THE FISHERIES IN AND AROUND COIBA NATIONAL PARK, PANAMA

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A report of the *Sea Around Us*

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"Don't forget about the port!"
Cenobio Martinez,
Administrator at the Maritime Authority of Panama in Puerto Remedios

EXECUTIVE SUMMARY

The Terms of Reference for the present report were to estimate the fisheries catches in and around Coiba National Park and its Special Zone of Marine Protection, as required to assess the degree of protection that the Republic of Panama affords to this World Heritage Site, following expressions of concern by the World Heritage Committee at its meeting in Doha (2014) and Istanbul (2016).

As very little published information on the fisheries in and around Coiba National Park (CNP) is available, and even less about its Special Zone of Marine Protection, after completing a preparatory desk study, the first author conducted a month of fieldwork in Panama, to obtain fisheries-related information from government officials, environmental NGOs, academics and other actors, with emphasis on Veraguas and Chiriquí Provinces, where she also conducted numerous interviews with artisanal fishers. While the information from government officials and other actors provided some context, the interviews with artisanal fishers and the quantitative data they provided enabled the estimation of a catch of about 2 t per fisher per year, and an annual catch density of about 1.7 t per km^2 in the coastal waters of Chiriquí and Veraguas Provinces.

Within the 2,025 km^2 of the CNP, the 13 larger "*artisanal plus*" boats licensed to fish there have an estimated annual catch of 310 t (confidence interval 260-480 t); most of these fishes are exported. The very tentative estimate of the annual recreational fisheries catch in CNP is smaller, 58 t. However, its ecosystem impact will be magnified by the fact that it targets large fish. Jointly, these two legal fisheries exert a pressure which threatens the Outstanding Universal Values of this World Heritage Site.

Illegal fishing in CNP takes two forms. One is the use of illegal gear or the targeting of the protected species in the park; this appears to be common. The other form is illegal entry into the park, mainly by unlicensed artisanal fishers; this also appears to be fairly frequent. However, for reasons explained in the text, this should not modify much the catch estimates provided above. Illegal industrial fishing inside CNP appears to have declined in recent years and may not be the problem that it was before.

The biodiversity of marine life in the CNP does not appear to be threatened specifically by one or the other fishery sector, as suggested by representatives of the other sectors. Rather, this biodiversity appears to be threatened by the fact that a fraction, however small, of the massive fishing operations that occur outside the park are also permitted to operate within the park. Artisanal fishing can have the same impact on biodiversity as industrial fishing. Moreover, the *pargueros* which are allowed to operate in the CNP, while considered artisanal boats by the Panamanian authorities, would be considered industrial vessels in quite a few other countries. The largely open-access artisanal fisheries in Chiriquí and Veraguas Provinces can currently exploit over 13,800 km^2 of coastal waters. It is bizarre that not even the small area around the CNP can be protected from this onslaught. If they were, it is not only CNP and its visitors that would benefit, but also the fishers along the coast of the two provinces, where the fish biomass has been much reduced and where the large fish that provide the eggs and larvae that could replenish the fish populations living in the area are becoming exceedingly rare.

Located in an isthmus and covering over 75,000 km^2 between Central and South America, Panama is a country bordered by the Caribbean Sea to the north and the Pacific Ocean to the south. Colombia is its neighbor to the east and Costa Rica stands on its western border. Panama's Exclusive Economic Zone (EEZ) is over 331,000 km^2 (VLIZ 2012) and includes both Atlantic (Caribbean) and Pacific waters. Of the two EEZs, the latter, which has a surface area of 189,000 km^2 (Figure 1), shows a greater abundance of fish species, generally of larger size (Fiedler *et al*. 1943), and has much higher fisheries catches (Harper *et al*. 2014).

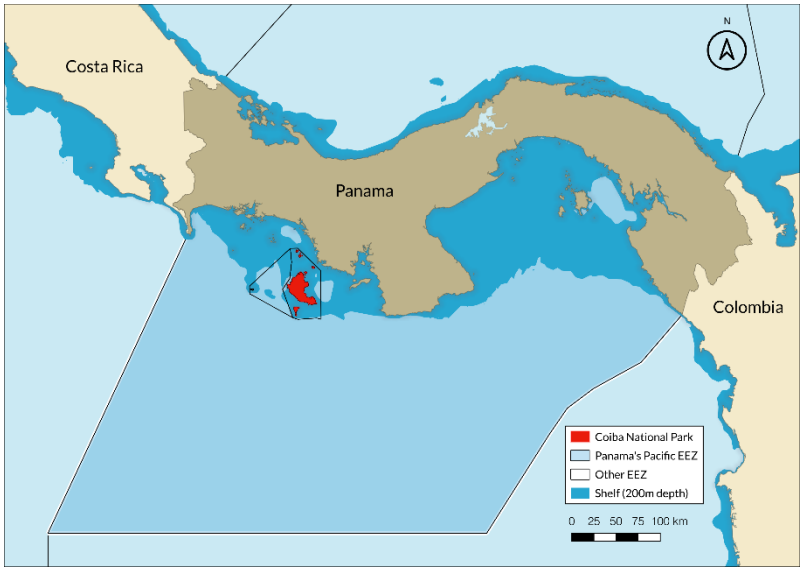

Figure 1. Map of the Panamanian EEZ in the Pacific covering an area of 189,000 km^2 (from Harper *et al*. 2016). The red land area identifies Coiba and neighbouring islands.

The Eastern Pacific reefs provide a key ecological link in the Tropical Eastern Pacific for the transit of numerous pelagic fishes as well as marine mammals. Such reefs also occur within Coiba National Park (CNP) and its Special Zone of Marine Protection, located southwest of the country's mainland in the Gulf of Chiriquí (Republic of Panama 2005). The CNP was established in 1991 by Resolution JD-021-91 of the National Institute of Natural and Renewable Resources. Later on, Law 44 of 2004, i.e., "*Creation of the Coiba National Park and Other Elements*," ratified its legal existence as a protected area. In 2005, the Coiba National Park and its Special Zone of Marine Protection were declared a UNESCO World Heritage Site by the World Heritage Committee in its 25th Session.

Coiba National Park (CNP) proper covers 2,025 km^2 of water and 537 km^2 of islands (Figure 2). It includes Coiba Island, the largest tropical island on the continental shore of the Pacific coast of the Americas, covering 503 km^2, along with 38 smaller islands, notable of which are Jicarón, Brincanco, Uva, Ranchería or Coibita, Canales de Afuera, Jicarita, Pájaros and Afuerita (Capson 2006).

The roughly triangular "Special Zone of Marine Protection" that is also part of the site covers an additional 1,607 km^2 (Figure 2). It incorporates Montuosa Island, of 1.36 km^2, 21 nm to the west of Coiba Island, and Hannibal Bank, 13 nm west of Coiba Island, an underwater seamount renowned for its extraordinary productivity and thus designated as a fisheries management zone (Capson 2006; Cunningham *et al*. 2013; UNESCO 2017).

