conservation measures based on how strict their protections are[1] and many other factors, including characteristics of the area like size and age, and community approval. MPAs are most effective at enhancing fish abundance and density when no fishing is allowed.[3] No-take reserves can have 343% higher biomass on average over reserves with only partial protections.[4] When there is reduced fishing pressure, fish become more abundant and grow larger, and these populations may then spill over into surrounding environments.[5] This spillover effect then increases the catch for fishermen in these areas, supporting their long-term livelihoods.[6] While moderately protected areas can be helpful, especially as part of a network of protected areas including no-take reserves, limited or weak restrictions on activities in protected areas often show little difference from unprotected areas in terms of fish abundance.[7] As of Sept. 26, 2022, the Marine Conservation Institute's Marine

Protection Atlas documented roughly 16,687 protected zones cover 8.1% of the global ocean. However, only 1,137 (about 1 in 14) are classified as fully or highly protected, where no fishing or resource extraction is allowed.[8]

While the focus of MPAs is often on reducing fishing pressure, some are specifically designed to protect valuable habitats and species from destructive fishing practices. Fishing gear comes in all shapes and sizes, and has varying impacts on marine habitat, wildlife and non-target fish. Bottom trawling uses large nets, weighted with heavy chains or doors that drag along the seafloor, effectively clear-cutting habitats like corals and sponges.[9] Trawling is indiscriminate,[9] catching all species in its path with high rates of bycatch: removing non-targeted fish and marine wildlife like marine mammals and sea turtles. Gillnets are mesh panels of varying size net that catch anything that tries to pass through them[10] and are notorious for catching non-target species much like trawling.[11,12] Gillnets can float at the surface, be anchored at the seafloor or fish in the water column.[10] Other gillnets are set to drift in the ocean currents to be retrieved by fishermen hours later.[10] These gill nets are often lost and become "ghost nets" that drift through the sea for years, continuing to catch and kill animals.[10] Longlining uses one fishing line that can be greater than 20 miles long and set with thousands of baited hooks.[13] Longlines often target swordfish and tuna, but also can seriously injure or kill seabirds, sharks, marine mammals, and turtles that are attracted to them.[14] There are many other types of fishing — in purse seining, a large net surrounds a school of fish then draws closed, while in dredge fishing, a metal grate with teeth is raked across the seafloor to collect shellfish. There is also pole-and-line fishing — the classic fishing rod. By limiting specific types of fishing gear within protected areas, managers can effectively protect specific marine wildlife, reduce bycatch, habitat destruction, and incidental take of important species.[15]

Responsible fisheries management is undermined by illegal, unreported, and unregulated (IUU) fishing, which ignores laws, is off the books, or is in an area or on a species that is not managed. This IUU fishing also threatens the effectiveness of MPAs. In less than three months, illegal fishing can reduce a healthy and productive MPA to an even worse state than before the MPA was established.[16] Expanding transparency of fishing vessels' activity is a valuable tool that would allow government and other management bodies to better monitor fishing and other vessel activity in and around MPAs. A low-cost and effective vessel tracking technology, such as an automatic identification system (AIS), provides one of the most promising datasets to achieve this goal.[17] AIS devices broadcast vessel position and identifying information, such as vessel name, flag state, and speed. Satellites and terrestrial receivers can detect these messages from vessels all over the world. Global Fishing Watch (GFW) — an international nonprofit developed in collaboration by Oceana, Google, and SkyTruth — analyzes AIS data to identify vessel movements and infer fishing activity and gear type, supplemented by registry information.

AIS data from GFW was used to survey fishing activity within 19 diverse MPAs between Jan. 1, 2017, and Dec. 31, 2020 **(Fig. 2).** These findings provide a snapshot of fishing and other vessel movements, potential illegal fishing in protected areas, and underscore the power of GFW data

for monitoring and enforcement of MPAs at scale. Increasing transparency and eliminating illegal fishing are crucial for the health of our oceans and coastal communities, and this report demonstrates the ubiquity and severity of this need.

Site-by-Site Findings

Marine Protected Areas, Parks, and Reserves

There are many types of MPAs, from national parks to marine reserves to internationally managed regions. The protected areas in this report are listed by the governing body under which they were established. Areas governed by multiple bodies are listed in the sections where they were first established. Analysis within the MPAs using the GFW platform identifies apparent fishing activity by vessel flag and by gear type and compares these to what is allowed within the area. This fishing activity is compared to the activity within a buffer zone that extends 10 nautical miles (NM) from the borders of the MPAs to standardize general fishing trends in the area. In areas with lower satellite coverage, the buffer zone serves as a control as the amount of detected fishing activity visible in the MPAs may change in these cases. In areas without any potential satellite coverage issues, the buffer zone can show whether vessels are active in the area targeting fish that migrate out of the MPA. The analysis identifies vessels that appear to go dark or disable their AIS equipment in and around the MPAs. MPAs were selected to represent a variety of sizes, ages, habitats protected, protection measures, and geographies **(Appendix 1).** The selected MPAs range in size from 391 to 9,991 sq. km, are between three and 50 years in age, and span 122 degrees of latitude and all inhabited continents **(Fig. 1)**. Further information about the GFW platform and detailed methodology can be found in the Appendix 1. This study had several difficulties, including finding management plans for each protected area — these were often not publicly available **(Table 3).** This lack of consistency and transparency of regulations and language used in rules (or in the names of the MPAs themselves) add to the challenges of management, monitoring, and enforcement of these protected areas.

There were six categories of protected areas evaluated in this study: United Nations Educational, Scientific, and Cultural Organization (UNESCO) biosphere reserves, UNESCO world heritage sites, Ramsar Convention sites, European Union's Natura 2000 sites, Oslo and Paris (OSPAR) Convention sites, and nationally protected areas. There were two to three sites selected for most of the categories (**Tables 1a-1b**) with the maximum number of eight sites in the nationally protected areas category **(Table 1c**). Methodology of the selections of the 19 MPAs in this study can be found in Appendix 1. These protected areas are located around the world and safeguard a wide range of habitats and unique marine resources **(Fig. 1).**

UNESCO

Biosphere Reserves

UNESCO biosphere reserves were first introduced in 1968. Currently 738 reserves span 6,812,000 sq. km across 134 countries.[18] These reserves are internationally designated protected areas that rely on local knowledge, encourage community engagement, and promote sustainability and conservation. To become a biosphere reserve, proposed sites must have a plan for sustainable development and cover several habitat types, including marine areas.[18] The exterior of each reserve is a "transition zone" where local people may reside and practice sustainable fishing and agriculture.[18] Beyond this is the "buffer zone," where activities such as research and education are permitted.[18] (Note: The "buffer zones" in biosphere reserves are distinct from the 10 NM buffer zones used for analytical purposes in this report.) At the center of the reserve is the "core zone," where biodiversity is tightly protected, and no human activity is allowed.[18]

Dalnevostochny Marskoy Zapovednik (Russia)

Dalnevostochny Marskoy Zapovednik, which translates to Far East Marine Reserve, is Russia's first true MPA, established in 1978.[19] It was designated a UNESCO Biosphere reserve in 2003.[20] The reserve consists of four zones totaling 6,432 sq. km in the Sea of Japan. The southernmost zone is adjacent to the Russian border with China and North Korea.[21] The region is home to some 340 species of birds and is a major migration stopover site along the East Asian flyway.[20] Russia has extensively surveyed the biology of Dalnevostochny Morskoy and found 184 fish species, three previously undiscovered, two bird species that are only found within the reserve, and an endangered species of sea cucumber.[19,22] Vessel traffic and artisanal fishing are permitted only in the exterior "transition zone" and by members of the local community.[22] The boundaries of the transition zone were not available online; thus, the analysis only considers the inner restricted zones.

Fishing Activity

Based on GFW data, fishing vessels in the Dalnevostochny Marskoy Reserve's inner restricted zone averaged 50 hours of fishing per year from 2017 to 2020, for 199 hours total **(Table 1a)**. The vessels fishing within the reserve were predominately Russian-flagged trawlers. In all four years of the study period, fishing pressure was at least twice as high in the 10 NM buffer zone as in the reserve itself. Fishing in the reserve tripled from 2018 to 2019 and was 10 times higher in 2020 than in 2018. Most of the apparent fishing in the MPA occurred in the middle and northern no-take zones of the reserve **(Fig. 3)**.

Dalnevostochny Marskoy is located in an area of high vessel traffic due to its proximity to the port of Vladivostok. There were 246 instances in which a fishing vessel's AIS signal was lost from the GFW platform for at least 24 hours from 2017 to 2020. All of these events involved a Russian-flagged vessel. Vessels seemed to "go dark" for a median time of 54 hours. Trawlers, pots and traps vessels, set longliners, and purse seiners all had gaps around the reserve despite

having no visible fishing within the reserve, meaning these vessels potentially fished in the reserve with their AIS off.

Dry Tortugas Ecological Reserve (United States)

The Dry Tortugas Ecological Reserve was designated in 2001 as a 391 sq. km area to protect diverse coral reefs, large spawning aggregations, and nurseries off the southeast coast of the United States.[23] Congress declared the purpose of the Dry Tortugas protections to "preserve and protect for the education, inspiration, and enjoyment of present and future generations nationally significant natural, historic, scenic, marine, and scientific values in south Florida."[24] The Dry Tortugas are an expansive aquatic landscape with impressively large corals, lobsters, and groupers. This region is isolated and located where the Florida Current and the Gulf Stream meet, transporting ample fish and invertebrate recruits to Florida's valuable fisheries.[25]

Fishing Activity

The GFW data showed apparent fishing every year within the 10 NM buffer zone, some of which was directly on the edge of the reserve but never inside it **(Fig. 4).** Nearly all fishing in the buffer zone was by U.S.-flagged trawlers **(Table 1a)**. There were six instances in which a fishing vessel's AIS appeared to be off within 10 NM of the reserve, all by U.S.-flagged vessels and primarily by trawlers **(Table 2)**. There was a median of about 74 hours during which vessels went "dark." These AIS off events were concentrated around the northeast corner of the buffer zone where fishing effort was also concentrated. In 2020, a U.S.-flagged trawler appeared to turn off its AIS for about 29 hours on the eastern side of the reserve **(Fig. 5)**.

Reserva de la Biosfera Islas Marías (Mexico)

A 6,415 sq. km area surrounding Islas Marías was declared an MPA in 2000, then a UNESCO Biosphere Reserve in 2010, and a new management plan was developed in 2011[26] and updated in 2022.[27] Located in the Pacific Ocean, the reserve is composed of four volcanic islands (Isla María Magdalena, Isla María Cleofas, Isla María Madre, and San Juanito). The largest island used to serve as a prison, since 1905.[28] However, in 2018, it stopped being a prison and now remains only a natural protected area. Around three of these islands are no-take zones protecting diverse coral reefs and mangrove forests home to over 54 endangered species of which 19 are found only on these islands. Islas Marías' waters are nursery habitat for shortfin mako sharks.[29]

Fishing Activity

A small amount of fishing was visible around the edges of the Islas Marías protected zone, but none within the no-take zones **(Fig. 6)**. All of the fishing within the reserve was by purse seiners flagged to Mexico **(Table 1a)**. All of the fishing visible around the reserve was also by Mexicanflagged purse seiners. There were two gaps in AIS near the reserve from 2017 to 2020, both by the same U.S.-flagged pole-and-line vessel in 2018 and 2019**.**

World Heritage Sites:

In 1972, UNESCO adopted the "Recommendation Concerning the Protection at National Level, of the Cultural and Natural Heritage," asserting the need to conserve sites of "cultural and natural heritage around the world considered to be of outstanding value to humanity."[30] There are currently 1,154 world heritage sites spanning 167 countries, of which about 19% are natural areas.

Aldabra Atoll (Seychelles)

Located nearly 400 km from the closest land mass, Aldabra Atoll is the second-largest coral atoll in the world and houses one of the world's most isolated ecosystems.[31] Aldabra is particularly isolated from the Seychelles, which manages the 2,430 sq. km reserve from over 1,000 km away. This isolation has enabled over 400 species found only in the Atoll's coral reefs and mangrove forests.[31] Aldabra was first designated a nature reserve in 1968 and became an UNESCO World Heritage Site in 1982.[32] The protected area is managed by the Seychelles Island Foundation (SIF). Subsistence fishing is allowed in certain areas within the reserve, but commercial fishing is banned outright.[33] Cargo ships are not allowed within the reserve, and oil tankers are not allowed within 30 NM.[33] In addition to its World Heritage Site status, Aldabra was officially designated an Important Marine Mammal Area,[34] a Conservation International Hotspot, a Ramsar Wetland of International Importance, and a BirdLife Endemic Bird Area.[31] The SIF's efforts to protect Aldabra were recognized by the Marine Conservation Institute in 2019 when Aldabra was named a platinum-level Blue Park, the highest level awarded by the Institute.[35]

Fishing Activity

No fishing was detected by GFW within the site; however, there were 23 hours of apparent fishing within the buffer zone **(Table 1a)**. Visible fishing in the buffer zone was to the north and west of the reserve, all by drifting longliners flagged to the fishing entity of Taiwan and the Seychelles **(Fig. 7)**. The closest fishing point was 6.5 NM away from the reserve's borders. There were no AIS gap events within 10 NM of the site.

Cargo ships and oil tankers have ignored the restrictions of this ecologically important area. Six cargo ships flagged to China, Panama, Liberia, and Marshall Islands passed through Aldabra since 2017 **(Fig. 8, 9)**, violating the site's management plan. These cargo vessels all passed through the northwest corner of the reserve.

Between January 2017 and December 2020, 859 tankers flagged to 39 countries came within the prohibited 30 NM of the reserve **(Fig. 9).** GFW does not distinguish oil tankers from other types of tankers when classifying vessels. The flag state with the most tankers violating the 30 NM boundary was the Marshall Islands (175 tankers), followed by Liberia (100), Singapore (76), and Panama (72).

Motu Maha Marine Reserve (New Zealand)

Motu Maha or the Auckland Islands are the largest sub-Antarctic islands of New Zealand, and have been granted World Heritage status for their tremendous amount unique life.[36] The islands themselves are home to yellow-eyed penguins, Gibson's wandering albatrosses, sooty shearwaters, Auckland shags, and nearly the entire world's population of white-capped mollymawks.[36] They are also a breeding ground for southern right whales, New Zealand sea lions, and New Zealand fur seals.[37] A marine mammal sanctuary was initially created in 1993, but a desire to protect the natural resources converted this area into a marine reserve in 2003.[37] In 2002, a moratorium on commercial tourism by the government was enacted to protect the marine mammal breeding season from April to October.[38] The reserve is 4,840 sq. km and stretches 12 NM around the islands.[37] Within that protected zone, all commercial fishing is banned protecting forage fish, an important part of the marine mammals' diet, and reducing the threat of bycatch in commercial fishing gear.[39]

Fishing Activity

Fishing within the buffer zone greatly exceeded that within the reserve, averaging 5,172 hours per year of trawling. Fishing also stopped abruptly at the northern border of the site, suggesting that fishing vessels are well-aware of the site's boundaries **(Fig. 10)**. All vessels detected via GFW are flagged to New Zealand as trawlers **(Table 1a)**. Some vessels appeared to trawl close along the southeast border of the site but rarely enter the site in the process **(Fig. 11)**. There were 16 instances of gaps in AIS transmission near the site's boundaries **(Table 2)**. Most of the gaps occurred in 2018. All the vessels involved in gaps were trawlers flagged to New Zealand.

An analysis by GFW in 2017 found that smaller fishing vessels come within the reserve to shelter from bad weather.[40] These vessels are not allowed to anchor, and so their movements can be mistaken for fishing.[40] In this analysis, the majority of apparent fishing within Motu Maha — 82.2% — was by vessels longer than 50 meters, who are less likely to need shelter from storms

due to their large size.[40] None of the apparent fishing from 2017 to 2020 was conducted by known New Zealand research vessels.[40]

Parc Naturel des Atolls d'Entrecasteaux (New Caledonia)

New Caledonia, a French-colonized archipelago to the East of Australia, boasts a staggering diversity and abundance of marine life, including over 400 species of corals, 2,320 species of fish, and 12 species of cetaceans.[41] At 3,164 sq. km, the Atolls d'Entrecasteaux Natural Reserve is one of New Caledonia's oldest and most important protected marine sites and is a critical nesting site for the endangered green sea turtle.[41] In 2008, New Caledonia's coral reef lagoons, including the Atolls d'Entrecasteaux, achieved UNESCO World Heritage status, prompting the government to implement further protective measures.[42] Two years later, New Caledonia and the rest of the Pacific Islands Forum ratified the "Pacific Oceanscape" program to effectively manage the marine ecosystems of the Pacific.[41] In 2014, New Caledonia established the Coral Sea Natural Park, the largest nature reserve on earth at the time, placing 100% of New Caledonia's exclusive economic zone (EEZ) under some form of protection and granting the territory a seat at the table for international environmental discourse.[41] The government further tightened conservation regulations in 2018, deeming all fishing, including for subsistence, prohibited and requiring government approval for entry — which is further restricted to boating, transportation of tourists, and scientific research.[43]

Fishing Activity

Over 800 fishing hours were observed in the buffer zone, but only 1% of this fishing occurred within the site itself **(Table 1a)**. Most of the fishing in the buffer zone occurred west of the site. From 2017 to 2020, five vessels appeared to fish in the site, for nearly 10 hours. The vessels were drifting longliners flagged to New Caledonia **(Fig. 12)**. There were no gaps longer than 24 hours within 10 NM of the site from 2017 to 2020 **(Table 2)**.

Ramsar Sites

The Ramsar Convention or the Convention on Wetlands of International Importance identifies and designates wetlands (any habitat where water is key to the environment and its wildlife) as areas of international importance. This international treaty was established by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1971 to protect rare or unique wetland habitats or threatened species and ecological communities and is now its own governing body separate from other UNESCO entities.[44] There are over 2,400 Ramsar sites

covering 2.5 million sq. km protecting habitats like swamps, lakes, estuaries, coral reefs, and mangroves.[44]

Parque Nacional Archipiélago de Los Roques (Venezuela)

Archipiélago Los Roques was designated in 1972 as a 1,646 sq. km national park, north of central Venezuela, and is the largest protected coral reef area in the country. The national park is an important site for the conservation of seabirds for the Caribbean.[45] Lemon sharks are also known to give birth within the park, which serves as a nursery habitat for juvenile sharks.[46] Los Roques National Park is a biodiverse ecosystem containing 69 species of corals, 200 species of crustaceans, 140 species of mollusks, 45 species of echinoderms, 77 species of sponges, 284 species of fish, and 23 species of sharks.[47] The park has seven management zones, four of which are closed to recreational and commercial fishing, transportation, and tourism. Shark fishing has been banned since 2012.[48] In 1972, spearfishing was banned followed by a ban on the use of nets in 1994. The queen conch and spiny lobster are the most fished (both legal and illegal) species from Los Roques. While the conch fishery has been closed since 1991, there is evidence that it is still being illegally harvested, especially when the spiny lobster season is closed for breeding from April to November.[49]

Fishing Activity

Based on GFW data, three fishing vessels appeared to spend 30 hours fishing in Los Roques since 2017 **(Table 1b)**. Two of the three vessels were tuna purse seiners and the other was a pole-and-line vessel, all flagged to Venezuela **(Fig. 13)**. Fishing within the MPA was highest in 2020. There were two events in which a fishing vessel appeared to turn off its AIS near the MPA, both by vessels flagged to Venezuela **(Table 2)**.

Natura 2000

Natura 2000 is the European Union's network of protected areas under their Habitat Directive and Birds Directive.[50] The sites are selected from within nine biogeographic regions across 27 EU countries. There are over 27,800 sites overall with over 1,358,000 sq. km under protection, including 573,131 sq. km of marine area.[51] Each proposed site is evaluated on how it contributes to conservation objectives for various habitat types and species. After being accepted, the site has up to six years to complete its designation by adopting the necessary conservation measures, such as through a management plan.[52]

Canal de Menorca (Spain)

Canal de Menorca (Minorca Channel) was proposed as a Natura 2000 site by Spain in 2014[53] and covers 3,356 sq. km between the Spanish islands of Mallorca and Menorca in the Mediterranean Sea. The site was established by law on July 21, 2014.[53] There are six major benthic communities within the site: shallow rhodolith beds (red marine algae resembling coral), sandy bottoms dominated by sea lilies and feather stars, gravelly and rocky bottom outcrops dominated by sponges, gorgonians and soft corals and vertical rock with sponges.[54] An endangered deep-water kelp found only in the Mediterranean also grows in the Canal de Menorca, as well as valuable coralligenous habitats.[55] According to Spanish VMS data, 34 vessels trawled in the site between 2007 and 2012.[54] In 2016, after extensive campaigns by Oceana, Spain enacted a bottomtrawling ban in parts of the site totaling 1,397 sq. km in accordance with an EU law requiring rhodolith beds and coralligenous habitat to be protected.[53,56,57] In line with EU legislation, the Canal de Menorca site needs to be effectively protected nationally within six years maximum from its designation.[52]

Fishing Activity

Apparent fishing pressure was higher within the Canal de Menorca MPA than in the 10 NM buffer zone in all four years of the study **(Table 1b)**. Fishing in Canal de Menorca was highest in 2020. Apparent trawling in the trawling ban zone increased by 557% from 2018 to 2019 and remained at a similar level in 2020. Instances in which AIS appeared to be turned off have also generally increased since 2017.

Since 2017, an average of 4,246 fishing hours per year occurred within the site, and 94 hours of trawling per year occurred within areas covered by the bottom-trawling ban **(Fig. 14, 15)**. All but 0.06% of apparent fishing in the site was by Spanish-flagged fishing vessels. While trawlers accounted for 39.5% of the vessels in Canal de Menorca, they conducted more than 93% of the apparent fishing hours. Trawlers were responsible for 76.4% of the apparent fishing hours specifically within the bottom trawl ban zone. There were 1,375 apparent AIS gaps around Canal de Menorca **(Table 2)**. All but two of the trawlers that fished in and around Canal de Menorca had at least one apparent gap in their AIS data.

Cetáceos da Madeira (Portugal)

The Madeira Archipelago is an autonomous region of Portugal in the North Atlantic, 600 km off the coast of Morocco.[58] Despite its remoteness, Madeira receives over a million tourists each year.[58] The islands force cold, nutrient-rich water up from the deep, resulting in high chlorophyll concentrations on the northern side of archipelago.[59] The name of the 6,816 sq. km site, which was established by law on Oct. 17, 2016, refers to the 29 species of cetaceans that can be found in Madeira's waters.[60] Whales traveling to Madeira's nutrient rich waters include the endangered

North Atlantic right whale, blue whale, fin whale, and sei whale, as well as the enigmatic beaked whales.[60–62] Madeira is also home to an endemic species of petrel that is endangered.[63] Cetáceos da Madeira joined the Natura 2000 site network as a Site of Community Importance in 2016 specifically to protect the bottlenose dolphin.[64] Similar to other areas around the world, it is illegal to fish, capture, or slaughter marine mammals in the reserve.[64]

Fishing Activity

Based on GFW data, fishing effort appeared to increase within the Cetáceos da Madeira from 2017 to 2019. While fishing in the site was lowest in 2020, 2020 was also the first year in which fishing pressure was higher in the site than in the 10 NM buffer zone **(Fig. 16)**. Approximately 30 vessels continue to fish within the site every year **(Table 1b)**. Portuguese-flagged pole-and-line vessels were the most common vessels that appeared to be fishing within the site. Nearly 1,000 hours of fishing in the site were by drifting longliners, flagged mostly to Portugal, which can easily hook or entangle marine mammals as they float through the ocean **(Fig. 17)**. Over 670 apparent gap events occurred around Cetáceos da Madeira from 2017 to 2020, primarily by Portuguese-flagged pole and line vessels **(Table 2, Fig. 18**).

OSPAR

The OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic) has 15 signatories from various countries and the EU to protect the North East Atlantic marine environment. The Oslo Convention began in 1972 to address dumping in the oceans while the Paris Convention of 1974 sought to combat other land-based sources of marine pollution. In 1992, a new OSPAR Convention updated and combined the two previous Conventions. This new convention aims to prevent and eliminate the pollution of the marine environment, including hazardous and radioactive substances and to safeguard valuable marine species and habitats through protection, restoration, monitoring, and regular assessments.[65]

Ålborg Bugt, Østlige del (Denmark)

Ålborg Bugt, Østlige del (eastern portion of Aalborg Bay) is one of Denmark's Natura 2000 MPA sites and designed to be a 1,783 sq. km bird sanctuary in 2009 by OSPAR.[66] Ålborg Bugt is inhabited by a variety of seabirds, including sea ducks, common scoters, velvet scoters, and common eiders, as well as the brent goose.[66] Planning documents for the site discuss the need to protect rocky reefs and the rare bubble reef habitats (reefs formed from methane bubbling from cold seeps) in the region from damage done by trawlers.[67] According to Danish VMS data, there is little domestic fishing pressure within Ålborg Bugt, with small amounts occurring at the northern and southern ends of the site.[67] The Danish government performed a baseline survey when the site was established and developed a management plan for Ålborg Bugt. Every six

years since the site was established, the area is resurveyed and the management plan is updated. Most industrial fishing is not permitted in the site; trawling, seining, gillnetting, jigging, longlining, trammel net fishing, and pole-and-line fishing are banned at the industrial scale.[68] In addition to regulating fishing, efforts are also underway to improve the water quality of the bay.[67] Sandwiched between this site and the Danish coast is another Natura 2000 site with similar protections.[69]

Fishing Activity

GFW data shows that fishing in the site was the highest in 2020. However, apparent fishing pressure in the buffer zone is consistently 10 times higher than within the site **(Fig. 19)**. Through GFW, 321 hours of apparent fishing are visible in Ålborg Bugt from 2017 to 2020 **(Table 1b)**. The majority of vessels (86.7%) were flagged to Denmark. Fishing effort was evenly divided between trawlers and set gillnetters, which are both bottom-contact gears. There were 424 instances of apparent gaps by fishing vessels within 10 NM of the site **(Table 2)**. All but four of these AIS gap events were by vessels flagged to Denmark.

Jan Mayen Naturreservat (Norway)

The Jan Mayen Nature Reserve encompasses an isolated Arctic island in the Norwegian Sea. Blue whales and seals regularly inhabit the area. The 4,683 sq. km reserve was established as a fisheries protection zone in 1980 and then as a protected site under OSPAR in 2012. Fishing that would cause "significant damage" to the seabed is not permitted, which is defined as gear that damages habitat-forming fauna, such as corals and kelp. Trawling for shrimp is permitted, as the management plan states that the shrimp primarily live in soft-bottom habitats.[70]

Fishing Activity

Very little fishing was visible in and around the Jan Mayen OSPAR site in 2017 and 2018. Fishing within the site rose dramatically in 2019, before decreasing in 2020. In both 2019 and 2020, fishing pressure was higher within Jan Mayen than in the 10 NM buffer zone **(Fig. 20)**. Most of the fishing was south of the island of Jan Mayen. The southeast is the leeward side of the island, so it is possible that vessels use the area of shelter from storms given the high latitude of the site, similar to Motu Maha, New Zealand. All vessels fishing in the site were flagged to Norway. Nearly all apparent fishing in the site, 99.3%, was by set longliners **(Table 1b)**. Set longlines contact the seafloor, although they are not as destructive as other gears, such as bottom trawls. There were three apparent gaps around the site, all by the same set longliner flagged to Norway in 2019 **(Table 2)**.

National-Level Protected Areas

Individual countries may also elect to designate protected areas. In these cases, the criteria and restrictions placed on the MPAs may differ depending on the respective country's policies. While some form of MPAs have existed for the better part of a century, the first World Congress on National Parks in 1962 helped kickstart the global movement by encouraging countries to protect their marine areas. By 1970, 27 countries had designated 118 MPAs. Today, that number has continued to grow to approximately 16,687 MPAs around the world, protecting 8.1% of the oceans.[71]

Área Costera Marina Protegida de Tortel (Chile)

Among the fjords of southern Chile is Caleta Tortel, a small town connected by raised walkways and a hot spot for ecotourism. On Feb. 27, 2018, through a joint effort, the municipality of Tortel, the regional office of the Environmental Ministry, and Oceana established a 6,707 sq. km Coastal Marine Protected Area for Multiple Purposes.[72,73] This was part of a larger effort that established a total of five new MPAs offering various levels of protection to 42% of Chile's marine area.[74] The Tortel MPA consists of two distinct protected areas, one inshore region where meltwater mixes with salt water, and a larger oceanic region.[75] Within the boundaries of the Tortel MPA are southern right whales, black-browed albatross, and Chilean dolphins.[75] This area has a history of marine conservation, such as blocking destructive salmon farming.[75] Chilean law prohibits trawling, purse seining, and gillnetting in the estuaries of southern Chile, which also covers the inshore part of the MPA.[75]

Fishing Activity

Tortel's MPA is divided into an inshore zone and oceanic zone. No fishing is visible in the MPA's inshore zone via AIS **(Table 1c)**. No vessels appeared to turn off their AIS near this zone **(Table 2)**.

Unlike the inshore region, fishing is visible in Tortel's oceanic zone. With AIS, 2,341 hours of apparent fishing were visible in the oceanic zone since it was established in February 2018. Vessels using AIS were all flagged as Chilean, operating as set longliners (78.1%), trawlers (20.9%), and an indeterminate gear type (1%). Fishing was concentrated away from the coast and out of the estuary **(Fig. 21)**. There were 6 gaps in AIS detections, primarily by Chilean-flagged set longliners in 2020 **(Table 2)**.

Dōngshā Huánjiāo Guójiā Gōngyuán (Taiwan)

Dongsha Atoll, also known as the Pratas Islands, is a coral atoll located in the South China Sea between Taiwan, China, and the Philippines. The South China Sea experiences some of the most intense fishing pressure in the world, with an estimated half of all fishing boats in the world operating in the area.[76] When the atoll was first surveyed in 1994, researchers found 137 species of coral and 369 species of fish.[77] The soft corals of Dongsha have been the subject of medical research, as they contain chemical compounds with anti-cancer, anti-viral, and antiinflammatory properties.[78–81] One soft coral species yielded three new anti-inflammatory and anti-cancer compounds.[80] Dongsha is also in the path of the strongest-known internal waves in the ocean, which come through the Luzon Strait[82] and generate mixing and quadruple the nutrients brought to the reef.[83] Because of the cold, deep waters the internal waves bring, Dongsha could be a refuge for corals in a warming ocean.[84] Unfortunately, fishing activity in the early 1990s and 2000s destroyed nearly 90% of Dongsha's reef. At one site, coral diversity fell from 45 species to three in a span of four years.[77] Dongsha Atoll National Park was established in 2007 as Taiwan's first marine reserve. Now, fishing is not permitted within the 3,584 sq. km national park, and no natural resource extraction is allowed in the immediate area around the reef.

Fishing Activity

No fishing was visible via GFW in or around the MPA **(Table 1c)**. There were only three instances of apparent gaps, one flagged to Taiwan and two flagged to China **(Table 2, Fig. 22)**. These instances occurred in 2018 and 2019**.**

Huon Commonwealth Marine Reserve (Australia)

Huon Commonwealth Marine Reserve is one of 14 marine parks making up Australia's Southeast Marine Parks Network, which covers 388,464 sq. km in total.[85] Part of Huon's area has been protected since 1999, but that marine park was revoked and incorporated into Huon when it was established in 2007.[85] Huon protects Australia's largest known cluster of seamounts.[86] Seamounts are important habitat for bamboo corals, which in turn provide habitat to other animals, but are also incredibly vulnerable to fishing.[86] Seamounts — underwater mountains formed from extinct volcanos — are a haven for bottom-dwelling marine creatures. Huon's seamounts are important stepping stones in the spread of marine organisms[87,88] and a hotspot of biodiversity for open-ocean species in an otherwise sparse ecosystem.[89] Some of Huon's seamounts have been damaged by fishing, but deeper mounts are likely pristine.[85] Great white sharks forage in Huon, and important commercial species — such as the ocean perch and blue warehou — use Huon as a spawning and nursery ground.[85] Throughout the MPA, bottom trawling, Danish seining, and scallop dredging are prohibited.[85] Within Huon, a 389 sq. km habitat protection zone prohibits mining and commercial fishing without a permit.[85] Commercial

shipping vessels are not allowed to anchor anywhere in the park.[85] A management plan is in place for the MPA covering 2013 to 2023.[85]

Fishing Activity

Using GFW, 107 hours of apparent fishing were visible in the 10 NM buffer zone, and 33 hours were visible within the MPA **(Table 1c)**. Apparent fishing in the MPA peaked in 2020 and was primarily by Australian-flagged set longliners. This fishing appeared to occur mostly along the edge of the continental shelf **(Fig. 23)**. No fishing was visible via GFW in Huon's 389 sq. km restricted-use zone. There were seven apparent gaps in AIS transmission around Huon from 2017 through 2020, five of which were by the same Australian-flagged trawler with one apparent gap that lasted over 104 hours **(Table 2; Fig. 24)**.

Namibian Islands Marine Protected Area (Namibia)

The Namibian Islands Marine Protected Area (NIMPA) was designated in 2009 to protect 9,500 sq. km of marine habitat, including 10 islands and eight islets. This was Namibia's first MPA, and the main priority of this protected area is to safeguard the breeding and foraging grounds of threatened and endangered species, such as African penguins, cormorants, Cape fur seals, leatherback turtles, southern right whales, and killer whales (orcas). Heaviside's dolphins, which are only found in a small region off the coast of Southwest Africa, also frequent this area. Historical overfishing of forage fish, such as sardines and anchovies, depleted the food sources for both seabirds and marine mammals in the protected area.[90] The NIMPA is divided into four zones with differing levels of protection ranging from multiuse to no-take. However, some fishing gear is prohibited throughout the entire MPA, including purse seining, trawling, long lining, and kelp harvesting. This MPA also has areas closed to all vessel traffic to protect seabirds.

Fishing Activity

From 2017 to 2020, 750 fishing hours were visible in the MPA via AIS **(Table 1c)**. Most of the apparent fishing on AIS was by trawlers flagged to Namibia, with significant portions also by pole and line vessels and purse seiners. South African-flagged trawlers accounted for 10.6% of apparent fishing within the MPA; one trawler of an indeterminate flag accounted for 9.2% of fishing. On average, fishing pressure was about 2.6 times as high in the MPA than it was in the adjacent buffer zone **(Fig. 25)**. Fishing in the MPA has steadily risen every year since 2018, while the trend in the buffer zone has been inconsistent. However, it appears vessels are avoiding the MPA's no-take zones **(Fig. 25)**.

AIS transmission appeared to be lost primarily by vessels flagged to Namibia (81.8%). There were nine apparent gaps by a vessel broadcasting an invalid MMSI near the MPA in 2017 and 2018 **(Table 2)**.

Olympic Coast National Marine Sanctuary (United States)

Established in 1994, the Olympic Coast National Marine Sanctuary (OCNMS) covers 8,260 sq. km off the coast of the state of Washington in the United States. It extends between 25 and 50 miles into the Pacific Ocean, covering major groundfish fishery areas and several submarine canyons.[91,92] A 2006 National Oceanic and Atmospheric Administration (NOAA) expedition found a diverse benthic community, including gorgonians, stony corals, and reef-building sponges.[91] An extensive array of marine mammals can also be found in the OCNMS, including humpback whales, gray whales, minke whales, orcas, porpoises, dolphins, Steller sea lions, and sea otters.[93] Endangered southern resident killer whales inhabit the OCNMS in the winter months.[94] Roughly 15% of the OCNMS' area is an Essential Fish Habitat (EFH) Conservation Area, where bottom trawling is not allowed, apart from tribal fishermen.[91] Bordering the OCNMS to the west are two other EFH areas where bottom trawling is also prohibited. The Makah, Quileute, Hoh, and Quinault tribes all have important cultural ties to the OCNMS and depend on its ecological resources.[92] Surveyors have recorded evidence of bottom trawling both inside and outside the EFH.[91]

Fishing Activity

Since 2017, over 90 vessels appear to have fished inside the OCNMS every year, including 21 trawlers per year within the EFH conservation area, where bottom trawling is prohibited **(Table 1c)**. Trawlers made up over two-thirds of the fishing activity in the MPA, totaling over 35,000 hours from 2017 to 2020, with trollers also contributing a significant portion. Within the EFH, 86.7% of the visible fishing was by trawlers, totaling over 1,700 hours of trawling from 2017 to 2020. Apparent trawling within the EFH in 2020 was more than three times lower than in 2017. Fishing is most concentrated in the western side of OCNMS, along the edge of the continental shelf **(Fig. 26, 27)**.

Across the OCNMS, an average of 87 apparent gap events occurred every year, mostly by U.S.flagged trawlers, general fishing, and troller vessels **(Table. 2)**. Approximately 12% of the AIS gap events involved Canadian-flagged fishing vessels.

Pondoland Marine Protected Area (South Africa)

Off the coast of South Africa, the Pondoland MPA was designated in 2004. This 1,237 sq. km area is designed to protect over-exploited fishes (linefish, rock lobsters, and other valuable fishes), allowing stocks time to reproduce and recover.[95] The MPA is composed of 21 zones with varying levels of protection.[95] Within restricted zones, no fishing is allowed, and all gear must be stowed when passing through the area.[95] Within the more common controlled zones, fishing is allowed only through authorization by the Minister of Fisheries.[95]

Fishing Activity

Fishing was only visible in the MPA and 10 NM buffer zone in 2018 **(Table 1c, Fig. 28)**. Two vessels, one flagged to South Africa and the other to Latvia, had visible fishing in the buffer zone. The South African-flagged longliner appeared to fish in Pondoland's no-take area for slightly less than an hour **(Fig. 29).** No events in which a vessel's AIS signal disappeared occurred around the MPA between January 2017 and December 2020 **(Table 2)**.

Reserve Aquatique de l'Abysse Bleu (Gabon)

Africa's west coast hosts some of the world's richest fishing grounds, and the highest levels of illegal fishing worldwide.[96] IUU fishing along Africa's west coast was estimated to result in $2.3 billion in losses in 2015 alone.[97] In addition to IUU fishing, the waters off Gabon also see the highest rates of piracy in the world.[98] In 2014, Gabon launched its Gabon Bleu) initiative to combat these issues and better develop its blue economy.[99] The Réserve Aquatique de l'Abysse Bleu was established on June 21, 2017, as part of an expansion of Gabon's MPA network that now covers 26% of its EEZ;[100] while some activities like artisanal fishing and sport fishing are permitted, longline fishing and industrial deep-sea trawling are prohibited.[101,102] This MPA covers 7,033 sq. km of open ocean on Gabon's border with Equatorial Guinea.[103] The MPA's average depth is over 4,100 meters[101] and is the deepest area of Gabon's waters, protecting the unique habitats found at those depths.[102]

Fishing Activity

Prior to the MPA's establishment, drifting longliners were the primary fishing vessels in the area, according to the GFW data, but tuna purse seiners dominated fishing in the reserve since 2017 **(Table 1c)**. This shift was also accompanied by a change in the flag states of fishing vessels active in the MPA area. From 2017 to 2020, 385 hours of fishing occurred in the MPA by vessels flagged to six different countries. The top flag states by apparent fishing hours were Belize (114 hours), Curaçao (112 hours), and El Salvador (68 hours). Fishing pressure was higher in the MPA than in the surrounding 10 NM buffer zone in 2019 and 2020 **(Fig. 30, 31)**.

According to GFW data, there were 13 apparent gap events near the MPA since its establishment, mostly by tuna purse seiners. As with fishing, a wide diversity of flag states was involved in these events around the MPA. Guatemala-flagged vessels had the highest number of gaps, followed by vessels flagged to Curaçao, El Salvador, and Panama. Most of these events occurred in 2019 **(Table 2)**.