Montuosa Island is surrounded by reefs belonging to 15 coral species and is rich in predators such as tiger and silky sharks (*Galeocerdo cuvier* and *Carcharhinus falciformis*, respectively), snappers, and several species of jacks. Hannibal Bank is a magnet for black marlin (*Istiompax indica*), striped

marlin (*Kajikia audax*) and blue marlins (*Makaira* spp.), sailfish (*Istiophorus platypterus*), yellowfin tuna (*Thunnus albacares*), and blacktip shark (*Carcharhinus limbatus*), silky shark and oceanic whitetip shark (*Carcharhinus longimanus*). Moreover, the Bank hosts seasonal spawning aggregations of several species of snappers, groupers and other highly-prized commercial fishes (Cunningham *et al*. 2013).

Coiba National Park consists of 2,025 km^2 of water and 537 km^2 consists of islands, i.e., Coiba and 38 smaller islands, e.g., Granito de Oro (pictured). Photo by Valentina Ruiz Leotaud, June 2018

Overall, the CNP provides habitat to over 700 species of bony fishes and 33 species of sharks (80% of which are unique to the area; Republic of Panama 2005), and 20 species of cetaceans, notably spinner dolphins and humpback whales (Appendix I). Such abundance is possible because of its location in the Tropical Eastern Pacific, which makes it part of the Tropical Eastern Pacific Marine Corridor, the Gulf of Chiriquí buffers against temperature extremes associated with the El Niño/Southern Oscillation phenomenon (UNESCO 2017). Also, the Tropical Eastern Pacific has an extremely high rate of endemism, i.e., 85-95% for most groups except corals. These corridors cover over 2 million km^2, encompassing five National Parks, and joins Coiba (Panama) to Malpelo and Gorgona Islands (Colombia), the Galapagos Islands (Ecuador) in the south and southwest, and the Cocos Islands (Costa Rica) in the northwest. The Tropical Eastern Pacific Marine Corridor thus provides connections between ecosystems and enables the migration of different species from one habitat to another.

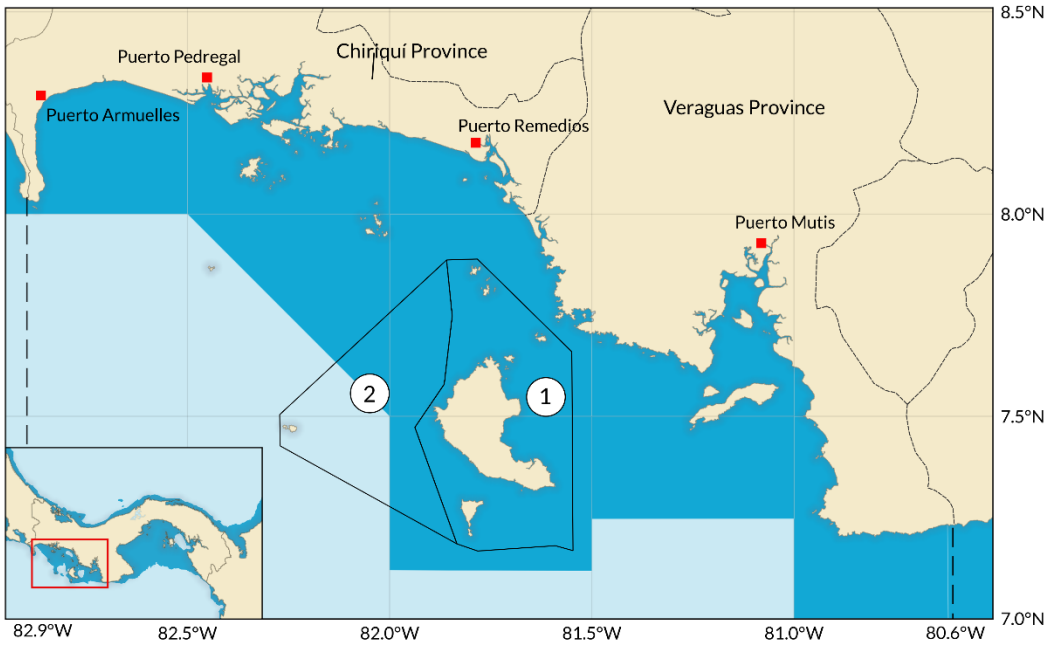

Figure 2. Map showing the ½ degree latitude/longitude cells used to estimate the coastal area of Chiriquí and Veraguas Provinces, which jointly represent about 1/3 of the Pacific coast of Panama (see text). Area 1 (Coiba National Park) covers 2,025 km^2 of water, while Area 2 (Special Zone of Marine Protection) covers 1,607 km^2.

The biological uniqueness of Coiba also replicates itself inland. A former penal colony, most of the main island remained uninhabited except for an inmate population that ranged from 100-1,000 prisoners between 1919 and 2004. Most of the territory is undisturbed and maintains about 85% of its original forest cover (Ibáñez 2001; Republic of Panama 2005). Plant species such as *camibar* (*Prioria copaifera*) and wild cashew (*Anacardium excelsum*), which are very rare and threatened in the rest of Panama and the Neotropics, are present on Coiba, as are 19 endemic subspecies of birds such as the Coiba spinetail (*Cranioleuca dissita*). These features, among others, encouraged UNESCO to accept, in 2005, Panama's nomination of Coiba National Park and its Special Zone of Marine Protection to the list of World Heritage Sites. Such sites are selected by the UNESCO based on their 'Outstanding Universal Value.' In other words, these sites are recognized for their unique marine biodiversity, singular ecosystem, unique geological processes and/or beauty (UNESCO n/d). Appendix II lists the 49 World Heritage Sites in 37 countries that have a marine component, along with publications describing the fisheries in the Exclusive Economic Zones in which they are embedded.

Operation of the Coiba World Heritage Site

World Heritage Sites must meet requirements for integrity and have adequate management in place to ensure conservation of the site's outstanding features. In Coiba, a multi-institutional 'Executive Council' is the park's highest authority, which leads in relevant decision-making processes and administers funds. Of the twelve members that make up the council, eight belong to either national or regional government institutions, two are industry representatives, one belongs to academia and one belongs to the environmental NGO community. This council does not appear to be sufficiently concerned with protecting the biodiversity in the World Heritage Site under its purview[2], although it has met repeatedly in the first half of this year to draft the regulations for the Special Zone of Marine Protection.

Panama's Ministry of the Environment is in charge of day-to-day operations. Coiba National Park has a Management Plan in place, which was approved in 2009, but does not apply to the Special Zone of Marine protection. Through Resolution No. AG 0153-2014, the original 2009-2014 plan was extended until 2019. A Sustainable Fisheries Management Plan, enforced by Panama's Ministry of Environment, conservation officers and local police is also in place. The plan establishes that only subsistence, artisanal, scientific, and recreational fishing activities are allowed in the park, and identifies the susceptible fishing areas, target species and fishing gears (Maté *et al*. 2015).