Curaçao and Panama are flags of convenience,[104] meaning they have a relatively inexpensive and oversight-free registry for vessels to join.[105]

Zone de Protection Marine du Banc-des-Américains (Canada)

Banc-des-Américains, known as the crown jewel of the Gulf of St. Lawrence, was designated as an MPA on Feb. 25, 2019, and covers 1,000 sq. km off Québec's Cap Gaspé in the Gulf of St. Lawrence.[105] Oceana and the Department of Fisheries and Oceans Canada conducted an expedition to the site in 2017 to document its diversity.[106] Banc-des-Américains has seasonal accumulations of krill, which attract small fish and baleen whales such as blue whales,[107] fin whales, and humpback whales.[105] The area's habitat-structuring corals and sponge forests are important to forage fishes, like capelin and herring, and large migratory marine species.[108] Bancdes-Américains is critical for commercially important fisheries, such as crab and shrimp; depleted ones, such as redfish and cod; and species-at-risk, including Atlantic wolffish and the North Atlantic right whales.[108] The rare Atlantic wolffish is classified as a species of concern by NOAA after likely being depleted by overfishing, bycatch, and habitat destruction by bottom trawlers.[109] Approximately 20 at-risk species reside within Banc-des-Américains, such as the blue whale.[105] Along and around the ridge, the only fishing allowed is non-commercial fishing by Indigenous peoples.[105,108] Vessels are also not allowed to anchor in this zone. In the zones on either side of the ridge, the only commercial fishing allowed is by trap, longline, handline, or angling.[108] This MPA was the first announced under the Canada-Quebec Collaborative Agreement for the Establishment of a Network of Marine Protected Areas in Quebec. [105]

Fishing Activity

Twenty-nine hours of apparent fishing were visible on GFW by one Canadian-flagged fixed-gear vessel within the MPA since it was established **(Table 1c)**. No fishing occurred in the nocommercial fishing zone along the ridge **(Fig. 32)**. All of the fishing visible in and around the MPA occurred in 2020. There were four instances of apparent gaps around the MPA since its establishment **(Table 2)**. Three of these vessels were trawlers and one was fixed gear, all flagged to Canada **(Fig. 33)**.

Conclusions

Marine protected areas guard some of the most biodiverse and abundant ocean places. Illegal fishing, vessel incursions, and other illicit activities can undermine the purpose of MPAs. Increasing the transparency of commercial fishing fleets, including requiring the transmission of AIS during the entirety of a vessel's trip, would allow governments to use technology, such as Global Fishing Watch, to monitor and track movements through their protected areas. Nations can safeguard their vital marine resources by establishing defined geographic areas where a broad range of activities can be restricted to protect the natural environment and ocean wildlife.[110]

Oceana found some level of fishing in most MPAs selected for this report, including some of the most destructive fishing gears like bottom trawlers. Perhaps more troubling, almost every MPA had instances of fishing vessels appearing to shut down their electronic tracking systems when approaching the protected area's boundaries. The MPAs in which the most fishing occurred were in areas where intense fishing pressure also occurs. Most MPAs with minimal fishing within their boundaries also had little fishing in the surrounding areas. With few exceptions, most vessels fishing within MPAs were flagged to the countries responsible for managing and enforcing that MPA's regulations. To increase the effectiveness of the management of these MPAs, regulations and boundaries need to be easy to find and made publicly available. Increasing the transparency of MPA regulations also lowers barriers to monitoring and enforcement within the area. Given the recent push to establish more MPAs, it will be important to assess which management and enforcement approaches are effective in creating real protection as opposed to merely having a "paper park."

Recommendations

To help ensure marine protected areas protect habitat and restore fisheries, Oceana recommends all countries:

- **Mandate transparency by requiring AIS use**: Governments and regional fishery management organizations should require the constant use of tamper-resistant AIS devices on all fishing vessels. These tracking systems are essential for transparency and public accountability of global fishing operations. In addition, they improve maritime safety, help combat illegal fishing, and increase compliance of laws and regulations.
- **Publicly release vessel monitoring system (VMS) data:** Governments should release VMS data to complement the AIS data and improve the surveillance of boats in areas

where AIS reception varies. These are two distinct systems that are best used with one another.

- **Improve monitoring and enforcement**: Governments should monitor and enforce relevant fishing regulations for their fleets worldwide. Coastal states should monitor and control foreign vessels that are allowed to fish in their national waters.
- **Require management plans:** Governments must adopt clearly defined management plans soon after MPA designation and provide the management plans to the public, which will improve managers' abilities to enforce the cessation of fishing or other prohibited activities. Precautionary restrictions on most harmful activities should apply as soon as sites are designated.

Note: Global Fishing Watch, a provider of open data for use in this report, is an international nonprofit organization dedicated to advancing ocean governance through increased transparency of human activity at sea. The views and opinions expressed in this report are those of the authors, which are not connected with or sponsored, endorsed, or granted official status by Global Fishing Watch. By creating and publicly sharing map visualizations, data, and analysis tools, Global Fishing Watch aims to enable scientific research and transform the way our ocean is managed.

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Appendix 1 – Methods

This report investigates apparent fishing and protection measures in 19 MPAs around the world from January 2017 to December 2020 **(Fig. 1)**. Data from Global Fishing Watch (GFW)** was analyzed to find vessels that appeared to fish within MPAs of various protection levels and restrictions, and to further identify the vessels' flags and gear types. Oceana also leveraged the GFW database to survey potential "dark" fishing by analyzing vessels that appeared to disable their AIS devices in these MPAs.

MPAs were selected to represent a variety of sizes, ages, habitats protected, protection measures, and geographies. The selected MPAs range in size from 391 to 9,991 sq. km, are between three and 50 years in age, and span 122 degrees of latitude and all inhabited continents **(Fig. 1)**. Some MPAs are part of a well-established conservation network, while others represent their country's first efforts at marine protection. MPAs smaller than 350 sq. km in area were not considered, to ensure the area was large enough to detect vessels using AIS. Conversely, MPAs larger than 10,000 sq. km were not considered to ensure some similarities between study sites. Whether the MPA had a management plan in place was not considered during the selection process, since the primary objective was to evaluate fishing in areas designated as protected. However, if a management plan was located at the time of writing this report, a link is provided **(Table 3).**

In addition to the management of the MPAs themselves, several factors influence the activity that can be seen via AIS data on GFW. While AIS signals can be received by satellites or landbased receivers, this coverage is not evenly distributed around the globe. If an area is not covered by land-based receivers, and satellites do not pass over it frequently, fewer AIS signals will be received and made available to GFW. Additionally, areas of high vessel density, such as the South China Sea, may have worse AIS coverage, as the signals sent from many vessels crowd each other out and cause interference. MPAs in regions with poor AIS coverage were excluded from this study. The second factor is the effect of increasing AIS receivers over time, which in turn increases the amount of AIS data over time. The amount of AIS data in GFW has increased steadily over time as more satellites are launched. Additionally, in 2017, GFW gained access to a new source of AIS data, which greatly expanded the amount of data available. To remove bias from this increase in data, this report begins its analysis in 2017.

As a result of these considerations, Oceana used several specific metrics to minimize the effects of reception and satellite coverage when comparing fishing across MPAs. To further account for increasing coverage over time, there was a comparison to changes in the amounts of fishing activity in the MPA against changes in a zone immediately adjacent to the MPA. This "buffer zone" was created by extending out the border of each MPA by 10 nautical miles (NM). Parts of the buffer overlapping with the coast were removed for analysis. Thus, even with the quantity of AIS data changing over time, the ratio of fishing in the MPA to that in the buffer zone should remain relatively stable. Fishing in the buffer zone and in the MPA were compared via the fishing concentration, calculated as the number of fishing hours divided by the size of the area. In addition to estimating fishing through the number of fishing hours detected, Oceana also calculated fishing vessel days. The purpose of this metric is to account for fishing hours that may have been missed in an MPA due to imperfect satellite reception. Each fishing vessel fishing within the MPA for any amount of time in a day counted as one vessel day. Vessel days are defined as the number of distinct days where fishing was detected for any amount of time.

Through GFW's AIS data, we can see more than 40 million hours of fishing activity covering over half of the ocean's surface every year.[111] AIS devices were originally created to improve safety at

sea. Consequently, AIS devices can be easily turned off or tampered with. With AIS off, GFW cannot detect a vessel's location or fishing behavior. In previous reports, Oceana has highlighted that vessels may use this as a loophole — e.g., turning off their AIS device when approaching areas in which they are prohibited from fishing, such as an MPA or a foreign state's EEZ.[112,113]

In this report, lack of AIS signal was considered an "AIS gap event" if transmission was lost to GFW for more than 24 hours. Using this time period minimizes the likelihood that poor satellite reception was the cause of transmission loss and points to intentional disabling. To further account for areas of poor reception, the gap was only considered if it was preceded by at least five position messages with an average of less than an hour in between each. Gaps longer than three months were also not included, as after this point it was considered unlikely that the vessel turned its AIS off solely to fish in one MPA. In this analysis, the vessel must have been able to travel from the point where its AIS signal disappeared to the point where it reappeared at an average speed below 10 knots. If this was not the case, it was assumed the vessel only had time to transit and therefore could not have fished. GFW uses two of the largest AIS datasets in the world, but these datasets do not contain all AIS data that are broadcast. Thus, it is possible that gaps in the AIS data available to GFW do not exist or are shorter with other AIS data unavailable to GFW. Despite these caveats, we consider gaps in the GFW data to be of concern because they limit the application of GFW's fishing detection algorithms to a vessel's activity and reduce opportunities for public oversight.

** = **Note**: Global Fishing Watch uses data about a vessel's identity, type, location, speed, direction and more that is broadcast using the Automatic Identification System (AIS) and collected via satellites and terrestrial receivers. AIS was developed for safety/collisionavoidance. Global Fishing Watch analyzes AIS data collected from vessels that our research has identified as known or possible commercial fishing vessels, and applies a fishing presence algorithm to determine "apparent fishing activity" based on changes in vessel speed and direction. The algorithm classifies each AIS broadcast data point for these vessels as either apparently fishing or not fishing and shows the former on the Global Fishing Watch fishing activity heat map. AIS data as broadcast may vary in completeness, accuracy and quality. Also, data collection by satellite or terrestrial receivers may introduce errors through missing or inaccurate data. Global Fishing Watch's fishing presence algorithm is a best effort
mathematically to identify "apparent fishing activity." As a result, it is possible that some fishing activity is not identified as such by Global Fishing Watch; conversely, Global Fishing Watch may show apparent fishing activity where fishing is not actually taking place. For these reasons, Global Fishing Watch qualifies designations of vessel fishing activity, including synonyms of the term "fishing activity," such as "fishing" or "fishing effort," as "apparent," rather than certain. Any/all Global Fishing Watch information about "apparent fishing activity" should be considered an estimate and must be relied upon solely at your own risk. Global Fishing Watch is taking steps to make sure fishing activity designations are as accurate as possible. Global Fishing Watch fishing presence algorithms are developed and tested using actual fishing event data collected by observers, combined with expert analysis of vessel movement data resulting in the manual classification of thousands of known fishing events. Global Fishing Watch also collaborates

extensively with academic researchers through our research program to share fishing activity classification data and automated classification techniques.

Tables Referenced:

Fishing Activity

Fishing Activity in UNESCO MPAs

MPA Name	Fishing Hours in Buffer	Fishing Hours in MPA	Fishing Hours in Restricted Zones	Number of Vessels Fishing in MPA	Average Fishing Hours by Vessel in MPA	Fishing Vessel Days in Buffer	Fishing Vessel Days in MPA	Fihsing Vessel Days in Restricted Zones	Number of Countries Fishing in MPA	Most Common Flag by Fishing Hours	Most Common Gear Type by Fishing Hours	Publicly Available Management Plan
Aldabra Atoll Special Reserve (Seychelles)	23.08 (5.77)	0 (0)	NA	0 (0)	NA	6 (1.5)	0 (0)	NA	0 (0)	NA	NA	Yes
Dalnevostochny Marskoy Zapovednik (Russia)	3,445.41 (861.35)	198.97 (49.74)	NA	16 (4.5)	12.44	543 (135.75)	48 (12)	NA	2 (1.25)	Russia (99.96%)	Trawlers (27.75%)	Unable to locate/Unavailabl
Dry Tortugas Ecological Reserve (United States)	779.31 (194.83)	0 (0)	NA	0 (0)	NA	103 (25.75)	0 (0)	NA	0 (0)	NA	NA	Yes
Motu Maha Marine Reserve (New Zealand)	20,216.83 (5,054.21)	472.46 (118.11)	NA	19 (11.75)	24.87	2,507 (626.75)	125 (31.25)	NA	1 (1)	New Zealand (100%)	Trawlers (100%)	In development
Parc Naturel des Atolls d'Entrecasteaux (New Caledonia)	809.74 (202.43)	9.93 (2.48)	NA	5 (1.25)	1.99	120 (30)	6 (1.5)	NA	1 (0.75)	New Caledonia (100%)	Drifting Longlines (100%)	Yes
Reserva de la Biosfera Islas Marías (Mexico)	374.84 (93.71)	32.68 (8.17)	0 (0)	7 (2)	4.67	83 (20.75)	10 (2.5)	0 (0)	1 (0.75)	Mexico (100%)	Tuna Purse Seines (100%)	Yes

Table 1a. Summary of GFW apparent fishing data for ***UNESCO*** MPAs between 2017 and 2020 [See Figure 2 for specific data ranges]. Yearly averages in parentheses.

Fishing Activity in Ramsar, Natura 2000, and OSPAR MPAs

MPA Name	Fishing Hours in Buffer	Fishing Hours in MPA	Fishing Hours in Restricted Zones	Number of Vessels Fishing in MPA	Average Fishing Hours by Vessel in MPA	Fishing Vessel Days in Buffer	Fishing Vessel Days in MPA	Fihsing Vessel Days in Restricted Zones	Number of Countries Fishing in MPA	Most Common Flag by Fishing Hours	Most Common Gear Type by Fishing Hours	Publicly Available Management Plan
Ålborg Bugt, Østlige del (Denmark)	9,725.65 (2,431.41)	320.78 (80.2)	NA	30 (11.25)	10.69	3,175 (793.75)	140 (35)	NA	3 (2.25)	Denmark (85.91%)	Trawlers (49.8%)	Yes
Canal de Menorca (Spain)	15,485.81 (3,871.45)	16,984.62 (4,246.16)	493.73 (123.43)	38 (25.5)	446.96	3,210 (802.5)	3,249 (812.25)	297 (74.25)	3 (1.5)	Spain (99.94%)	Trawlers (93.21%)	In development
Cetáceos da Madeira (Portugal)	37,146.4 (9,286.6)	18,872.76 (4,718.19)	NA	50 (32.5)	377.46	4,000 (1,000)	2,964 (741)	NA	2 (2)	Portugal (99.8%)	Pole and Line (63.77%)	In development
Jan Mayen Naturreservat (Norway)	458.39 (114.6)	1,055.53 (263.88)	NA	5 (1.25)	211.11	63 (15.75)	101 (25.25)	NA	1 (0.5)	Norway (100%)	Set Longlines (99.34%)	Yes
Parque Nacional Archipiélago de Los Roques (Venezuela)	768.54 (192.13)	29.6 (7.4)	NA	3 (1)	9.87	134 (33.5)	9 (2.25)	NA	1 (0.75)	Venezuela (100%)	Pole and Line (87.39%)	Unable to locate/Unavailable

Table 1b. Summary of GFW apparent fishing data for ***Ramsar, Natura 2000, and OSPAR*** MPAs between 2017 and 2020 [See Figure 2 for specific data ranges]. Yearly averages in parentheses.

Fishing Activity in National Level MPAs

MPA Name	Fishing Hours in Buffer	Fishing Hours in MPA	Fishing Hours in Restricted Zones	Number of Vessels Fishing in MPA	Average Fishing Hours by Vessel in MPA	Fishing Vessel Days in Buffer	Fishing Vessel Days in MPA	Fihsing Vessel Days in Restricted Zones	Number of Countries Fishing in MPA	Most Common Flag by Fishing Hours	Most Common Gear Type by Fishing Hours	Publicly Available Management Plan
Área Costera Marina Protegida de Tortel (Chile)	3,302.04 (1,160.8)	2,340.67 (822.84)	NA	16 (12.68)	146.29	408 (143.43)	257 (90.35)	NA	1 (1.05)	Chile (100%)	Set Longlines (78.08%)	In development
Dōngshā Huánjiāo Guójiā Gōngyuán (Taiwan)	0 (0)	0 (0)	NA	0 (0)	NA	0 (0)	0 (0)	NA	0 (0)	NA	NA	Unable to locate/Unavailable
Huon Commonwealth Marine Reserve (Australia)	74.1 (18.52)	32.56 (8.14)	NA	2 (0.5)	16.28	18 (4.5)	8 (2)	NA	1 (0.5)	Australia (100%)	Set Longlines (98.91%)	Yes
Namibian Islands Marine Protected Area (Namibia)	155.73 (38.93)	750.32 (187.58)	NA	20 (8.75)	37.52	43 (10.75)	170 (42.5)	NA	6 (3.5)	Namibia (86.48%)	Trawlers (61.09%)	In development
Olympic Coast National Marine Sanctuary (United States)	47,607.84 (11,901.96)	52,506.65 (13,126.66)	2,028.58 (507.15)	165 (99)	318.22	6,254 (1,563.5)	6,047 (1,511.75)	576 (144)	2 (2)	United States (99.31%)	Trawlers (67.76%)	Yes
Pondoland Marine Protected Area (South Africa)	2.33 (0.58)	0.5 (0.12)	0.5 (0.12)	1 (0.25)	0.5	2 (0.5)	1 (0.25)	1 (0.25)	1 (0.25)	South Africa (100%)	Drifting Longlines (100%)	Yes
Reserve Aquatique de l'Abysse Bleu (Gabon)	465.61 (131.83)	384.85 (108.97)	NA	12 (7.65)	32.07	114 (32.28)	83 (23.5)	NA	6 (4.81)	Belize (29.66%)	Tuna Purse Seines (100%)	In development
Zone de protection marine du Banc-des-Américains (Canada)	0.69 (0.37)	29.47 (15.92)	0 (0)	1 (0.54)	29.47	1 (0.54)	6 (3.24)	0 (0)	1 (0.54)	Canada (100%)	Fixed Gear (100%)	In development

OCEANA

Gap Events

MPA Name	Number of Gaps	Number of Vessels with Gaps	Median Gap Distance (km)	Median Gap Length (Hours, Days)	Most Common Flag with Gaps (% of Vessels)	Most Common Geat Type with Gaps (% of vessels)
Ålborg Bugt, Østlige del (Denmark)	424	67	6.19	66.02, 2.75	Denmark (94.03%)	Trawlers (55.22%)
Área Costera Marina Protegida de Tortel (Chile)	6	3	10.5	56.27, 2.34	Chile (100%)	Set Longlines (66.67%)
Canal de Menorca (Spain)	1375	48	3.41	60.67, 2.53	Spain (81.25%)	Trawlers (50%)
Cetáceos da Madeira (Portugual)	673	45	21.61	52.65, 2.19	Portugal (84.44%)	Pole and Line (84.44%)
Dalnevostochny Marskoy Zapovednik (Russia)	246	97	34.1	54.16, 2.26	Russia (100%)	Set Longlines (29.9%)
Dōngshā Huánjiāo Guójiā Gōngyuán (Taiwan)	3	3	411.17	94.1, 3.92	China (66.67%)	Set Longlines, Squid Jigger, Trawlers (33.33% each)
Dry Tortugas Ecological Reserve (United States)	6	6	43.95	73.98, 3.08	United States (100%)	Trawlers (83.33%)
Huon Commonwealth Marine Reserve (Australia)	7	3	306.8	66.85, 2.79	Australia (100%)	Set Longlines, Drifting Longlines, Trawlers (33.33% each)
Jan Mayen Naturreservat (Norway)	3	1	16.41	87.38, 3.64	Norway (100%)	Set Longlines (100%)
Motu Maha Marine Reserve (New Zealand)	16	7	31.2	43.12, 1.8	New Zealand (100%)	Trawlers (100%)
Namibian Islands Marine Protected Area (Namibia)	77	6	29.73	56.8, 2.37	Namibia (50%)	Pole and Line (50%)
Olympic Coast National Marine Sanctuary (United States)	350	121	53.2	62.72, 2.61	United States (77.69%)	Trawlers (34.71%)
Parque Nacional Archipiélago de Los Roques (Venezuela)	2	2	107.19	84.58, 3.52	Venezuela (100%)	Tuna Purse Seines (100%)
Reserva de la Biosfera Islas Marías (Mexico)	2	1	863.62	265.39, 11.06	United States (100%)	Pole and Line (100%)
Reserve Aquatique de l'Abysse Bleu (Gabon)	13	8	162.86	58.3, 2.43	Curaçao, El Salvador (25% each)	Tuna Purse Seines (87.5%)
Zone de protection marine du Banc-des-Américains (Canada)	4	3	20.08	42.98, 1.79	Canada (100%)	Trawlers (66.67%)

Table 2. Summary of GFW apparent AIS gaps for ***all 20 MPAs*** between 2017 and 2020 [See Figure 2 for specific data ranges].

Management Plans

Marine protected area name	Management plan link
Dalnevostochny Marskoy Zapovednik (Russia)	Unable to locate/Unavailable
Dry Tortugas Ecological Reserve (United States)	https://www.nps.gov/drto/learn/management/upload/drtogmprod.pdf
Parque Nacional Arrecife Alacranes (Mexico)	https://www.conanp.gob.mx/datos_abiertos/DGCD/78.pdf
Reserva de la Biosfera Islas Marías (Mexico)	https://www.conanp.gob.mx/datos_abiertos/DGCD/95.pdf
Aldabra Atoll (Seychelles)	https://www.sif.sc/sites/default/files/downloads/Aldabra%20Atoll%20Management%20Plan. pdf
Motu Maha Marine Reserve (New Zealand)	In development
Parc Naturel des Atolls d'Entrecasteaux (New Caledonia)	https://mer-de-corail.gouv.nc/sites/default/files/atoms/files/management_plan_21th_december.pdf
Parque Nacional Archipiélago de Los Roques (Venezuela)	Unable to locate/Unavailable
Parque Nacional Marinho Dos Abrolhos (Brazil)	https://www.icmbio.gov.br/parnaabrolhos/images/stories/downloads/Plano_de_Manejo_-_Parque_Nacional_Marinho_dos_Abrolhos.pdf
Canal de Menorca (Spain)	In development In development

Cetáceos da Madeira (Portugal)	https://mst.dk/media/129844/n14_n2000plan_2016-21.pdf
Ålborg Bugt, Østlige del (Denmark)	https://www.regjeringen.no/globalassets/upload/fkd/vedlegg/hoeringer/2009/regulering-av-fiske-med-bunnredskap/forslag-tilforskrift.pdf
Jan Mayen Naturreservat (Norway)	
Área Costera Marina Protegida de Tortel (Chile)	In development
Dōngshā Huánjiāo Guójiā Gōngyuán (Taiwan)	Unable to locate/Unavailable
Farasan Islands Protected Area (Saudi Arabia)	Unable to locate/Unavailable
Huon Commonwealth Marine Reserve (Australia)	https://parksaustralia.gov.au/marine/pub/plans/se-network-management-plan2013-23.pdf
Namibian Islands Marine Protected Area (Namibia)	Unable to locate/Unavailable
Olympic Coast National Marine Sanctuary (United States)	https://nmsolympiccoast.blob.core.windows.net/olympiccoast-prod/media/archive/management/managementplan/mgmtplan_complete.pdf
Pondoland Marine Protected Area (South Africa)	Unable to locate/Unavailable
Pulau Lembata (Indonesia)	Unable to locate/Unavailable
Reserve Aquatique de l'Abysse Bleu (Gabon)	In development
Taman Wisata Alam Laut Kepulauan Banyak (Indonesia)	Unable to locate/Unavailable
Zone de protection marine du Banc-desAméricains (Canada)	In development

Table 3. Compilation of management plans for selected MPAs.

Figures Referenced:

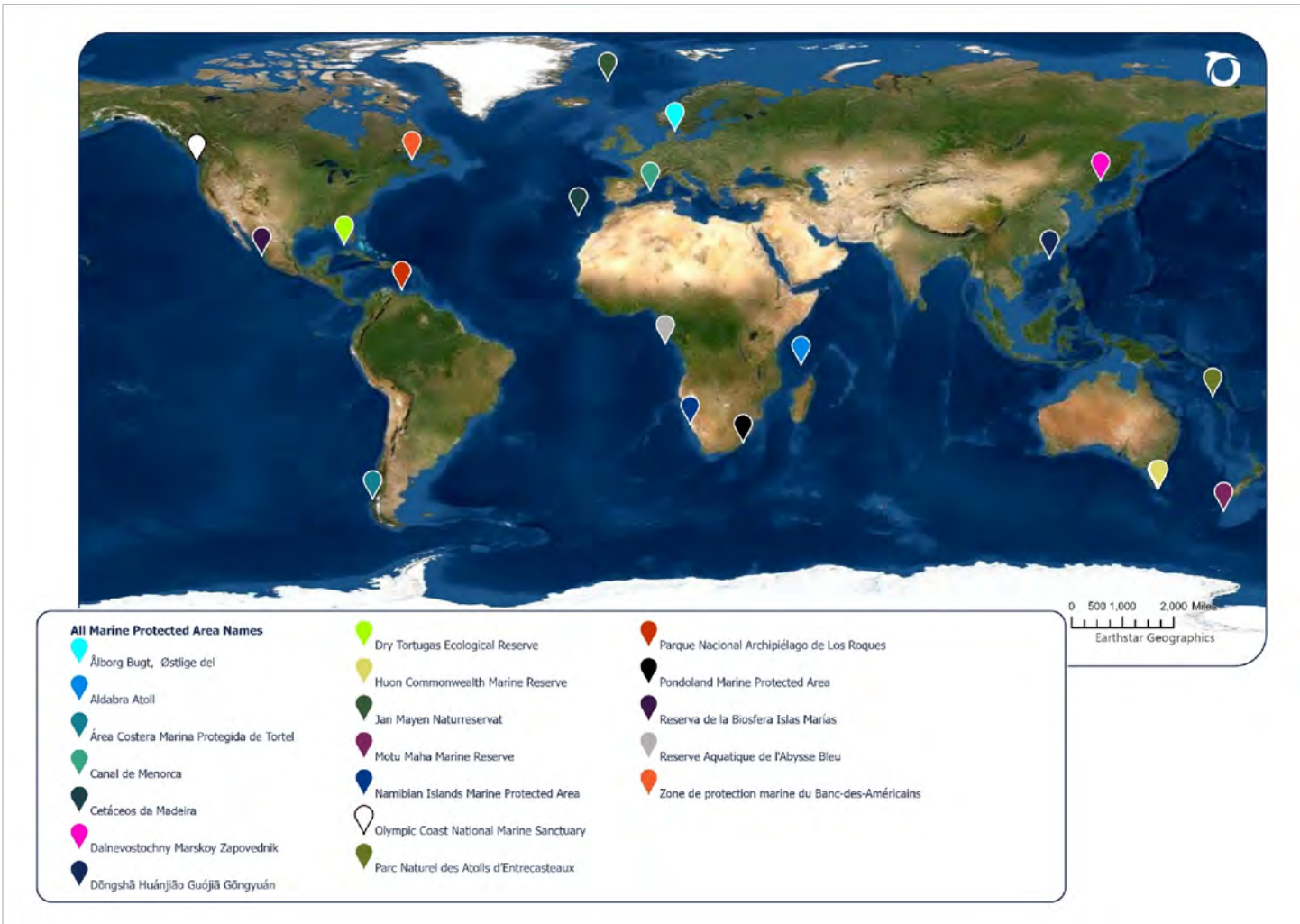

Figure 1. Locations of the 19 Marine Protected Areas (MPAs) selected for evaluation in this study. See Appendix 1 for method of selection.

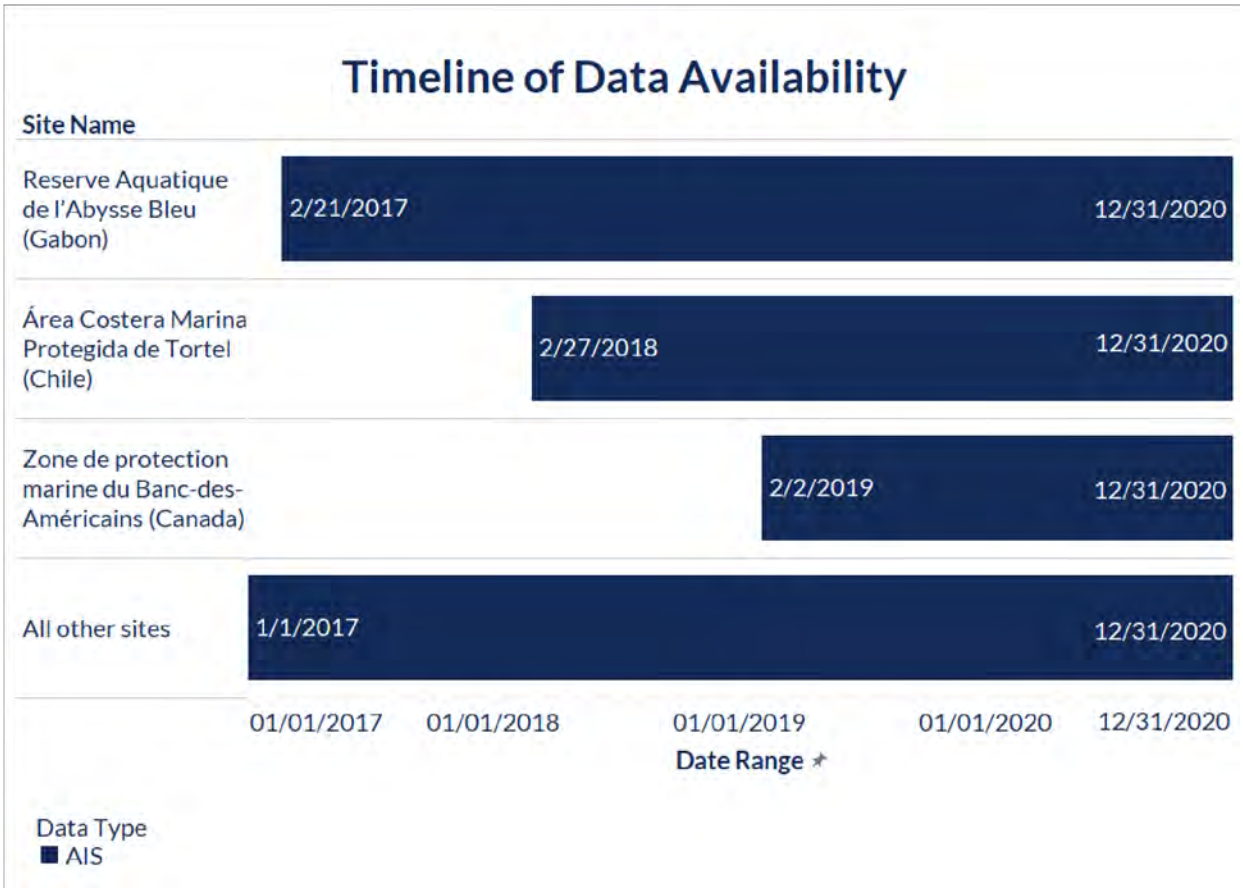

Figure 2. Date ranges for each MPA's data sources. For all sites but those specified above, data is available for the entire time period (Jan. 1, 2017, to Dec. 31, 2020). Three MPAs (Reserve Aquatique de l'Abysse Bleu, Área Costera Marina Protegida de Tortel, and Zone de protection marine du Banc-des-Américains) were designated after January 2017, so our analysis did not include any data prior to MPA establishment.

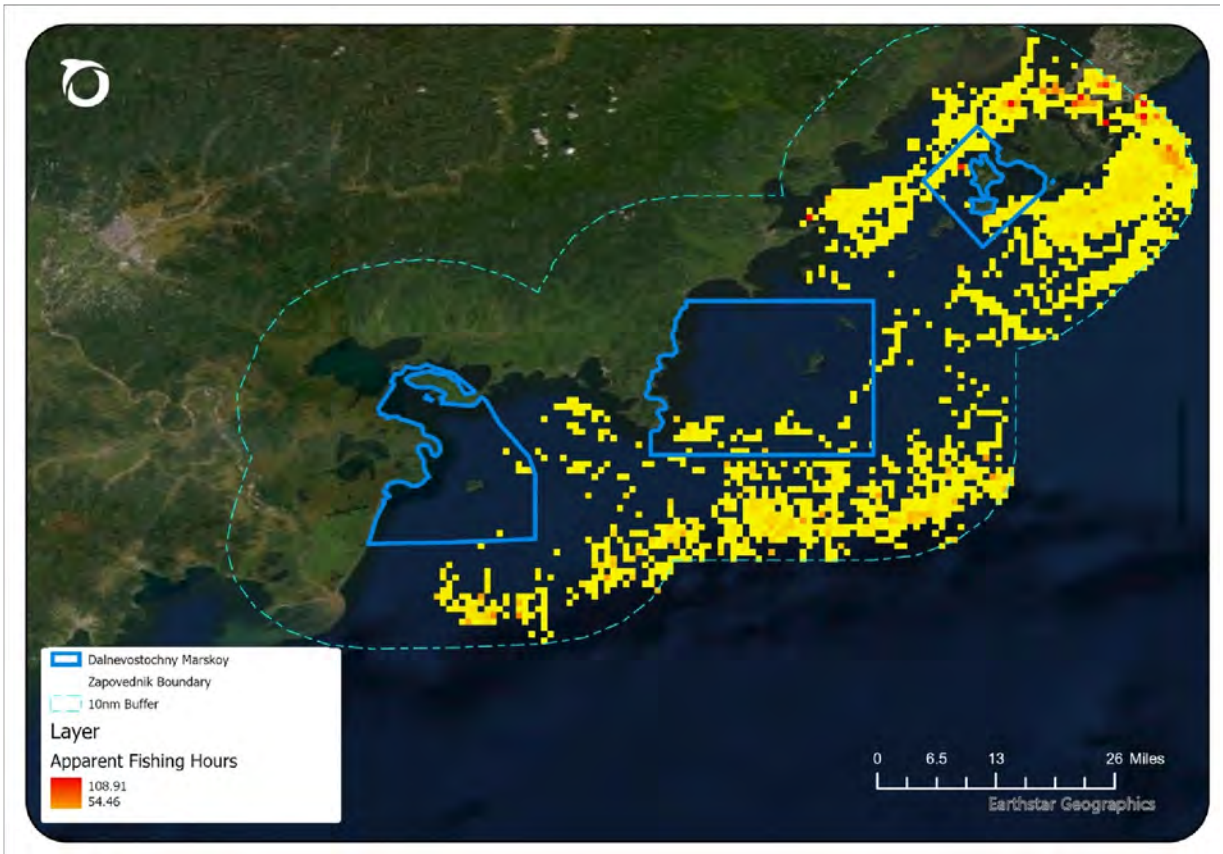

Figure 3. Apparent fishing effort in Dalnevostochny Marskoy Zapovednik (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

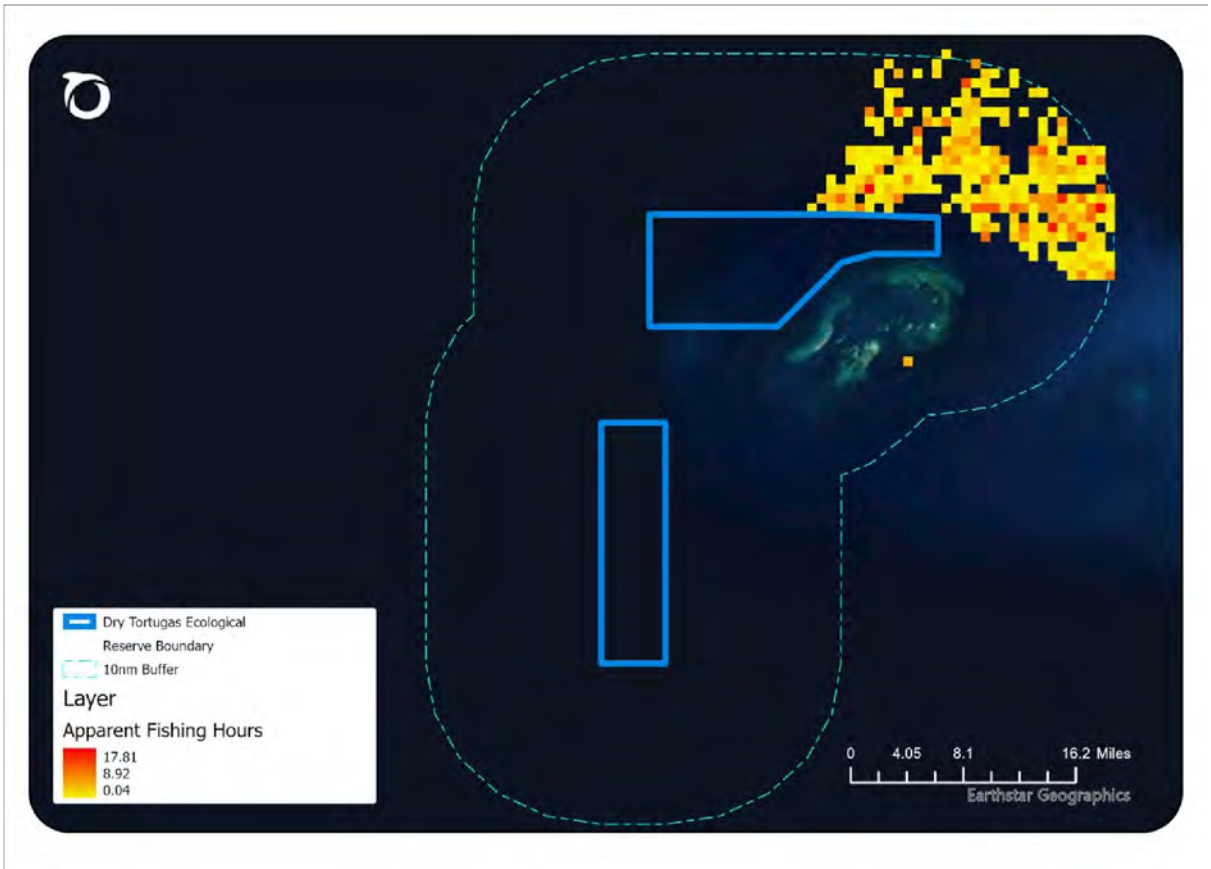

Figure 4. Apparent fishing effort in Dry Tortugas Ecological Reserve (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

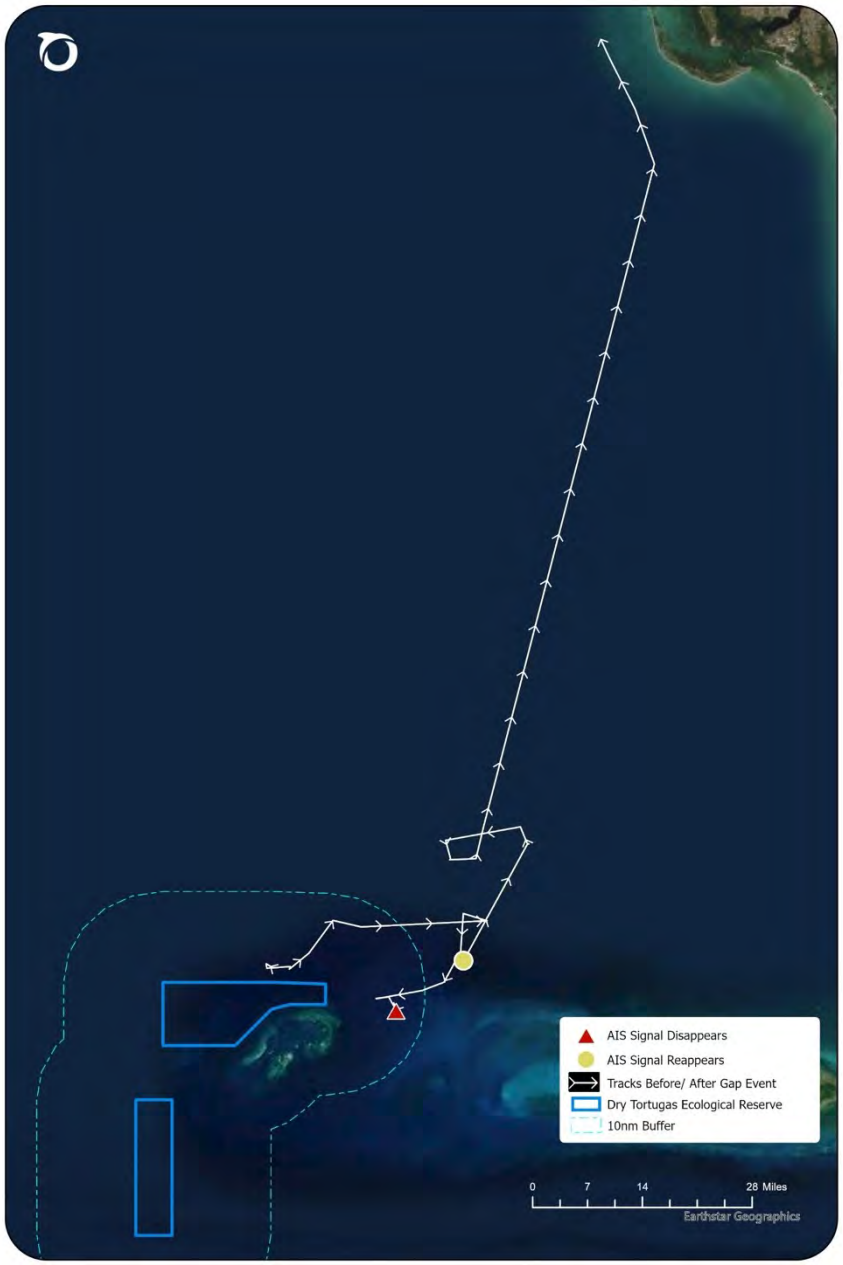

Figure 5. An apparent gap in AIS by a U.S.-flagged trawler in 2020 in Dry Tortugas.