Omar Enrique, a *parguero* allowed to fish in CNP (as is manifest in the red color of its hull), about to sail out from Coiba Island after receiving its fishing permit from the Ministry of Environment. Photo by Valentina Ruiz Leotaud, June 2018.

[2] Two informants (Angel Vega and Juan Maté; see Table 1) suggested that the majority of its members, who belong to government institutions, regularly side with the representative of the fishing industry.

Despite such guidelines, there is a growing concern about the pressures exerted on the ecosystem by fishing, i.e., artisanal and recreational fisheries targeting marlin, sailfish, dolphinfish and tuna mostly with longlines and gillnets, and possibly with purse seines (Etchelecu 2008; Cunningham *et al*. 2013; Vega *et al*. 2016). "*The greatest threat to the OUV (Outstanding Universal Value) of the property is through fishing activities which are either unsustainable, or which cause prejudice to threatened species through lost nets, pollution, capture and disturbance. These problems could be greatly improved if fishing was not allowed within the property…*" (Strahm 2016).

Dolphinfish caught around Coiba National Park. Photo by Valentina Ruiz Leotaud, June 2018.

Fisheries around the Coiba World Heritage Site

As previously implied, fishing activities are considered politically difficult, as they are important sources of income for a large number of people in the area, particularly artisanal fishers, processing plant workers and recreational fishing tour operators (Montenegro 2007). Strangely, however, the catch of the fisheries around the CNP does not appear to have been estimated – at least not in a transparent fashion. This will be attempted in the next sections of this report, after the following general description of these fisheries, and a description of the field work that enabled key data to be acquired.

Artisanal fisheries

Maté (2006) suggests that about 95% of Panama's fisheries operate in the Pacific and that in 2005, there were 4,639 artisanal vessels registered to fish on Panama's Pacific coast. Of these, 2,431 were allowed to catch 'scale' fish (i.e., bony fish, as opposed to sharks and rays), 2,066 to catch shrimps and 142 to catch lobsters[3]. Maté (2006) observed 44 fishing communities in Veraguas Province with over 1,100 registered artisanal boats, and 28 fishing communities in Chiriquí Province, with more than 700 boats. However, this study emphasized that these are likely underestimates, because many fishers failed to register their boats.[4] Artisanal fishers in the Panamanian Pacific use trammel nets to catch shrimp and '*revoltura*,' i.e., a mix of low-value fish. Although national authorities are not certain about the volume caught, they recognize the considerable contribution of this fishery to the overall artisanal shrimp landings (ARAP 2017).

Every month, larger boats called "*pargueros,*" licensed to fish in Coiba are allowed to make two fishing trips of about eight days into the park. The number of such fishing licenses is limited to 47 *pargueros* which can target groupers, snappers and dolphinfishes (only with longlining). However, there are no set limits in terms of the volume of fish that can be caught. Due to infractions and some licenses having been underutilized, only 13 *pargueros* are currently operating in the park (Strahm 2016; D. Nuñez, Director CNP, pers. comm., June 7, 2018).

The Government of Panama identifies fishing operations conducted from *pargueros*, with a crew of 5 as 'artisanal' (or "commercial artisanal"). These boats can thus legitimately operate in the World Heritage Site because they are not 'industrial.' However, these boats, which the *Alianza para la Conservación y el Desarrollo* (2010) calls "*artisanal plus*", supply predominantly foreign markets, particularly in Florida (USA). Thus, until 2017, 40% of the boats in Puerto Remedios were owned by two seafood processing companies, Pacific Export Corporation[5] and Gabrimar Export Fish, which exert 95% of the fishing effort and target spotted rose snapper (*Lutjanus guttatus*), Pacific red snapper (*L. peru*), yellow snapper (*L. argentiventris*), Colorado snapper (*L. colorado*), and Pacific dog snapper (*L. novemfasciatus*), as well as star-

The *Niña Isabel* is a *parguero* (length=11 m) allowed to operate in Coiba. Of 47 artisanal vessels allowed to fish in Coiba, 13 are active. Here, the vessel is about to depart from Puerto Mutis, Veraguas Province. Photo by Valentina Ruiz Leotaud, June 2018.

[3] These boat numbers are almost double the numbers in the early 1970s (Harper *et al.* 2014).

[4] Given that the Chiriquí and Montijo Gulfs (located in the southern part of the Veraguas and Chiriquí provinces) are part of Coiba's buffer zone or zone of influence (i.e., many fishers travel from these areas to CNP and its surroundings; Vega *et al.* 2016), we estimate that only 50% of the fishers operating there registered their boats. However, this should have no effect on our catch estimates, see text.

[5] Pacific Export Corporation ceased operations recently (Government of Panama 2017), which means that fishing activities in Coiba are currently dominated by boats owned by Gabrimar Export Fish operating from Puerto Remedios.

studded grouper (*Hyporthodus niphobles*), olive grouper (*Epinephelus cifuentesi*), spotted grouper (*E. analogus*), and dolphinfish (*Coryphaena* spp.; see also Vega *et al.* 2016).

It is quite remarkable that a World Heritage Site should be a place where an export-orientated 'artisanal' fishery is allowed to operate, and target species at least one, which is on the IUCN Red List (olive grouper *E. cifuentesi*, which is 'Near Threatened'; see Appendix I), but so it is.

Large-scale fisheries

Both the Gulf of Chiriquí and the southeastern Gulf of Panama, separated by some 370 km, have well-developed trawl shrimp fisheries, which operate mainly from May to July and October to December and target mostly seabob (*Xiphopenaeus kroyeri*), western white shrimp (*Litopenaeus occidentalis*) and crystal shrimp (*Farfantepenaeus brevirostris*). In addition, a small lobster fishery targeting mainly the green spiny lobster (*Panulirus gracilis*) and the shield fan lobster (*Evibacus princeps*; Harper *et al.* 2014) also occurs in this area.

The Gulf of Panama hosts a lucrative fishmeal industry that targets Pacific anchoveta and herring. The catches of both species added up to 78,250 t in 2014 (Harper *et al.* 2014). The Pacific coast of Panama also has tuna and billfish fisheries, with skipjack and yellowfin tuna targeted using purse seines and tuna longlines, and catching up to 3,200 t in 2014, with sharks as bycatch. However, the bycatch rates are reported to be rather low considering that most vessels use purse seines whose bycatch is about 1% of the target species. Discards are also considered to be low, as there is a local and a foreign market for sharks. In fact, a targeted shark fishery is in place in the Pacific since the 1980s and even artisanal fleets got into the business, with 63% of its boats targeting shark and up to half of their catch being shark (Harper *et al.* 2014)[6]. Given that sharks have wide ranges, such targeted fishery, even if somewhat distant, is likely to also impact Coiba National Park and its Special Zone of Marine Protection, and reduce its Outstanding Universal Value.

Panama's Pacific waters also host a dolphinfish fishery, whose annual catches from 2006 to 2009 were of about 1,000 t (Guzmán *et al.* 2015). In Coiba, dolphinfish can be fished specifically in the Dolphinfish Longline Fishery Subzone, which extends for 108 km within the Resource Management Zone, starting at the outside border of the Marine Reserve and reaching to the outer boundaries of the CNP. The species is allowed to be caught in the CNP from March 1 to May 31 and from September 1 to October 31 every year, using horizontal longlines (Del Cid *et al.* 2014).

One might question the wisdom of placing a Dolphinfish Longline Fishery Subzone immediately adjacent to a World Heritage Site. Indeed, the marine biodiversity that is part of the CNP's Outstanding Universal Values is bound to be strongly impacted by this.

Increasing fishing effort and management concerns in and around the park

There is a major concern that the increasing fishing effort over the past decades is causing the decline of fish stocks in and around the park (Maté 2006; Montenegro 2007; Etchelecu 2008;

[6] It may be mentioned here that the research which led to the contribution of Pauly et al. (2014) on China's distant-water fishery, identified a source stating that "[i]*n 2001, two Chinese fishing vessels left China to fish in waters of Panama and a total of 20 fishing vessels will be sent to that area in the future.*" (Huang 2001). However, China's Ministry of Agriculture state that it has not licensed vessels to fish in Panama's EEZ since 2010 (confidential pers. comm. to D. Pauly, August 5, 2018).

Strahm 2016). Coiba's Marine Reserve, where no fishing is allowed, occupies almost 477 km^2 and extends from the coastline of each island, islet and emerged rock up to 1.8 km out in the sea. Media reports observed that the boundaries of the reserve are not always respected (e.g., La Estrella de Panamá 2013), and illegal fishing activities are observed in the area. The perpetrators were mostly *pargueros*, with a handful of industrial vessels also seen fishing in the area. From 2004 to 2016, more than 80 legal cases were filed against boats breaking into the no-take area or fishing within the permitted zone but using gear that is not allowed (La Estrella de Panama 2013; also data from the Ministry of the Environment[7]).

In spite of the fact that purse-seines and any fishing gear that affects billfish, dolphins, cetaceans, turtles and others are banned inside the CNP according to Law 44 of 2004, the absence of regulations ("*ordenamiento*") impedes full implementation of the Law (Strahm 2016). Some solutions are being attempted, e.g., the Special Zone of Marine Protection (SZMP) regulation, which was drafted, submitted and awaiting publication in the Official Gazette at the time of writing of this report. According to the Authority of Aquatic Resources of Panama, this regulation was the result of a consensus between all sectors represented in Coiba's Executive Council (A. Peña, ARAP, pers. comm., June 5 2018). However, there is disagreement as to the efficiency of this regulation as it allows for everyone, including industrial fishing vessels, to operate in the area. "*The Special Zone's plan authorizes boats 16 to 25 m long so even if they don't call them 'industrial,' these are vessels with capacities way bigger than that of pangas. The other thing is that the plan opens the possibility for trawl fishing. They talk about an assessment to see if it gets authorized because there is a lot of pressure from shrimp fishers. What I see they did with the regulation for the Special Zone of Marine Protection is they asked fishers what they needed and so if the largest recreational vessel was 45 m long, then the length limit is 45 m. Basically, they're legislating so that everyone goes in.*" (Professor Angel Vega, University of Panama-Veraguas, pers. comm., June 7 2018). UNESCO itself expressed concerns about this new regulation and whether it guarantees the long-term preservation of the Outstanding Universal Value of Coiba National Park (UNESCO 2018a).

These types of incidents, combined with issues such as the absence of comprehensive monitoring data, led the World Heritage Committee to issue a Danger List warning for Coiba National Park and its Special Zone of Marine Protection in 2017. "*Recalling the concerns repeatedly expressed by the Committee over the absence of effective fisheries regulations within the property, it is recommended that the Committee urge the State Party to take immediate measures to ensure that fishing is strictly controlled and that fisheries permitted within the property are sustainable. This should include measures to improve the enforcement of regulations within Coiba National Park and revision of the proposed regulations for the SZMP to ensure that no fishing is permitted within its territory which would be incompatible with the World Heritage status of the property, particularly industrial fishing. In case fish stocks do not show a recovering trend, consideration should be given to a temporary moratorium on all fishing within the property, in line with the mission's recommendations*" (UNESCO 2018b).

[7] Information on the number of cases filed that were actually prosecuted was not available. ARAP seems to have a different set of records, as information provided on August 2, 2018 (via email) states that they only registered 11 cases of illegal fishing in and around Coiba Island between 2010 and 2015. According to ARAP, four vessels (of which three were from Costa Rica and one a Panamanian industrial vessel) were fined a total amount of US $22,000 and their entire catch was seized.

Besides providing habitat to 760 species of marine fishes, 33 species of sharks and 20 species of cetaceans, Coiba National Park is home to some 147 bird species, e.g., including this brown pelican (*Pelecanus occidentalis*). Photo by Valentina Ruiz Leotaud, Coiba Island, June 2018.

There are currently 49 UNESCO World Heritage Site with a marine component (see Appendix II). If UNESCO determines that the values of a site are threatened, that site could be inscribed in the List of World Heritage in Danger. The situation has reached a point where the Authority of Aquatic Resources of Panama and Panama's Maritime Authority had to sign a cooperation agreement to better strategize in the fight against illegal, non-declared or non-regulated fishing activities in the country's waters (ARAP 2018).

Desk study and field work

Given this state of affairs, it was imperative to conduct independent research on the fisheries in and around CNP, incorporating interviews with local actors, and through which it may be possible to document the extent of fishing activities taking place in and around CNP. Participant observation should allow to:

- Record the number of boats operating in the area;
- Record boat sizes, gears and numbers of crew members;
- Get first-hand information about catch trends over time;
- Record the effort the fishers are putting into fishing operations; and
- Obtain a first idea of the extent of illegal fishing, if any.

To prepare for such field work, a desk study was undertaken during the initial phase of this project. A literature search yielded over 50 documents, which, among other things, provided information about the criteria that allowed for a place to be declared a World Heritage Site. Once these criteria were understood, the research focused on understanding what made Coiba National Park a good candidate to become a UNESCO World Heritage Site, what challenges had to be addressed in order to present a successful nomination, and what challenges CNP is currently facing.

In parallel, it was important to look at the *Sea Around Us* database (see www.seaaroundus.org) and published papers on Panamanian fisheries (notably Harper *et al*. 2014), with special attention to its Pacific fisheries. These papers provided useful references to other studies and authors that took a closer look at Coiba. Reports from different government departments such as the Authority of Aquatic Resources of Panama and the Marine Authority of Panama, as well as studies produced by the University of Panama, the Smithsonian Tropical Research Institute and NGOs such as MarViva and Conservation International were also reviewed, as were local news stories related to fisheries in and around the CNP.

Two of the vessels actively and legally fishing in Coiba, Pepito and Niña Isabel, depart from and land their catch in Puerto Mutis, Veraguas. About 50 artisanal boats operate from this port, according to the Maritime Authority of Panama. Photo by Valentina Ruiz Leotaud, June 2018.