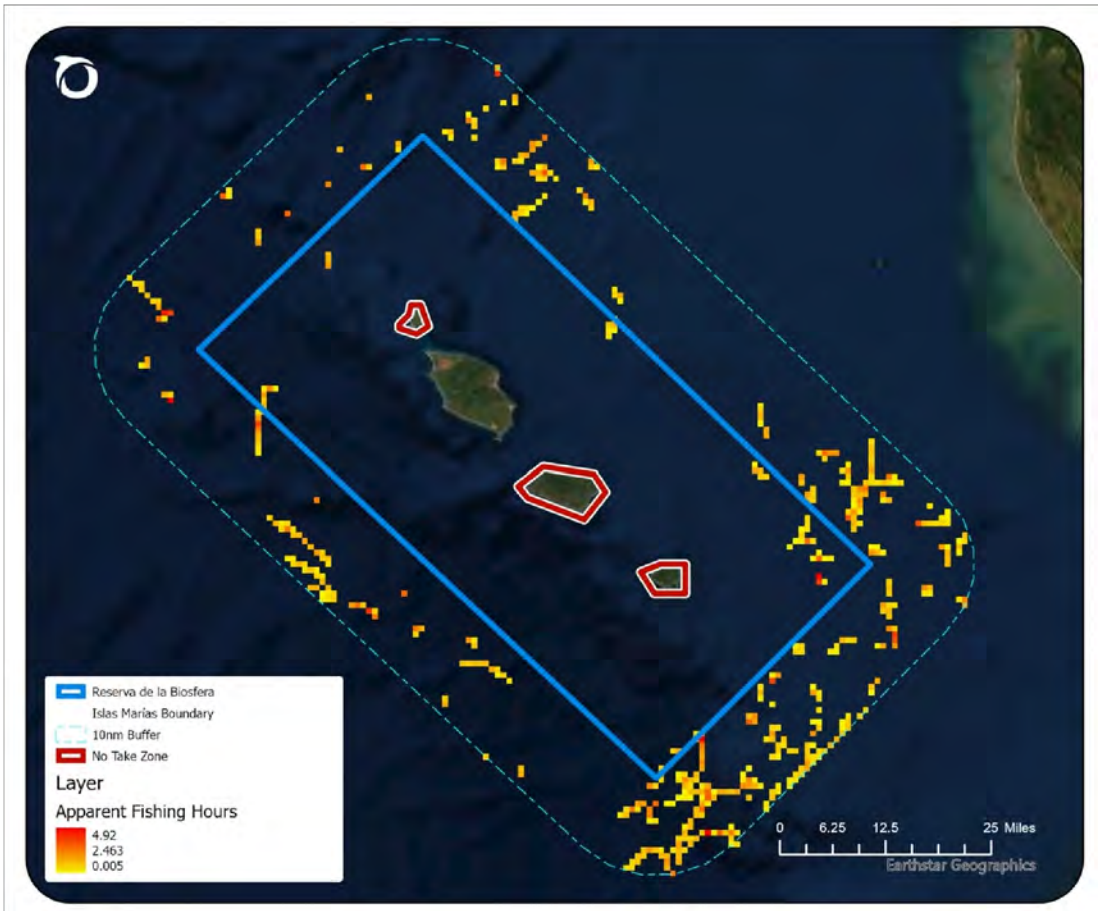

Figure 6. Apparent fishing effort in Reserva de la Biosfera Islas Marías (blue), its restricted zone (red), and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Oct. 15, 2019 — when Mexico's VMS data became unavailable.

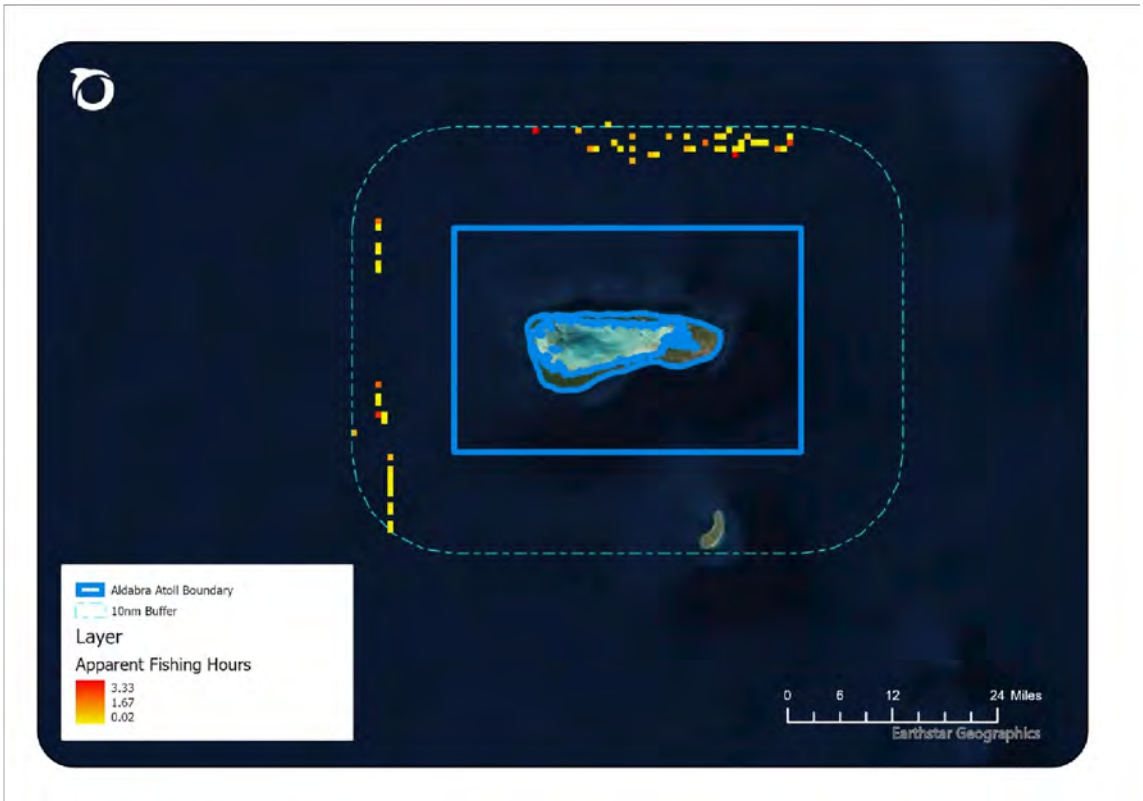

Figure 7. Apparent fishing effort in Aldabra Atoll (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

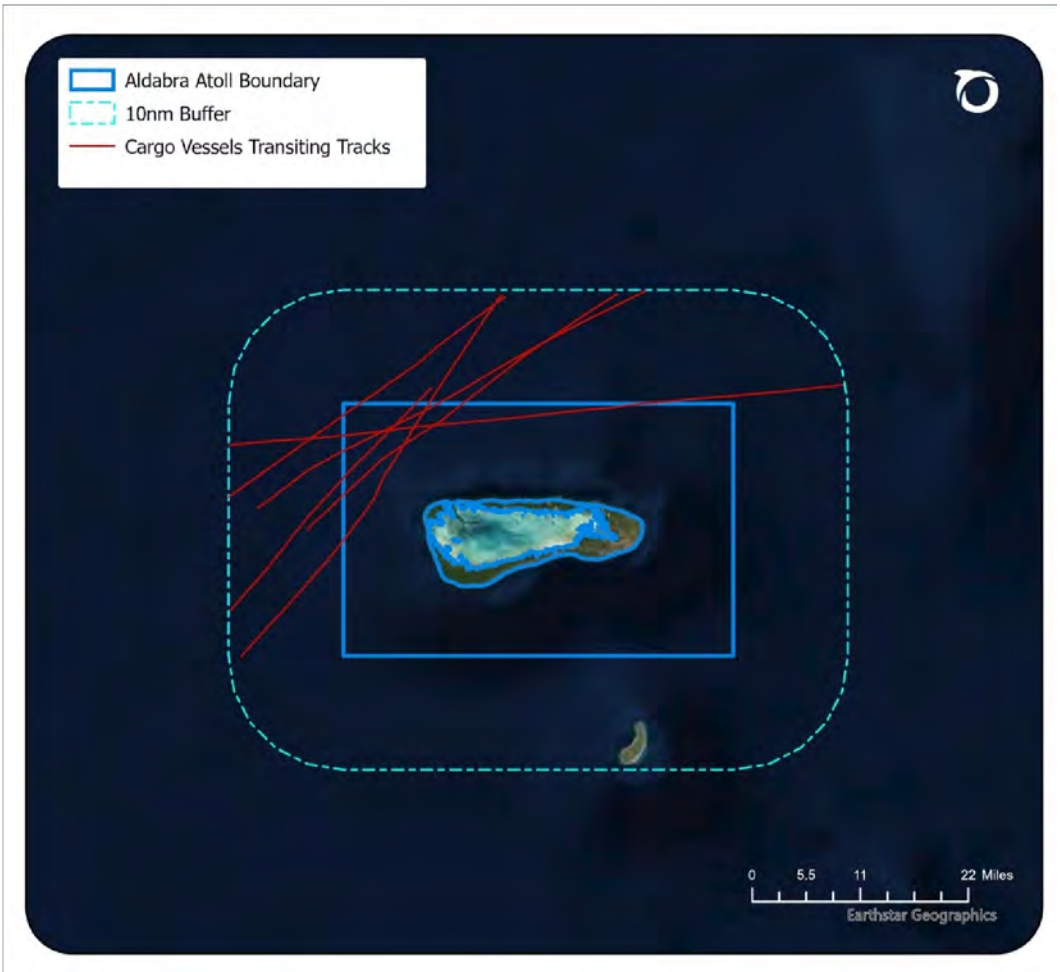

Figure 8. Tracks of cargo vessels that entered Aldabra's boundaries between January 2017 and December 2020.

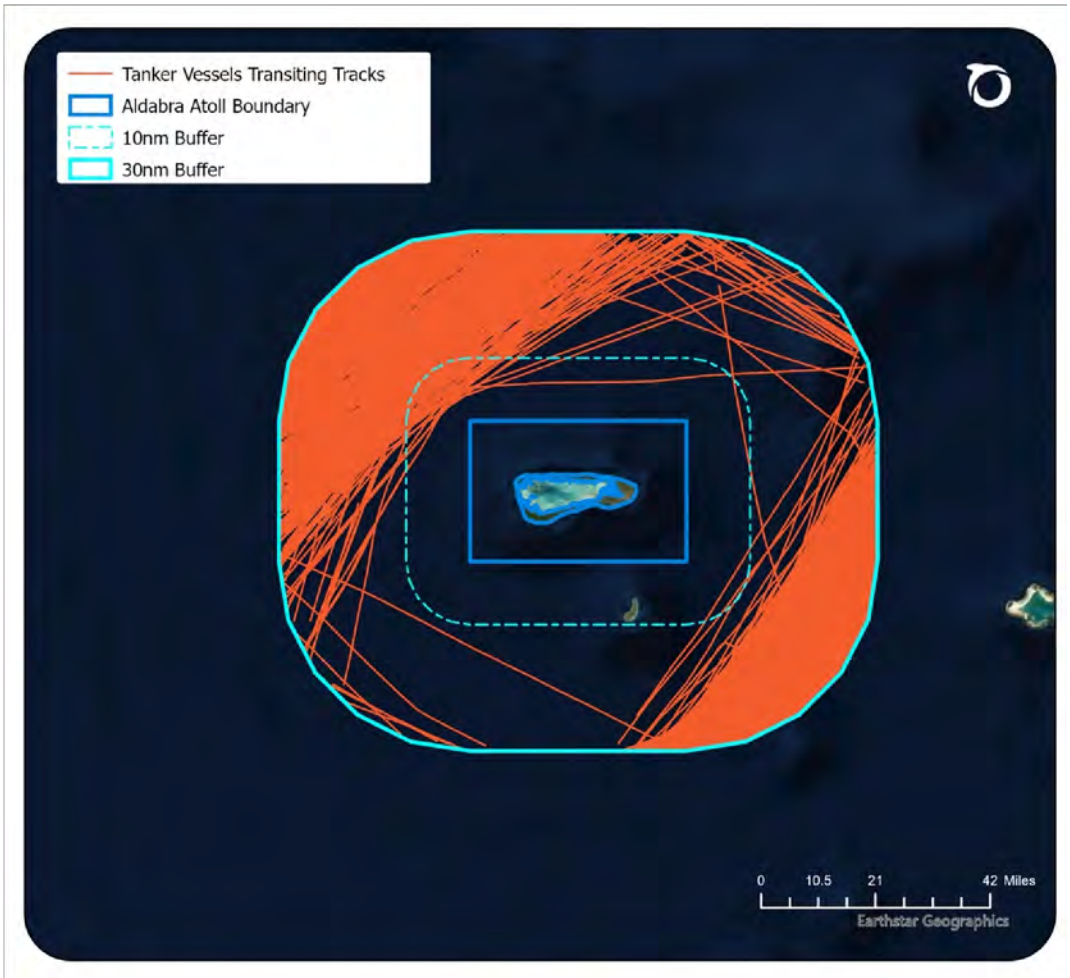

Figure 9. Tracks of tanker vessels that entered Aldabra's boundaries between January 2017 and December 2020.

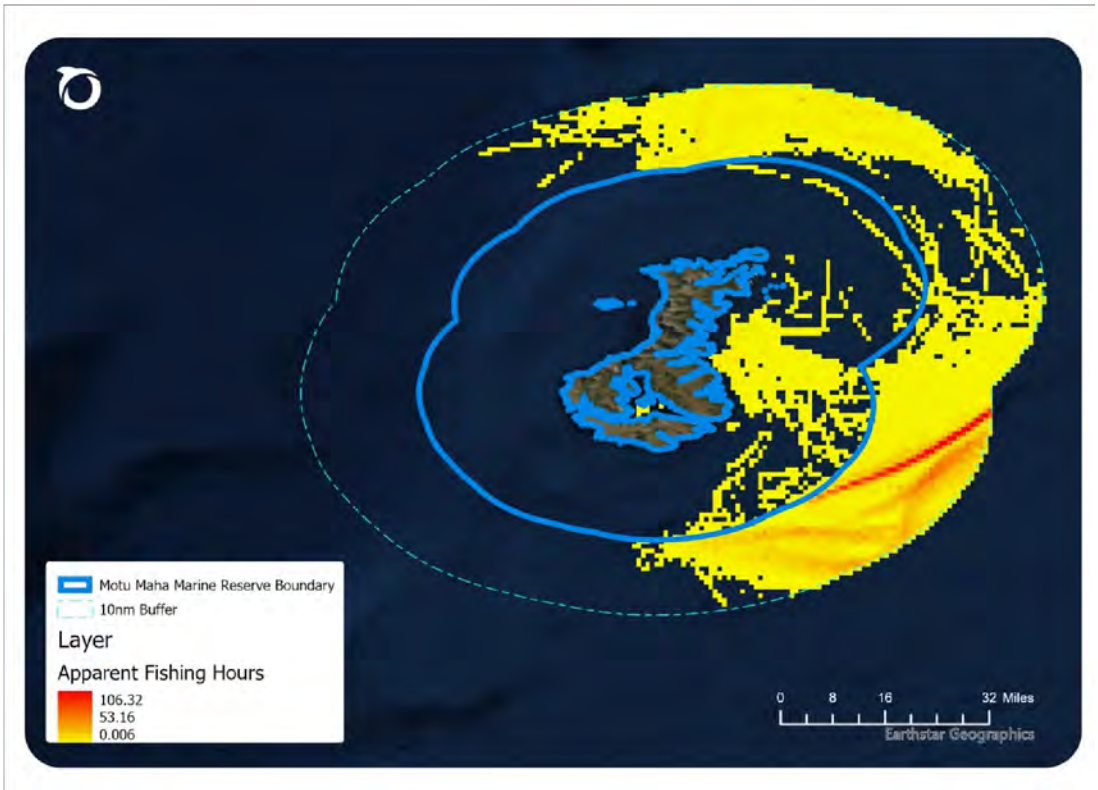

Figure 10. Apparent fishing effort in Motu Maha Marine Reserve (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

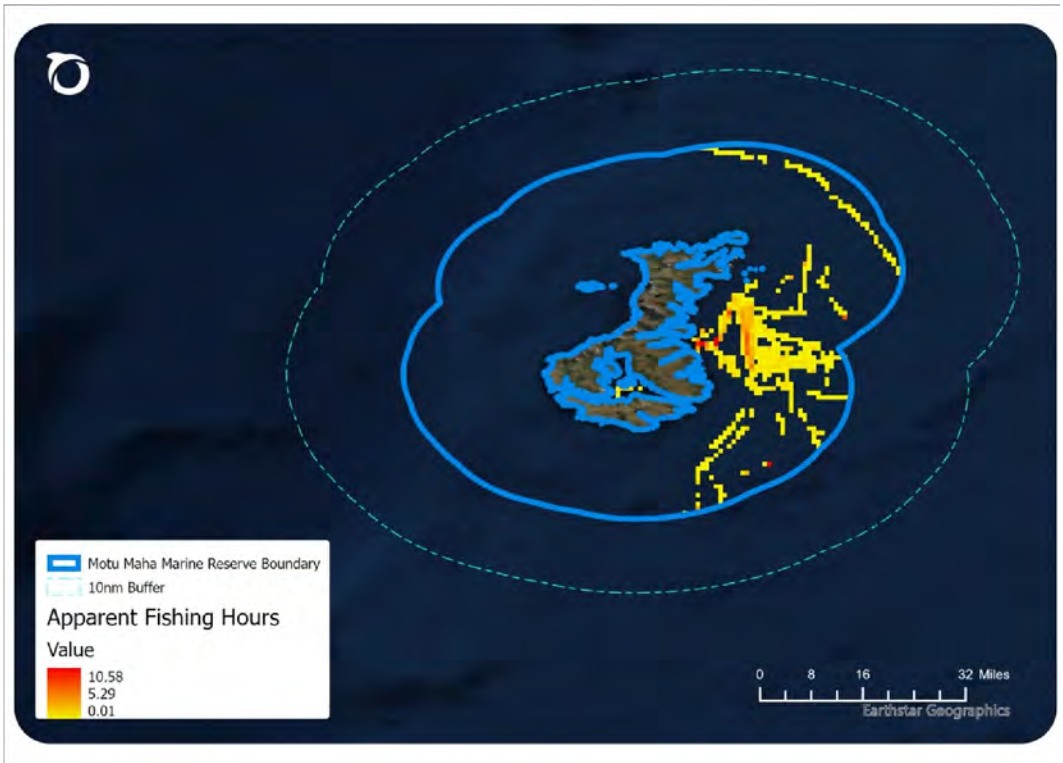

Figure 11. Apparent fishing by all New Zealand-flagged trawlers within the reserve from 2017 to 2020.