The field trip of the first author started on May 29, 2018 and ended on June 27, 2018. During this time, she was half of the time in Panama City, mainly to interview government officials and NGO representatives, the other half in Santiago de Veraguas, from which she visited the communities of El Pito, Guarumal, Guarumalito, Hicaco, Lagartero, Palo Seco, Puerto El Bongo, Puerto Mutis and Santa Catalina in Veraguas Province and Puerto Pedregal and Puerto Remedios in Chiriquí Province as well as the CNP. She conducted

30 interviews with fishers[8] (see Appendix III) and representatives of government institutions, academia and NGOs (Table 1). Also, she obtained catch data from fishing communities (Appendices IV and V) and submitted public information requests to the following institutions:

- Authority of Aquatic Resources of Panama (*Autoridad de Recursos Acuaticos de Panama*, or ARAP), both at its national headquarters and at the Veraguas Division;
- Maritime Authority of Panama;
- Ministry of Environment – Protected Areas and Wildlife Division and Coastal Areas and Oceans Division;
- Coiba National Park Direction;
- Fundación MarViva; and
- University of Panama – Veraguas division.

Table 1. Persons with institutional knowledge about Coiba National Park, Panama, and who were informally interviewed by the first author between May 29 and June 27, 2018.

Interviewee	Title	Interview location
Angel Vega	Researcher/Professor of Marine Biology, University of Panama, Veraguas Division; Member of Coiba's Scientific Committee	Santiago de Veraguas
Yolanis Robles	Professor of Marine Biology, University of Panama Veraguas Division; Member of the Team that drafted Coiba's Management Plan	Santiago de Veraguas
Héctor Guzmán	Researcher, Smithsonian Tropical Research Institute; Member of Coiba's Scientific Committee	Panama City and Santiago de Veraguas
Juan Maté	Researcher, Smithsonian Tropical Research Institute; Coordinator of Coiba's Management Plan	Panama City
Kevan Mantell	Owner, Dive Base Coiba and Member of Planning Team, Coiba's Management Plan	Phone interview
Tania Arosemena	Fundación MarViva	Panama City
Annissamyd Del Cid	Fundación MarViva	Panama City
Juan Posada	Fundación MarViva	Panama City
Iván Alvarez	Member, El Bongo Sport Fishing Club, Owner Cábaco Pacific Lodge	Santiago de Veraguas
Alexis Peña	Biologist (recreational fisheries); Authority of Aquatic Resources of Panama	Panama City
Marco Mendizabal	National Director of Research and Development, Authority of Aquatic Resources of Panama	Panama City
Lucas Pacheco	National Director of Integral Management, Authority of Aquatic Resources of Panama	Panama City
Didiel Núñez	Director - Coiba National Park	Santiago de Veraguas
Edgardo Díaz-Ferguson	Executive Director, Scientific Station Coiba-AIP, National Secretariat of Science, Technology and Innovation	Panama City
Capt. Omar De León	Director, Vigilant Fishers Program, National Aeronaval Service	Panama City

[8] Both authors of this report completed the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Course on Research Ethics (TCPS 2: CORE)* required in Canada for work with human subjects.

Given the lack of timely response from the Authority of Aquatic Resources of Panama with respect to data requests, the researcher decided to visit regional divisions of the Maritime Authority of Panama as well as fisher's associations to consult their landing records. Those internal records and the interviews conducted with fishers provided most of the information on catches used here.

Estimating artisanal catches in and around Coiba National Park

Available information on the website of the *Autoridad de Recursos Acuaticos de Panama* suggests that there are 34,191 coastal fishers currently operating in Panama (ARAP 2014). To reduce this number to those presumed to operate along the Pacific coast, we used the ratio of the artisanal catch along Panama's Caribbean coast (280 t) to that along its Pacific coast (16,060 t), i.e., 0.017, to estimate that 33,610 fishers work along the Pacific coast[9]. Here, we define as the coastal waters of Chiriquí and Veraguas Provinces (Figure 2) as the waters 'around Coiba National Park.' However, as we could not use 'coastline length' (see Wikipedia on the *Coastline Paradox*), we counted the number of ½ degree latitude/longitude cells which are 'coastal' (i.e., touch on land) along the Pacific coast of Panama and along the coasts of Veraguas and Chiriquí Provinces in Figure 2. These are 21 *vs*. 7 cells, i.e., the coast of these two provinces represent approximately 1/3 of the Pacific coast of Panama[10]. Thus, assuming an equal distribution of artisanal fishers along the Pacific coast, we estimate that 11,200 fishers operate in the Veraguas and Chiriquí Provinces[11].

There are two datasets that can be used to estimate the catch per artisanal fisher along Veraguas and Chiriquí provinces. The first relies on Table 2, which summarizes the data for field interviews in Appendix IV, pertaining to artisanal boats (*panga*, or <7.6 m long) with two fishers each. Thus, the annual catch per artisanal fisher in years in Veraguas Province would be: 349*12/2=2,094 kg. The second estimate of catch per artisanal fisher refers to those operating from '*pargueros*' of a length of 10-12 m and a crew of five (Vega *et al.* 2016), and which were reported to catch 412 kg in 2006-2007, 396 kg in 2009-2010 and 368 kg per trip in in 2010-2011 (Vega *et al.* 2016; their Figure 37)[12].

Table 2. Mean monthly catch per month of pangas in Veraguas Province (2013 to 2018)

Association (# of members)	Data from Appendix table	Catch/effort (kg/month)
Guarumal (22)	IVB; per trip	289
Guarumalito (17)	IVC; per month	173
El Pito (20)	IVC; per trip	550
Hicaco (22)	IVA; per month	416
Palo Seco (22)	IVD; per month	316
Mean	-	349

[9] The artisanal catches pertain to a 5-year average (2010-2014), based on data reported by Harper *et al.* (2014) and available at www.seaaroundus.org (accessed July 15, 2018).

[10] This 1/3 figure is confirmed by ARAP (2014), which states that 5,940 artisanal vessels operated in 2014 in Panama of which about 5,219 operated along the Pacific coast, with 837 in Chiriquí and 1,158 in Veraguas provinces, i.e., 1995 boats, or 38%, which is close enough to 33%.

[11] At low latitudes, ½ degree cells are approximate squares of 30 x 30 nm, i.e., extend at most 30 miles (or about 56 km), which is roughly the maximum offshore extent of artisanal fisheries (Chuenpagdee and Pauly 2008); this is the reason why the *Sea Around Us* allocate small-scale fisheries catches to ½ coastal cells (see Zeller *et al*. 2016).

[12] Contrary to Vega *et al.* (2016), we found no obvious temporal trends in the catch per trips data for *pargueros* (and *pangas*) presented in Appendix IV (and V), which is the reason why we averaged over 2011-2018 (the data for 2016-2018 were preponderant in any case).

Small artisanal fishing boats (*pangas*) that operate from Hicaco, Veraguas. Many of them sell their catch to the Hicaco Artisanal Fishers Association. Photo by Valentina Ruiz Leotaud, June 2018.