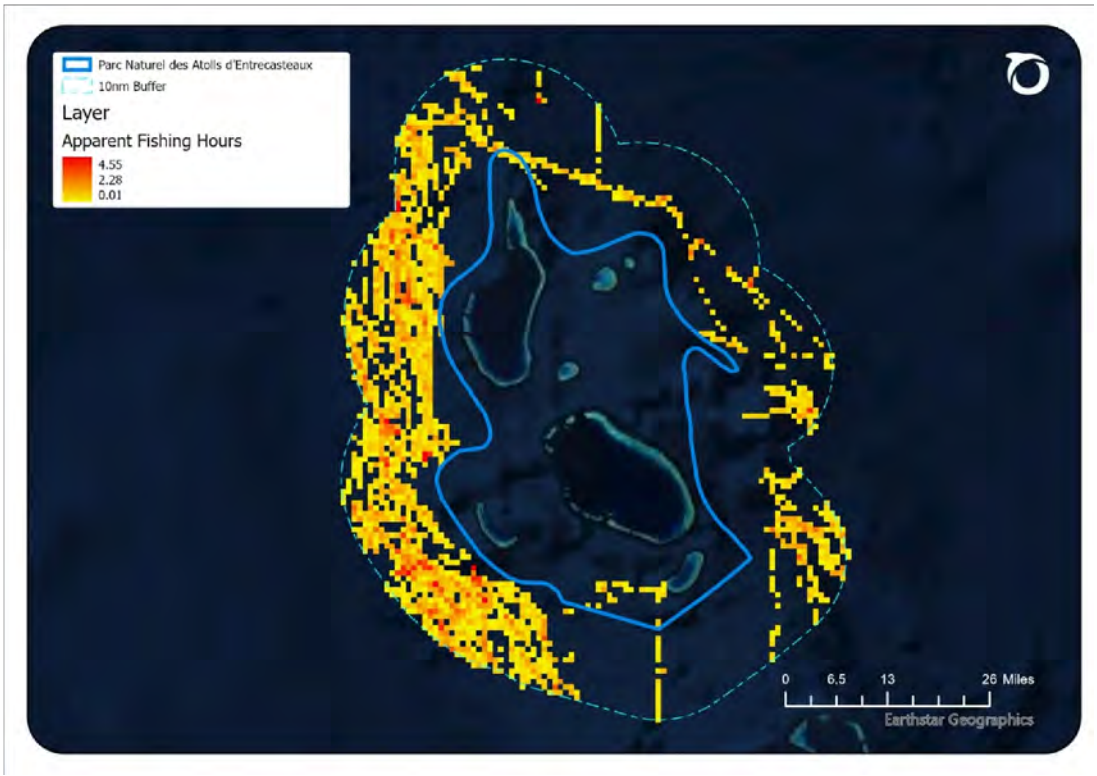

Figure 12. Apparent fishing effort in Parc Naturel des Atolls d'Entrecasteaux (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

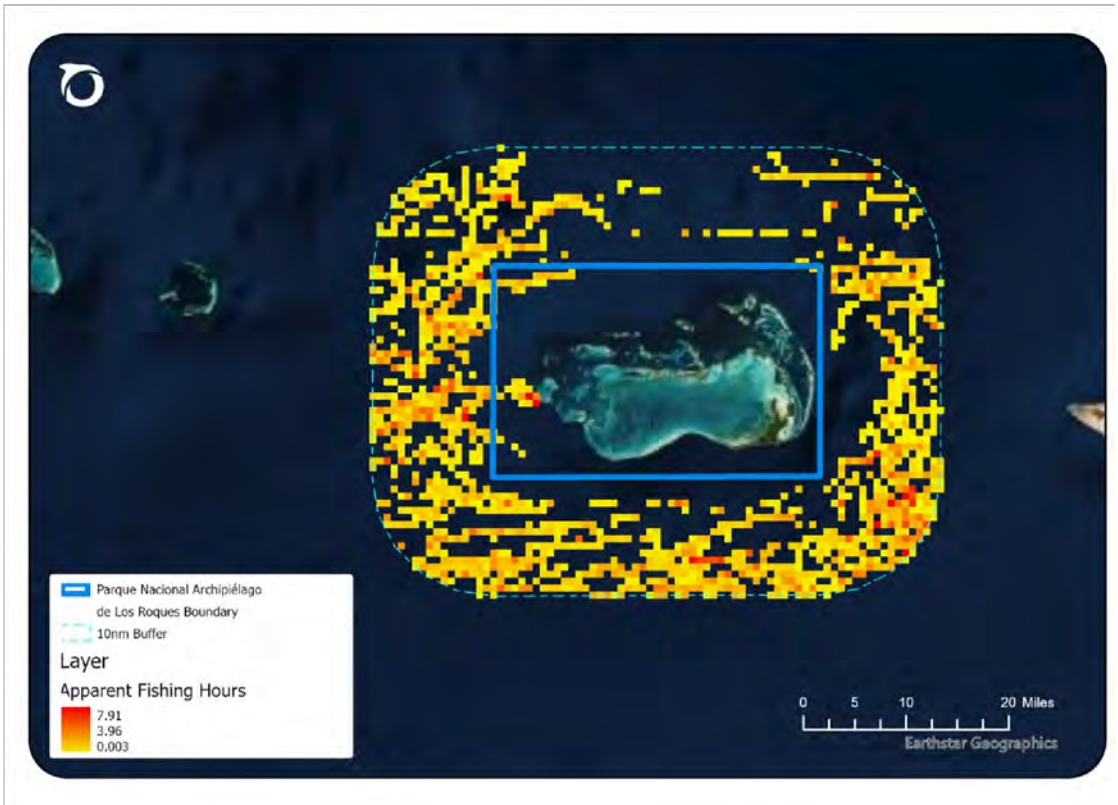

Figure 13. Apparent fishing effort in Parque Nacional Archipiélago de Los Roques (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

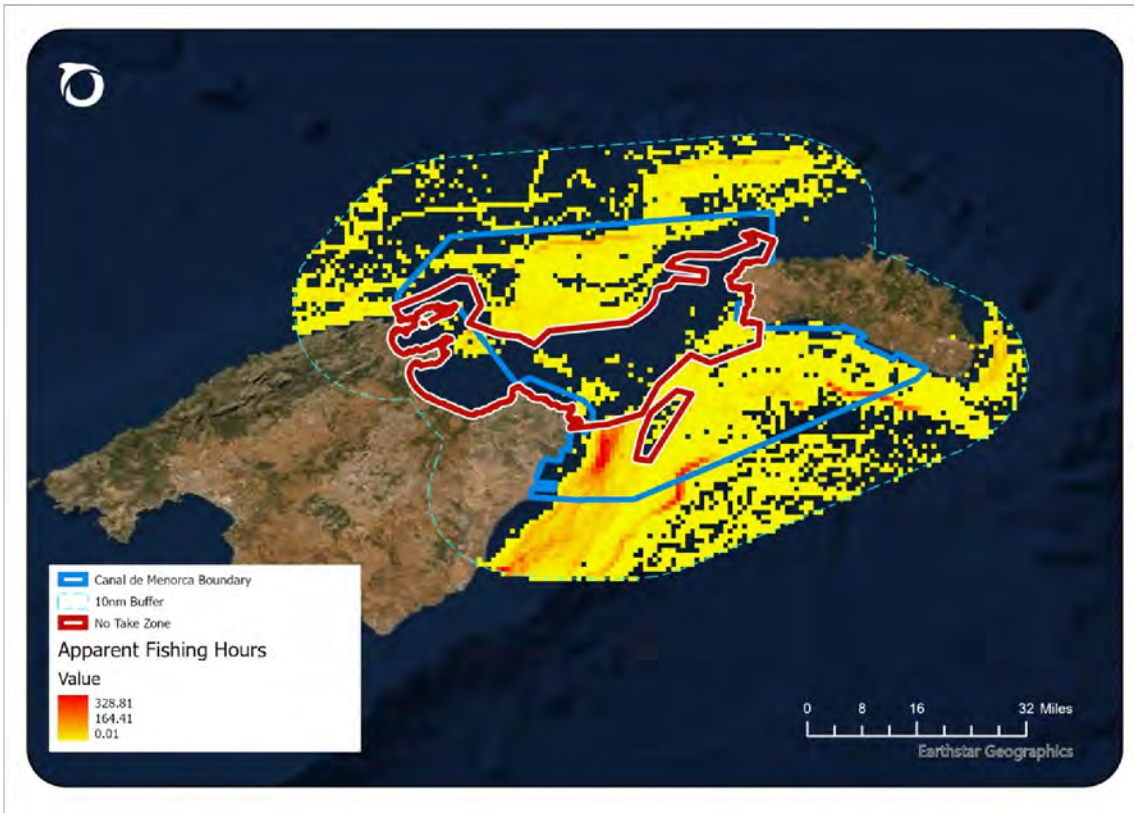

Figure 14. Apparent fishing effort in Canal de Menorca (blue), its and bottom trawl ban zones (red line), and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

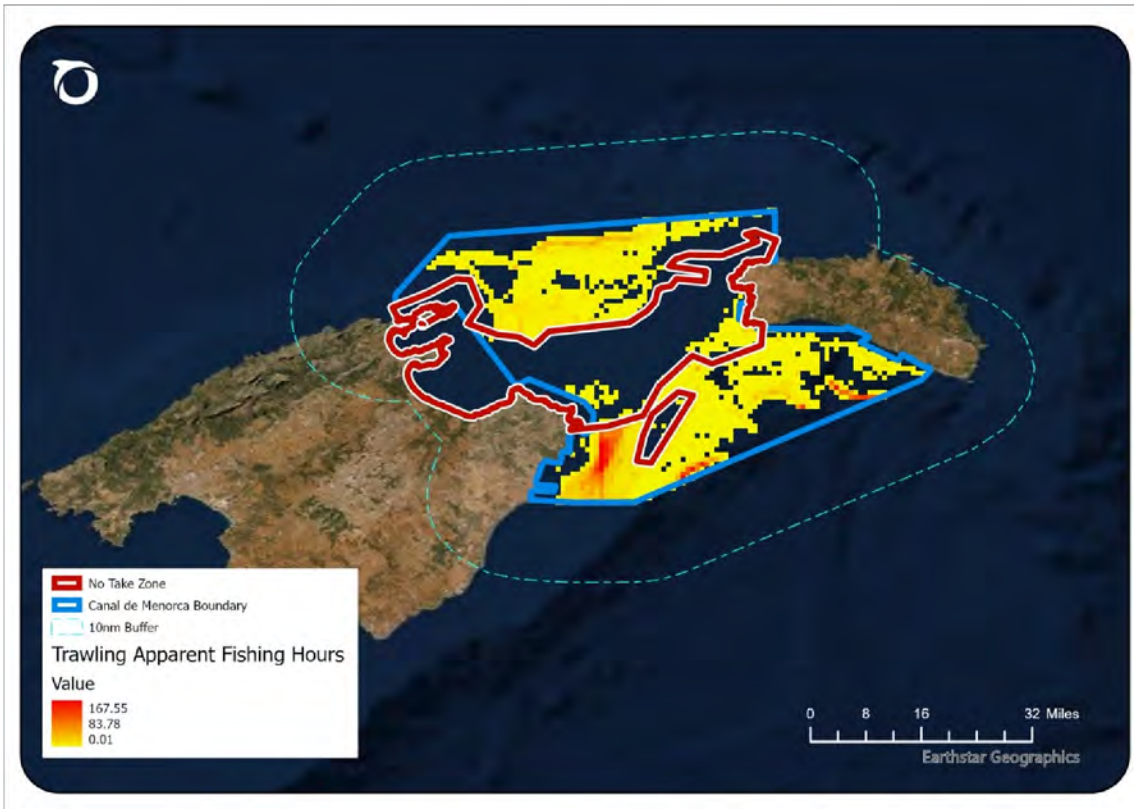

Figure 15. All trawling activity in the Canal de Menorca MPA (darker blue line) and bottom trawl ban zones (red line) between the ban's establishment in January 2017 and December 2020 at 0.01 x 0.01 degree resolution.

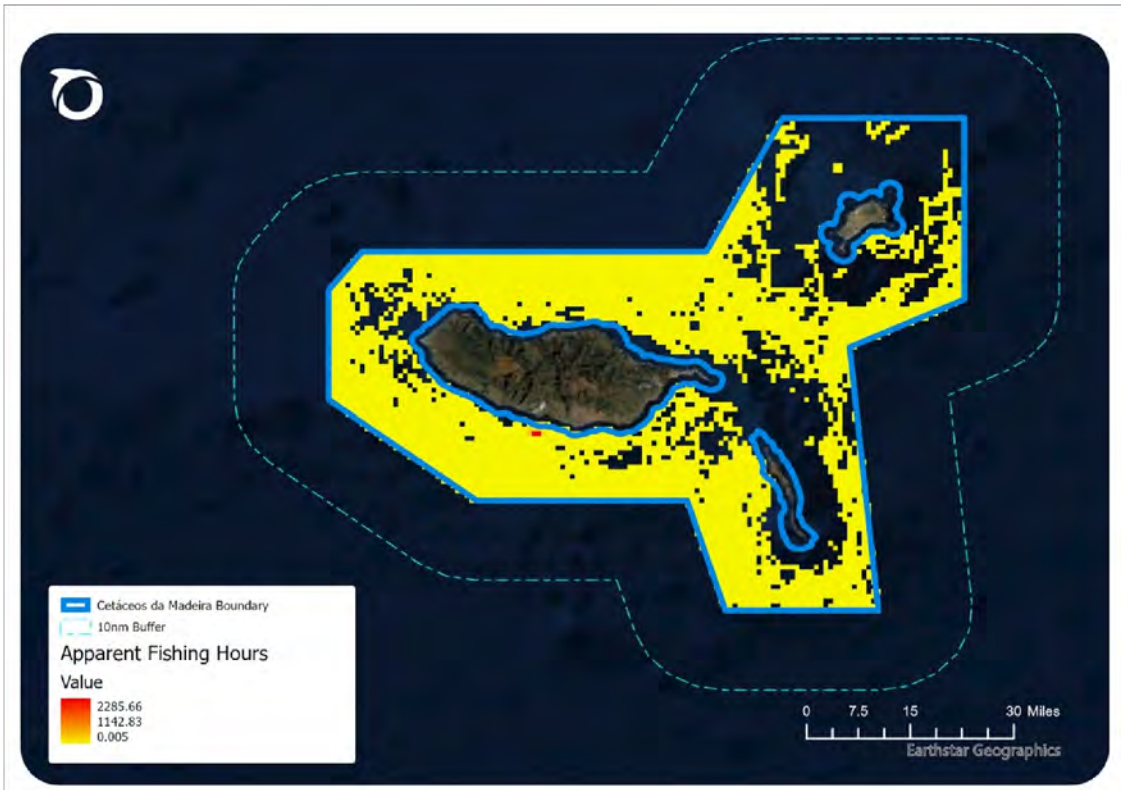

Figure 16. Apparent fishing effort in Cetáceos da Madeira (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

Figure 17. Apparent fishing activity of a Portuguese drifting longline vessel. The vessel may have spent 936.8 hours fishing in the MPA since 2017.

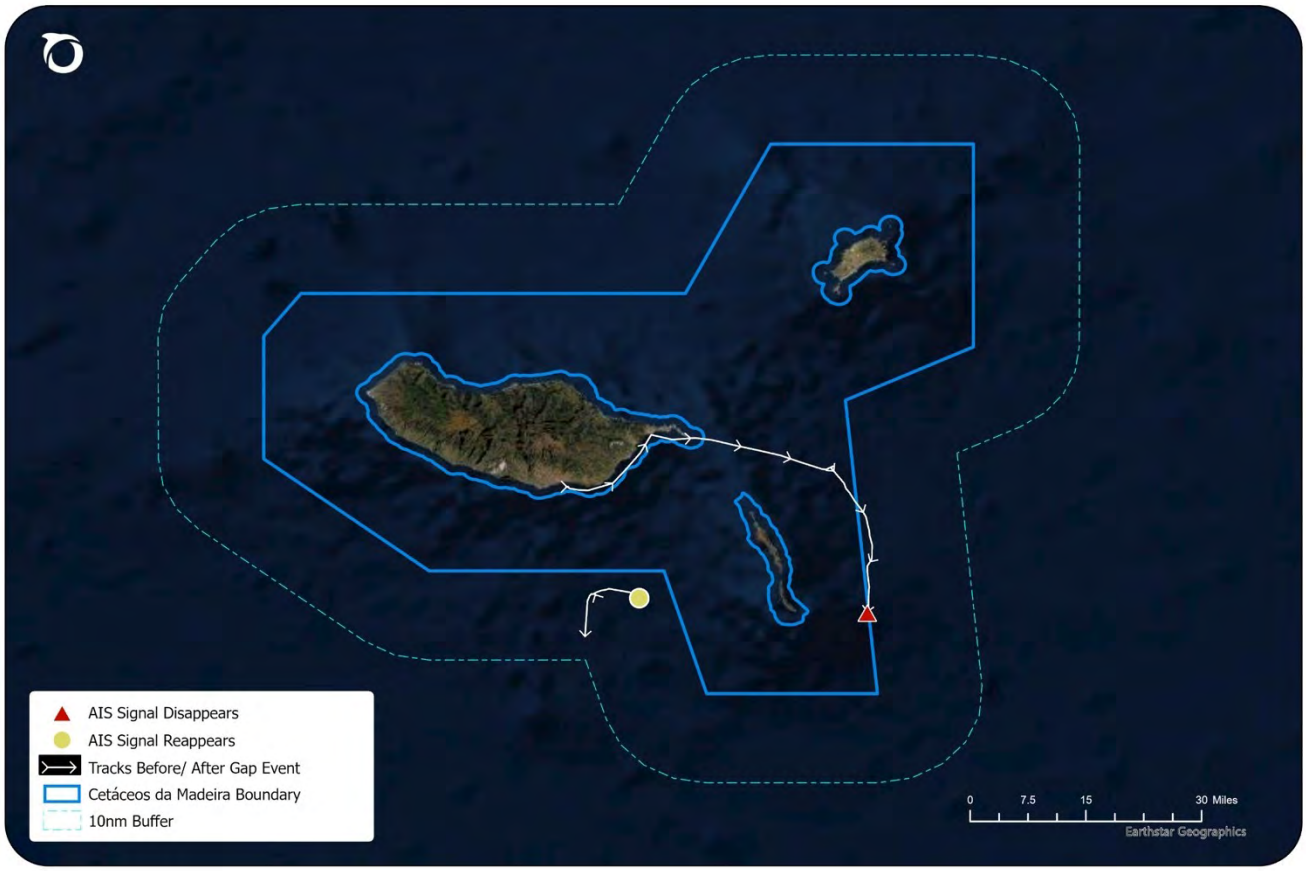

Figure 18. A Portuguese-flagged pole-and-line vessel appearing to turn off its AIS in 2017 for over 32 hours around Cetáceos da Madeira.