Our new estimates, based on interviews and internal records, pertain to two types of *pargueros*, i.e., those not permitted to fish in CNP, and those that are. The former (whose number was not available to us) tend to perform two 7-day trips per month and they have a mean catch of 960 kg per month (Appendix VB). This corresponds to an annual catch of 960*12/5 = 2,304 kg, i.e., 2.3 t per fisher.

The ratio of *pargueros* to smaller boats along the Pacific coast of Panama is not known but it is likely that there are many smaller than larger boats. Thus, we used the Pareto Rule (or 80:20 rule) to obtain an estimate of the weighted mean annual catch per artisanal fisher from two boat-specific estimates given above, i.e., ((4*2.09)+2.3)/5=2.13 t per year. (Note that this estimate will not be affected much by deviation from the Pareto Rule, given that the annual catch estimates for the two boat types were close to each other to start with[13])

With an individual catch of 2.13 t per year and an estimate of 11,135[14] artisanal fishers operating in Veraguas and Chiriquí Provinces, we can derive an artisanal catch of 23,718 t per year for the two provinces. This corresponds to an annual catch intensity of 1.72 t per km^2 in the dark blue coastal area of Figure 2, between 82.9˚W and 80.6˚W longitude west, which covers 13,809 km^2.

On the other hand, the 13 *pargueros* which are licensed to operate in CNP and which perform 2 eight-day trips per month (Appendix VA), have a mean monthly catch of 1,984 kg per month. Thus, their total catch in the CNP is 13*1,984*12 = 309,504 kg, i.e., 310 t per year, taken by 13*5 = 65 fishers, i.e., 4.77 t per fisher, which is considerably higher than for other fishers in the area[15], and a catch per area of 309,504 kg/2,025 km^2 = 153 kg per km^2.

[13] Also note that 2 t per artisanal fisher per year happens to also be the very estimate for countries such as Panama with mid-level Human Development Index estimated from a wide variety of countries by Chuenpagdee and Pauly (2008).

[14] That is 11,200 fishers minus the 65 working on the 13 *pargueros* licensed to fish in CNP.

[15] This relatively high value suggests that the fish density around Coiba Island is 2–2½ times higher than along the coast of Chiriquí and Veraguas Provinces, which is appropriate given that only a few *pargueros* and recreational vessels are authorized to fish in the CNP. This, however, fail to explain why the 13 *pargueros* authorized to fish in CNP would ever want to fish elsewhere, which they appear to do, at least occasionally. Another explanation may be that these 13 *pargueros* are larger and/or operate more efficiently than the ones not licensed to fish in the CNP. Finally, the data of Appendix V may be biased upward in a way that we cannot identify. (See the Discussion and Recommendation section).

Table 3, initially developed by the Intergovernmental Panel on Climate Change and adapted from several of the catch reconstructions in Appendix II, may be used to assess the uncertainty of this estimate. Here, we assess that its reliability is 'low,' because of "medium agreement" between datasets of "medium" evidentiary value, which would imply a confidence interval ranging +/- 30% the midpoint estimate. Applied to 331 t, this would result in the catch taken from CNP ranging from 220 to 400 t per year.

Table 3. Scoring system for evaluating the quality and reliability of time series of reconstructed catches, as used for deriving uncertainty (reliability) bands for such catches. Modified from Mastrandrea *et al.* (2010).

Score	Reliability	+/- %[1]	Corresponding IPCC criteria[2]
1	Very low	50	Less than high agreement and less than robust evidence
2	Low	30	High agreement and limited evidence ***or*** medium agreement and medium evidence ***or*** low agreement and robust evidence
3	High	20	High agreement and medium evidence ***or*** medium agreement and robust evidence
4	Very high	10	High agreement and robust evidence

[1] Percentage uncertainty derived from Monte-Carlo simulations (Ainsworth and Pitcher, 2005; Tesfamichael and Pitcher, 2007).

[2] 'Confidence increases' (and hence percentage ranges are reduced) 'when there are multiple, consistent independent lines of high-quality evidence' (Mastrandrea *et al.* 2010).

The recreational fisheries of Coiba National Park

Given that recreational fishing is allowed in the CNP, an estimate of the recreational catch should be available as well, although scarcity of quantitative data makes such exercise, i.e., a Fermi Solution (von Bayer 1993), unable to provide more than order-of-magnitude estimates. Fifteen recreational vessels are allowed every day at the CNP, and 3,600 are recorded per year (Maté, 2015), implying that an average of only 10 vessels visit the park per day, less than allowed. Based on the first author's interview with a representative of the tourism industry, the waters around Coiba Island are expensive to access. Thus, we assume the Pareto Rule (80:20) for the ratio of private recreational boats to tour boats (many of which are refurbished fishing boats). The ARAP staff in charge of looking at recreational fisheries (A. Peña, pers. comm. June 5, 2018) revealed some preliminary details of an upcoming report in which the Authority polled 108 individual recreational fishers. Of those, 18.4% came from Chiriquí and 5.1% from Veraguas Province. This leaves 76.5% coming from other provinces of Panama, or from abroad. Some have large and fast yachts which tend to be much faster than those of the park rangers; thus they are rarely apprehended when fishing illegally (H. Guzmán, Smithsonian Tropical Research Institute, pers. comm., June 11, 2018).

Recreational fishers target marlin, sailfish, swordfish, dolphinfish and tuna (Etchelecu, 2008; Cunningham *et al*. 2013; Vega *et al*. 2016), but with set limits for each boat ('bag limits'). Privately owned boats are allowed to take eight fishes per day of the same or different species, while the boats of tour operator are allowed to take five. Some recreational fishers are reported to sell part of their catch, exceed their bag limits, or not releasing billfishes as required under Coiba's

Sustainable Fisheries Management Plan (J Maté, pers. comm., 5 June 2018; H. Guzmán, pers. comm., 11 June 2018).

Assuming that tour operators (20% of 3,600 boats visits per year) each catching ½ of their authorized boat-specific bag limits in the form of fish weighing 5 kg each would lead to: 3,600*0.2*2.5*5=9,000 kg for the annual catch of anglers on tour boats, or 9 t per year. With similar assumptions for the privately-owned vessels, the estimate leads to: 3,600*0.8*4*5=57,600 kg, for the annual recreational fishers on board their own boats, or 58 t. Jointly, these two forms of recreational fishing would thus catch annually about 67 t per year, an estimate that is extremely rough, but which can be easily corrected by modifying the terms of the two serial multiplications.[16] Important here is that this estimate of recreational catch within the CNP appears to be near two orders of magnitude smaller than the estimated catch of the artisanal fishery.

Tourism boat that, if requested, takes people on fishing trips in or around Coiba. Photo by Valentina Ruiz Leotaud, June 2018.

[16] Thus, recreational fishers would catch about 270 t if the individual fish they caught averaged 20 instead of 5 kg, etc.