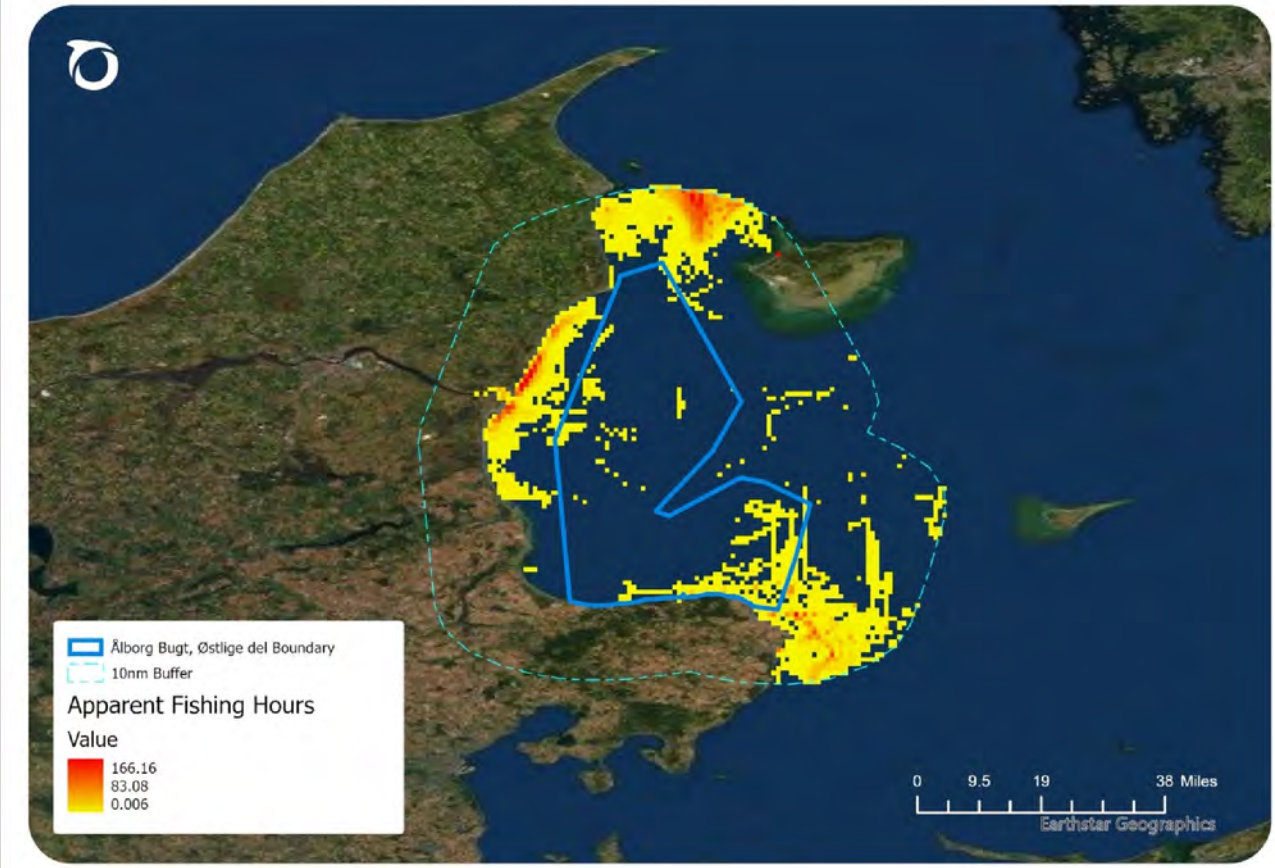

Figure 19. Apparent fishing effort in Ålborg Bugt, Østlige del (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

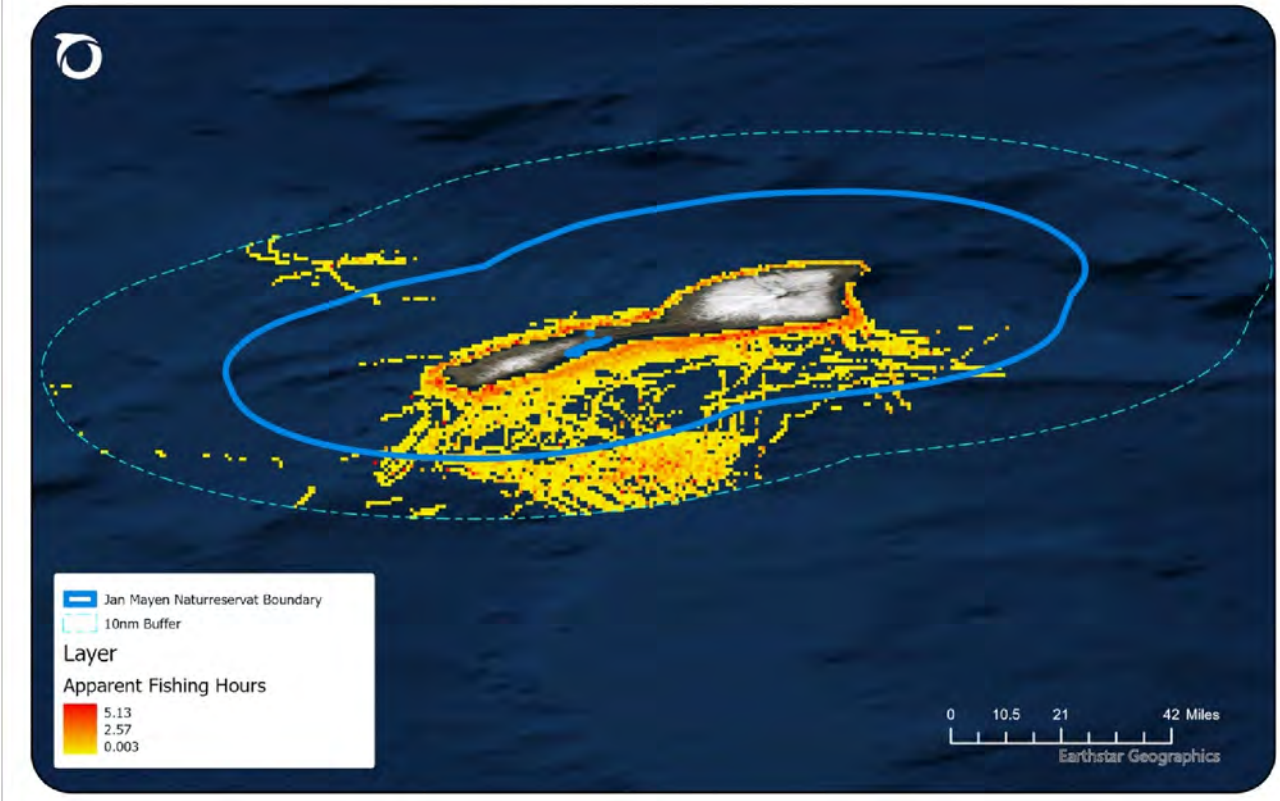

Figure 20. Apparent fishing effort in Jan Mayen Naturreservat (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

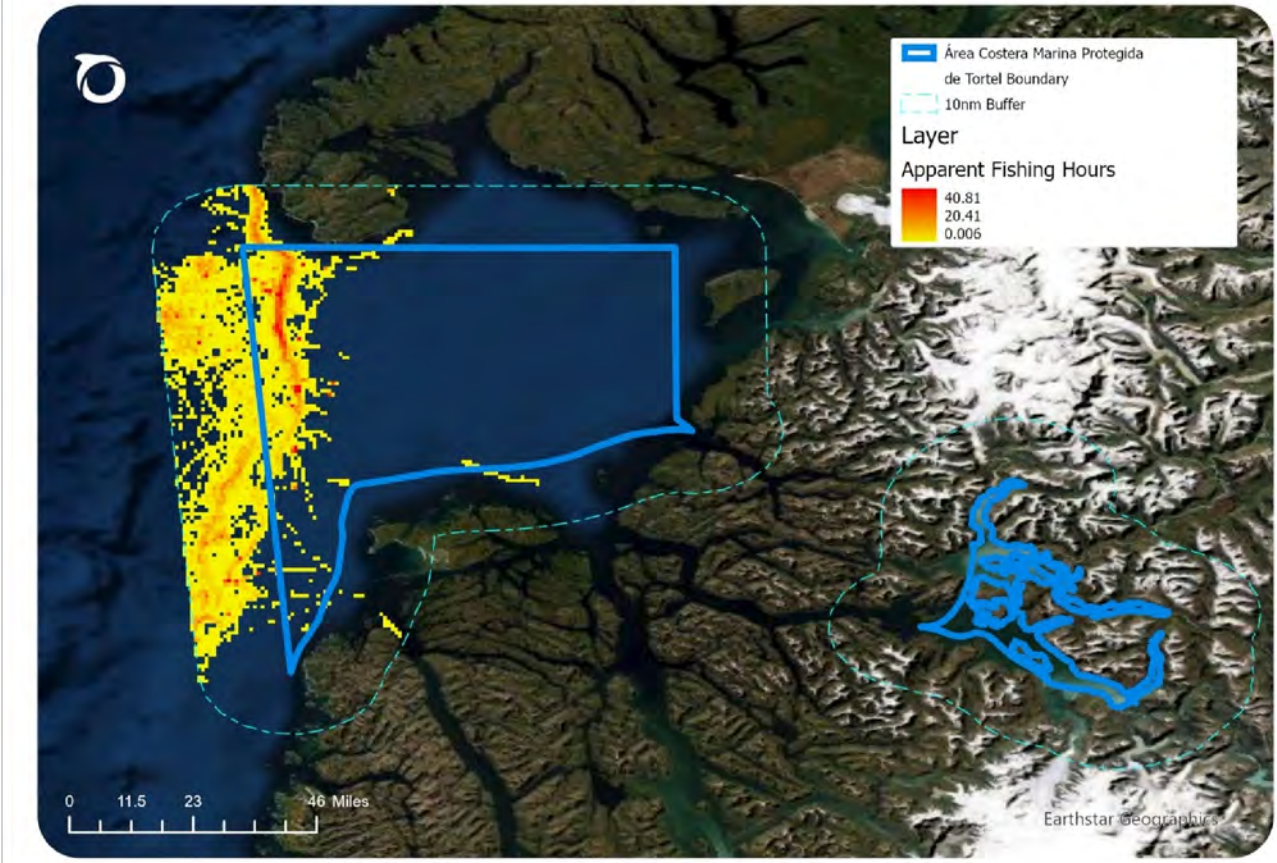

Figure 21. Apparent fishing effort in Área Costera Marina Protegida de Tortel and 10 NM buffer zone (dotted blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Feb. 27, 2018 — when the reserve was designated — through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

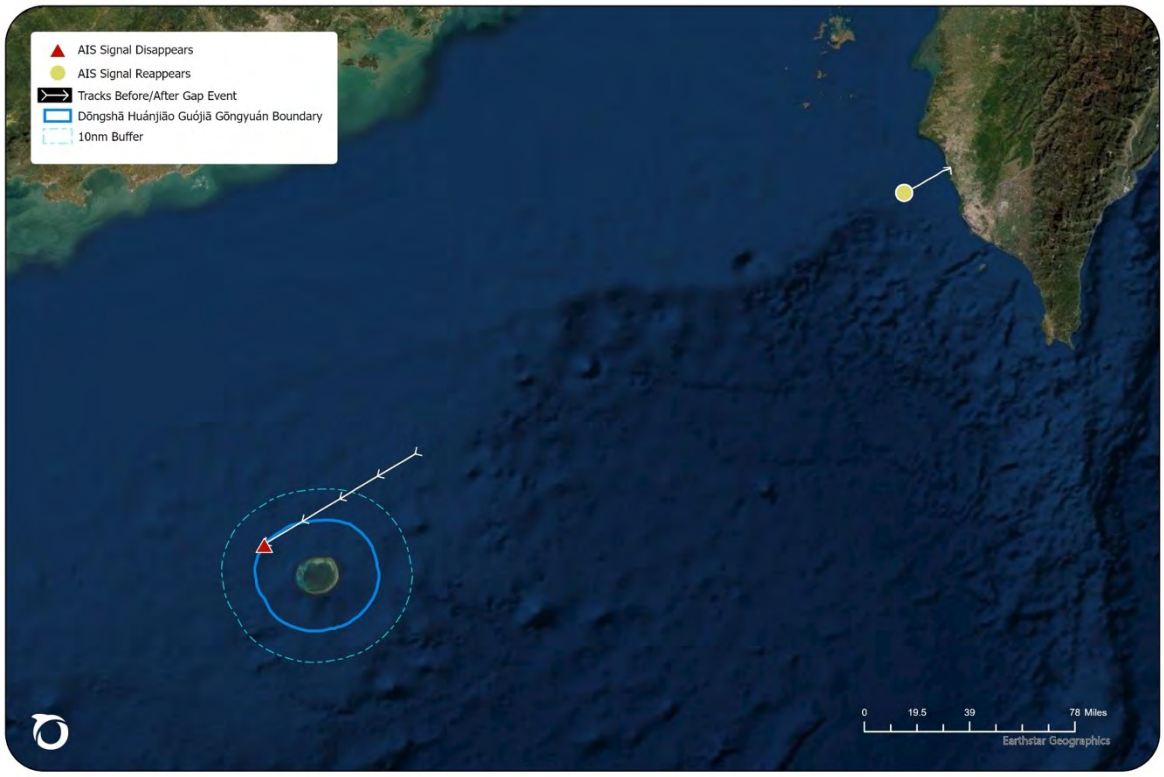

Figure 22. A trawler flagged to Taiwan appeared to turn off its AIS in 2018. The trawler's AIS signal was not seen for 273 hours (11 days), disappearing just outside of Dōngshā Huánjiāo Guójiā Gōngyuán's boundary and reappearing as the vessel came to port.

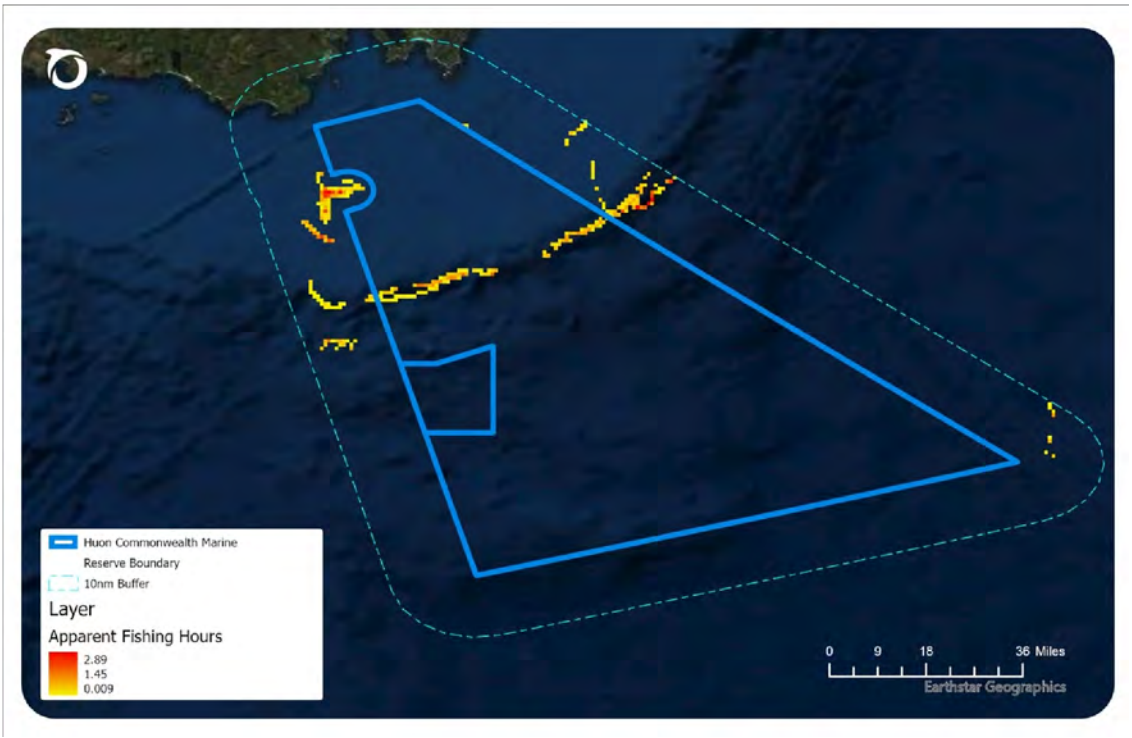

Figure 23. Apparent fishing effort in Huon Commonwealth Marine Reserve (blue) and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

Figure 24. An Australian-flagged trawler that appeared to turn off its AIS for over 104 hours (four days) in 2018. The vessel's AIS signal was lost on the western side of Huon and reappeared on the eastern side before the vessel went back to port.

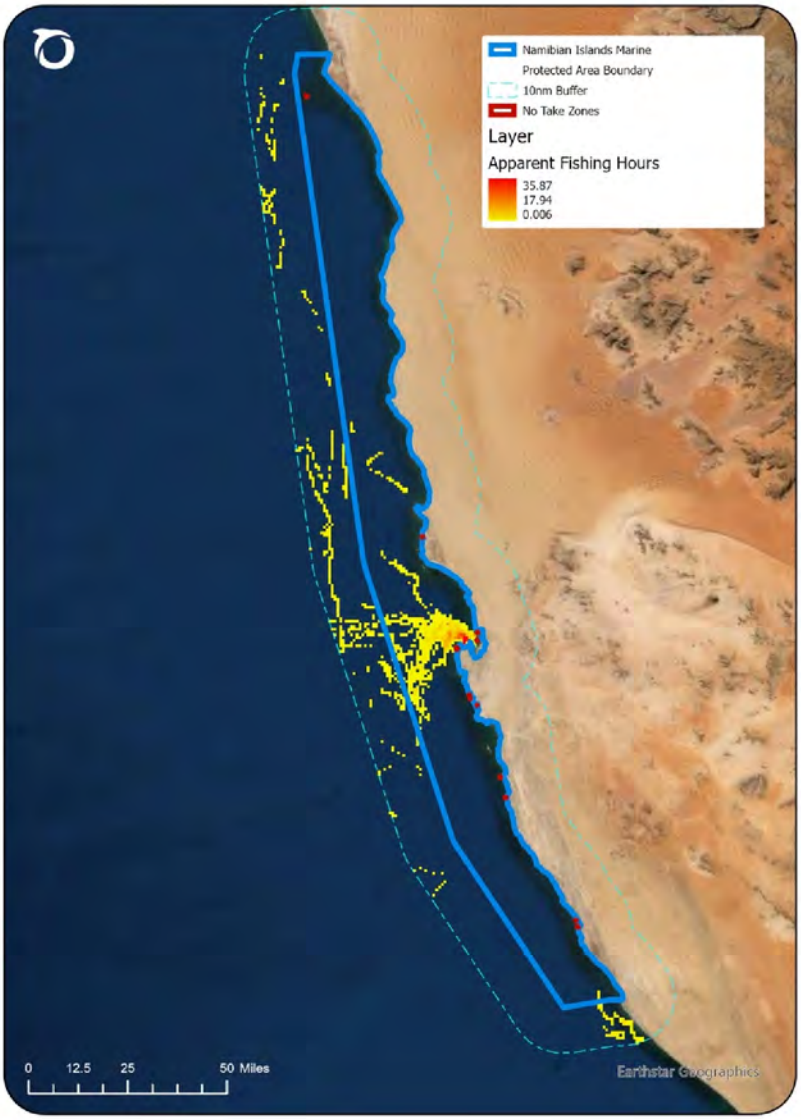

Figure 25. Apparent fishing effort in the Namibian Islands Marine Protected Area and 10 NM buffer zone (light blue), its restricted zones (red), and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period. Note: The restricted areas are small dots overlapping the MPA border along the coast.