Illegal Fishing inside Coiba National Park

There are two forms of illegal fishing in the CNP: (1) artisanal fishing with boats that may operate within the CNP, but using gear deemed illegal, or used to catch protected species; and (2) fishing by *pargueros* that are not licensed to operate within the CNP, or by industrial boats. According to the CNP's director, item (1), i.e., fishing with trammel nets, catching prohibited species such as Pacific goliath grouper, or fishing during a closure (e.g., January 1 to April 30 for snapper), is one of the main threats to the integrity of the protected area (D. Núñez, pers. comm., June 7, 2018). The most common occurrence is the use of trammel nets, which are frequently spotted later on by SCUBA divers (A. Vega, University of Panama, pers. comm., 7 June 2018). Spearfishing, which is forbidden in Coiba, also occurs within the limits of the park, particularly around Jicarón and Jicarita Islands, and Hannibal Bank and Montuosa Island (K. Mantell, pers. comm. June 1, 2018). Records kept by the legal department of the Veraguas Division of Panama's Ministry of Environment show that out of the 89 infractions on file for the years 2004-2016, 72 (or 81%) occurred in the CNP. Twenty-one illegal fishing infractions in the CNP were carried out by boats allowed to fish in the park. Even though the records do not provide details of what these infractions were, it can be inferred that the boats in question, which were licenced to operate in the CNP were using illicit fishing gear or catching prohibited species. This also applies to recreational fishers who commit infractions such as trolling in the one-mile no-take zone around the islands that comprise the CNP and the two-mile no-take zone around Montuosa Island (H. Guzmán, personal communication, June 11, 2018; K. Mantell, pers. comm., June 1, 2018), or who sell their catch.

These are underestimations of the actual number of fishing-related infractions occurring in the CNP, which according to its director, has limited resources to deal with such cases, i.e., there are 13 rangers currently working in the park, but, 45 is required. In addition, the CNP rangers work only during office hours and their boats do not have engines powerful enough to be able to catch violators (D. Núñez, pers. comm. June 7, 2018).

The boat in this photo is used by rangers of the Ministry of Environment for surveillance in Coiba National Park. It is too slow to catch most of the boats potentially or actually operating illegally in the CNP. Photo by Valentina Ruiz Leotaud, June 2018

The second form of illegal fishing in the CNP, involves mainly *pargueros* not licenced to fish in the CNP. During her field work, the first author heard accounts of *pargueros* operating within the CNP, mostly at night, when there is no surveillance. Indeed, the fact that there are not enough park rangers to perform overnight shifts encourages illegal fishing. Fish caught during the night is landed very early in the morning, before officers from the Maritime Authority of Panama or the Authority of Aquatic Resources of Panama are in the ports (J Maté, pers. comm. June 5, 2018), or at landing sites that are not monitored (H. Guzmán, pers. comm., June 11, 2018). However, non-licenced *pargueros* can be assumed to be illegally operating in the CNP (at the risk of being caught and fined) only if they can expect the catch within its confines to be markedly higher than outside. Given that the CNP is small relative to the coastal waters of Chiriquí and Veraguas Provinces, this is a situation not likely to occur frequently.

This assumption is here justified by the field interviews that the first author conducted in June 2018, which indicated that even the 13 *pargueros* which are authorized to fish inside the CNP (and whose hulls are painted red for easy identification) also operate outside the CNP, as may be expected given unevenly distributed resource species and their variability in time (Vega *et al*. 2016). Indeed, such behaviour is straightforwardly reproduced given so called 'gravity models,' where the word 'gravity' refers to the density of an exploited resource relative to some gradient, usually the cost of sailing from certain ports (Pelletier and Mahévas 2005). On the average, as could probably be demonstrated using a gravity model of the type mentioned above, *pargueros* not licensed to operate within the CNP will avoid doing so unless the potential catch exceeds that in the surrounding area enough to justify the risk of being caught and fined (Sumaila *et al*. 2006).

Finally, industrial fishing, with shrimp or other trawlers, or with the purse seiner that contribute to the bulk of Panamanian fisheries catches does not appear to be much of a current problem, despite earlier reports of illegal incursions .One reason for this is that the CNP does not have an abundance of the type of resources industrial vessels exploit along the Panamanian Pacific coast (e.g., tuna and anchovies), or because their earlier abundances have declined. The other reason is that these vessels are now mandated to be equipped with Automatic Information System (AIS), which allow their detection through satellite monitoring (A. Vega, pers. comm. June 7, 2018).

DISCUSSION AND RECOMMENDATIONS

Table 4 recalls our three key results, i.e., the catch estimates we obtained for each fishery in Coiba National Park (CNP). With this, we have achieved our goal of somehow quantifying the annual catch taken from CNP, i.e., about 370 t, with a confidence interval ranging from 260 to 480 t per year. However, we remind the reader that confidence intervals pertain to the *precision* (i.e., reproducibility) of our estimates, whose main problem is, however, their accuracy, as determined by unknown bias, e.g., in the catch per effort data gathered through interviews and internal records of the associations and the Maritime Authority of Panama (Appendices IV and V). Therefore, we also made the simple serial multiplications explicit which led to our key estimates so that they can be calculated with other inputs by anyone who could provide better values for their parameters.

We believe, however, that an estimate of the annual catch by a single fisher of about 2 t is reasonable for Chiriquí and Veraguas Provinces, as it is similar to other values from tropical countries similar to Panama (see Chuenpagdee and Pauly 2008). Thus, the estimate of a higher daily catch per trip, and an annual catch of 4.8 t per fisher on the *pargueros* operating in the CNP would suggest that the density of fish within the CNP is over twice that along the coast of Chiriquí and Veraguas Provinces. As for the recreational fishery catches, they appear to be still smaller than those of the *parguero* fishery.[17] However, the fish caught by the recreational fishery are usually large, which imply that they have a disproportionally large impact on their ecosystem (see, e.g., Barneche *et al.* 2018).

The data in Table 4 do not by themselves allow assessing the state of a fishery, or the ecosystem in which this fishery is embedded. However, estimates of annual fisheries yield per area exist with which the value obtained here, i.e., 368 t/2,015 km^2 = 0.18 t per km^{-2} can be compared. Thus, Kapetsky (1984) estimated mean values of 5.9 t per km^{-2} from 20 shelf locations, and 4.9 t per km^{-2} from 15 reefs, while Caddy *et al.* (1998) suggested lower values for tropical/subtropical shelves, based, however on FAO catch data now known to be underestimates (Pauly and Zeller. 2016). This would suggest that the catch from Coiba National Park is quite low.

Table 4. Estimates of the annual catch taken out of the 2025 km2 of Coiba National Park (see text for assumptions and details on methods)

Fishery	**Catch (t per year)**	**Method and remarks**
"Artisanal plus"	310	Based on catch per effort of 13 licensed *pargueros* (see Appendix V A
Recreational	58	Very uncertain estimate (see text)
Industrial (illegal)	??	Assumed to be negligible in 2018
Total	**368**	**258 – 478**[a)]

a) Based on a score of 3 in Table 2.