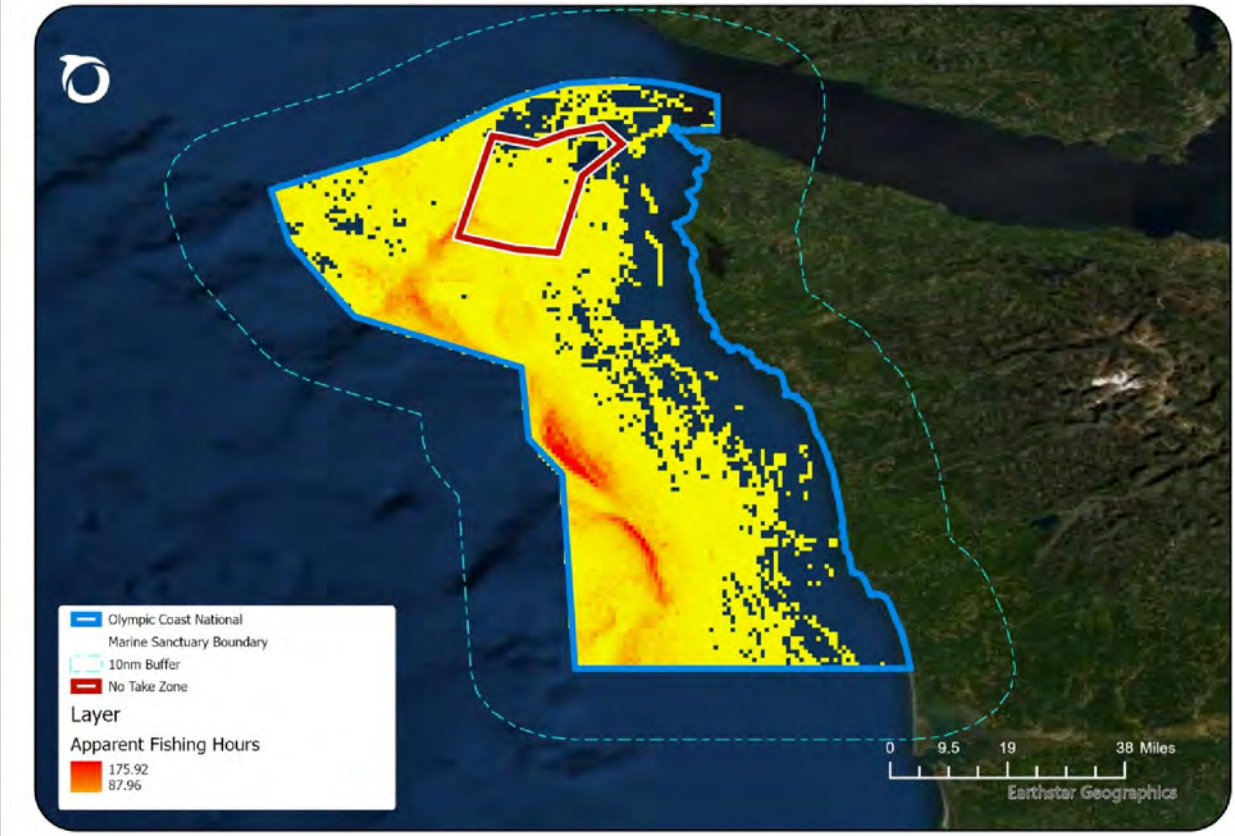

Figure 26. Apparent fishing effort in the Olympic Coast National Marine Sanctuary (blue), its restricted zone (dark red), and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

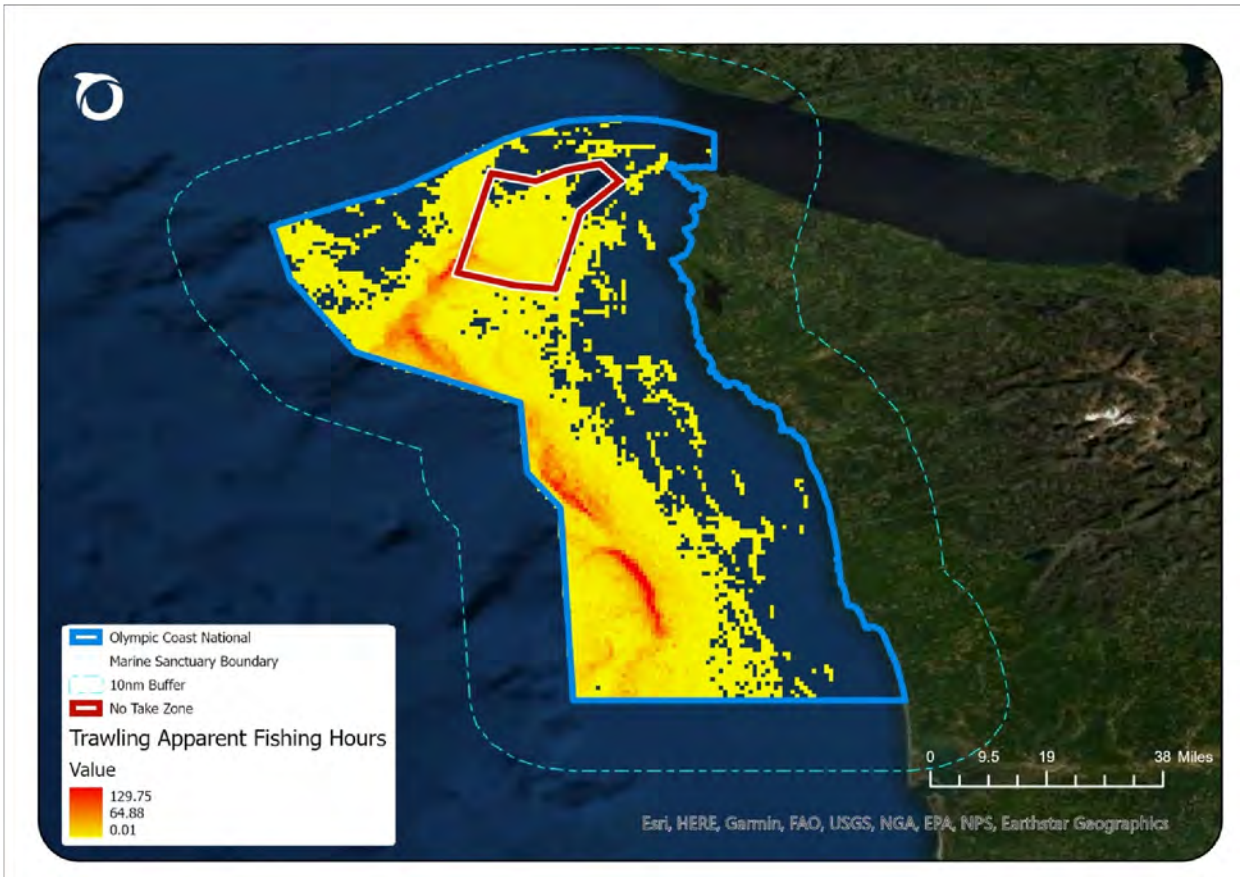

Figure 27. The distribution of all apparent trawling in the OCNMS (blue) and restricted zone (red) from January 2017 to December 2020.

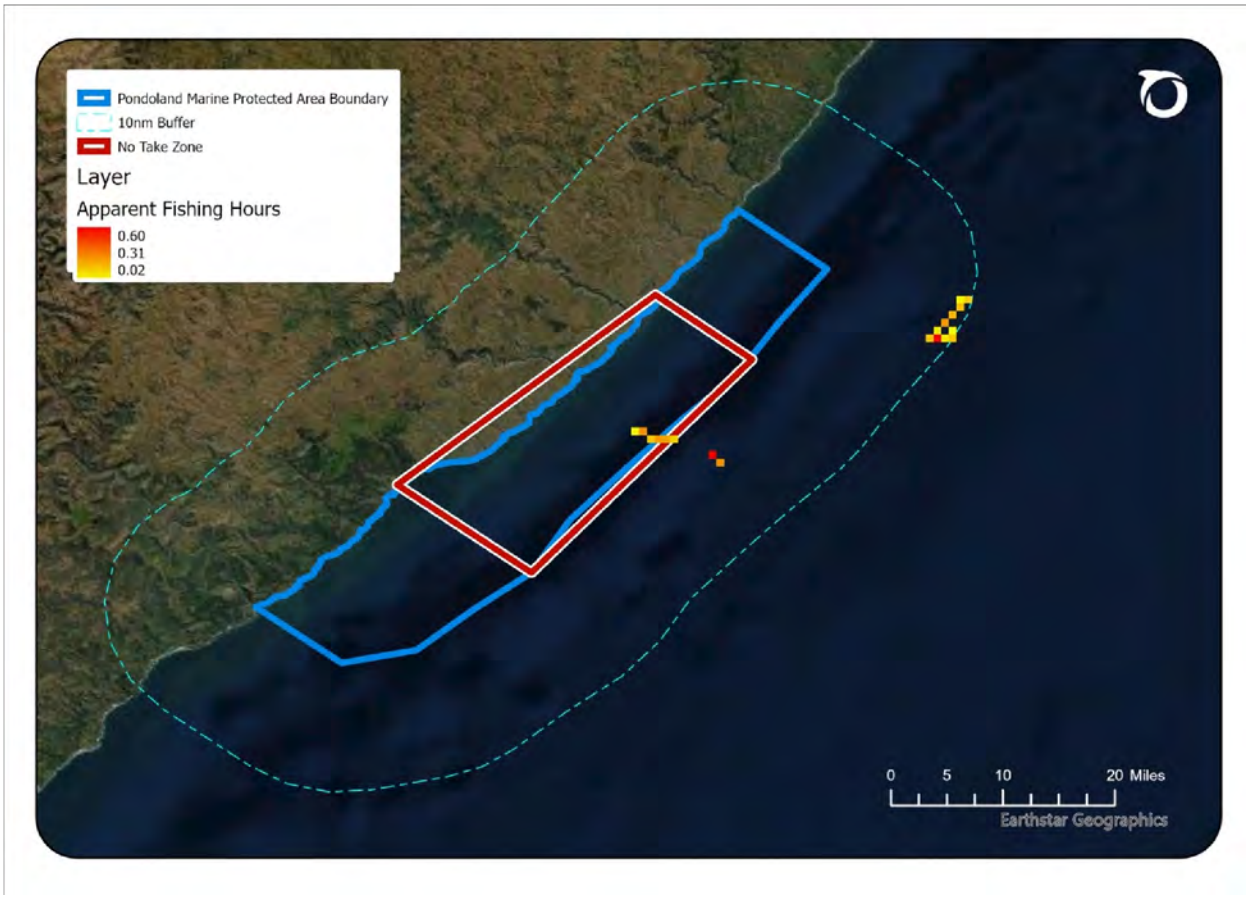

Figure 28. Apparent fishing effort in Pondoland Marine Protected Area (blue), its restricted zone (dark blue), and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

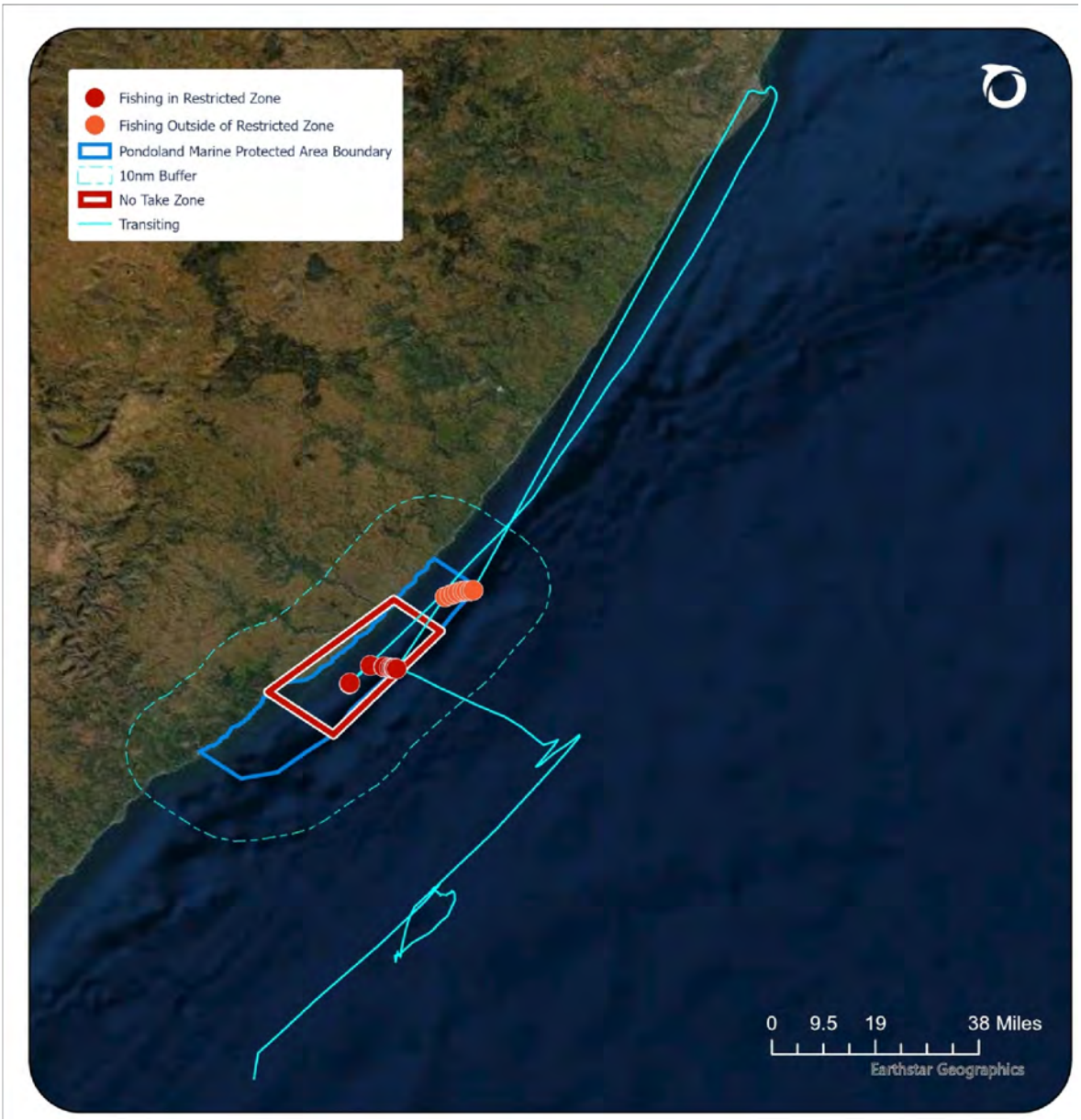

Figure 29. Apparent fishing by a South African-flagged longliner in 2018.

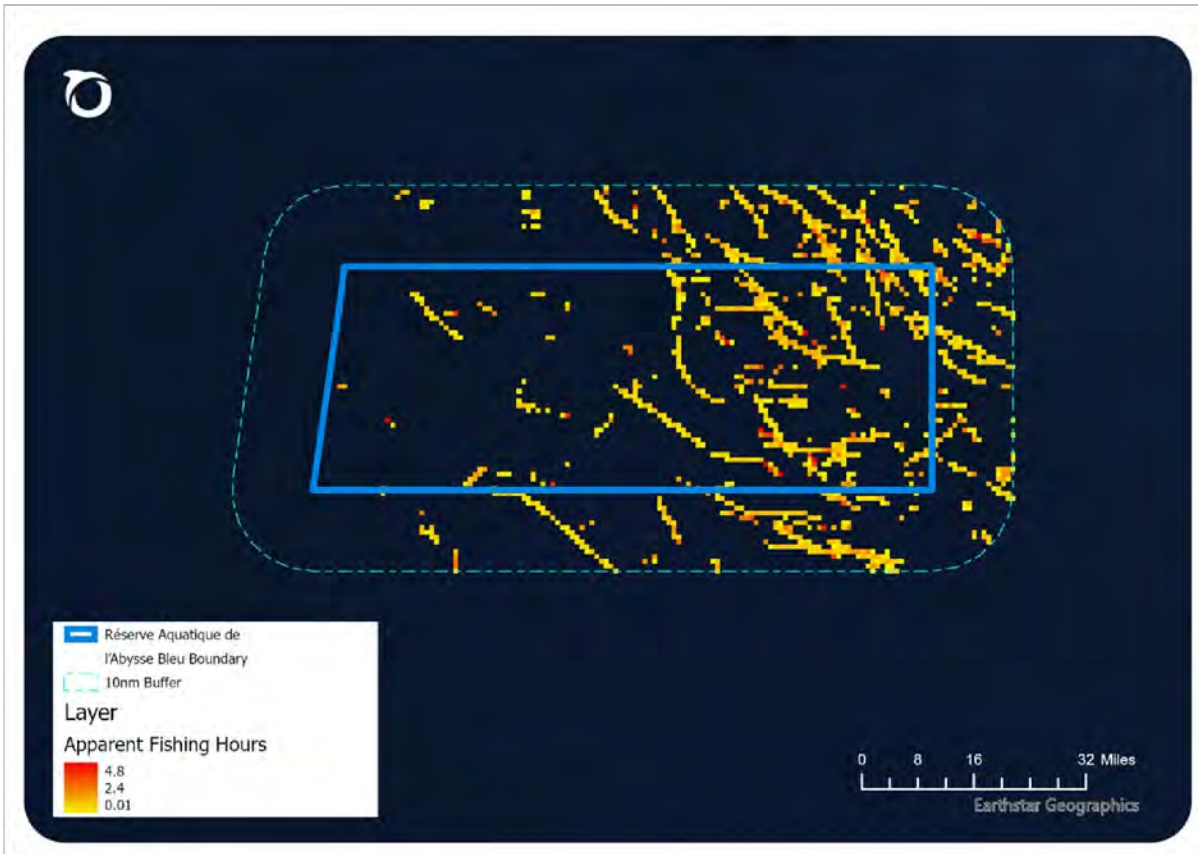

Figure 30. Apparent fishing effort in Reserve Aquatique de l'Abysse Bleu and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Jan. 1, 2017, through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

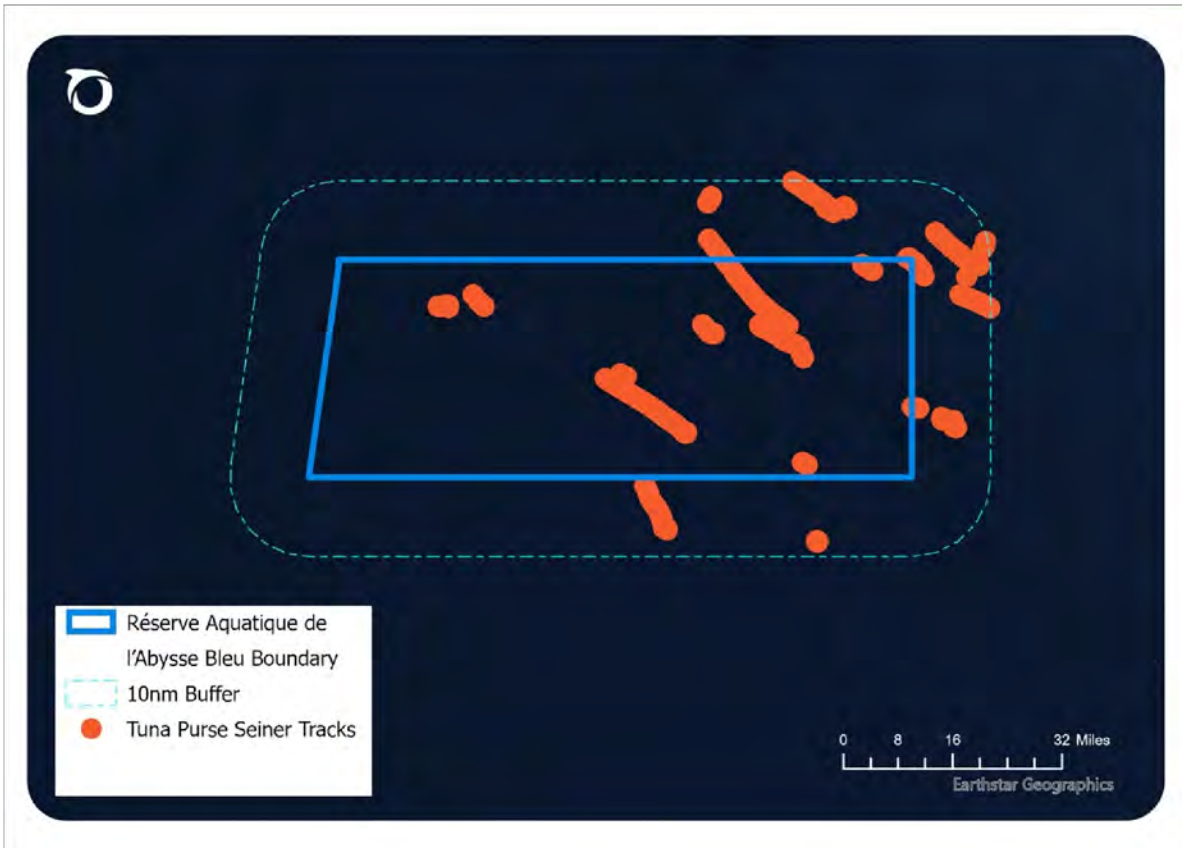

Figure 31. A tuna purse seiner flagged to Curaçao appeared to spend over 116 hours fishing within Reserve Aquatique de l'Abysse Bleu from 2017 to 2020.

Figure 32. Apparent fishing effort in Zone de Protection Marine du Banc-des-Américains (blue), its restricted zone (dark blue), and 10 NM buffer zone (light blue) via automatic identification system (AIS) data from Feb. 25, 2019 — when the MPA was designated — through Dec. 31, 2020. Color intensity corresponds to the magnitude of fishing hours during the study period.

Figure 33. The path of a Canadian-flagged trawler that appeared to turn its AIS off in May 2019. This vessel's AIS signal went missing for about 47 hours, disappearing on the southern side of the MPA's restricted zone and reappearing further north.

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