[17] The method we used to estimate the catch of the recreational fishery is very rough. However, one advantage of this method is that it makes the parameter very explicit that must be available for an estimate to be obtained (and thus encourages research devoted to estimate them reliably), and that there is no reason to assume that all of them should be over- or underestimated.

In fisheries, catches can be low because there is little fishing, or because fishing is excessive (Figure 3). It possible that it is the latter which applies here, i.e., that the fisheries are past their peak (Caddy *et al.* 1998), given the signs of overfishing alluded to in Douvere and Herrera (2014), notably the increasing landings of juvenile fish, including juvenile sharks. Finally, we believe that incursions by industrial vessels into the CNP may be a problem of the (recent) past, given Automatic Identification Systems, i.e., satellite monitoring.

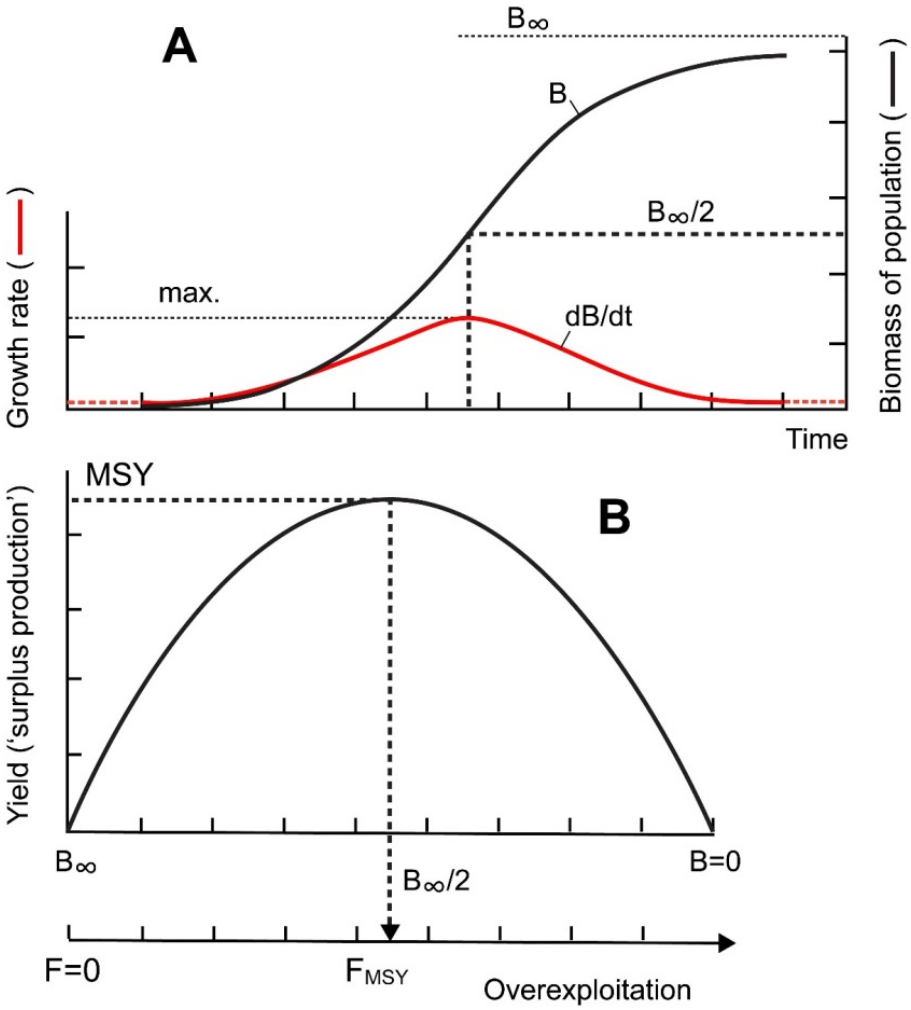

Figure 3. Basic principles behind a common fisheries model. A: the population size (i.e., biomass; B) of any living organisms (incl. fish) will, if released into a new ecosystem, increase slowly, then rapidly, then again grows slowly as the carrying capacity of the ecosystem (B_∞) is approached. B: The growth of that population (dB/dt), when plotted against biomass, generate a parabola, with low values of dB/dt (i.e., 'surplus production' or the fisheries yield which can be sustainably taken) near carrying capacity (B_∞) and near B=0. This yield has a maximum value at $B_\infty/2$, corresponding to Maximum Sustainable Yield (MSY). When the fishing mortality caused by an excessive fishing effort increases past the level generating MSY, dB/dt decreases, and only low catches can be sustained. Thus, a fishery can overfish a resource 'sustainably,' as is probably the case along the coat of Chiriquí and Veraguas Provinces, and around Coiba (see text).

The catch estimates presented above were obtained, and the inferences based thereon were drawn in the context of an acute scarcity of reliable data, as occurs in many developing tropical countries[18]. However, the objective constraints provided by the difficulty of collecting data from disparate multi-species tropical fisheries[19] were here aggravated by a number of subjective constraints, the first of which is a marked reluctance of Panamanian authorities to share data and/or to put data in the public domain, Civil Society and researchers to use. The fact that the Authority of Aquatic Resources of Panama (or ARAP), since its creation in 2006 has 'centralized' the information it holds (Muñoz, 2007) makes it very difficult to obtain fisheries-related data, both current and historical, for several reasons. One of these reasons is that its Regional Divisions hesitate to provide data that they hold. Even though the Access to Public Information Law establishes a maximum of 30 days to receive a response to information requests (Government of Panama 2002), the agreement from the national authorities for Regional Divisions to release data may be dragged on indefinitely. "*I have been here for years and sometimes they do not share the data with me. Some journalists resort to* 'habeas data' *and lawsuits to be able to obtain information*," said Héctor Guzmán (pers. comm. Smithsonian Trop. Res. Inst., June 20 2018), a co-author of the *Sea Around Us*' catch reconstruction for Panama (Harper *et al*. 2014; and see Appendix VI).

For this research, two information requests were submitted to the ARAP at its headquarters in Panama City. The first was on June 1, 2018, and the second on June 7, 2018. Another information request was submitted to ARAP's Regional Division in Santiago de Veraguas on June 7, 2018, to no avail. Follow-up phone calls and messages always received the same response: "*We are working on it*." The fact that it is so difficult to get fisheries information from the authority that is supposed to provide it creates a situation in which some of those who gather their own data are hesitant to share them. "*Here, NGOs get the information and then they don't want to share it, like if it was a state secret*," (A Vega, Univ. Panama, pers. comm. June 7 2018).

Another problem is the suboptimal use of the available data and wasting precious resources on the collection of data of limited use, for example, data on the reproductive biology of various fish species or their feeding habits and diet composition[20]. Such data can be used only in the context of ecosystem modeling (see, e.g., Pauly *et al.* 2000, and the contributions in Christensen and Pauly 1993), which, however, cannot be undertaken in the absence of basic information on the fishery such as catch per boat trip, catch by fisher, number of fishers, etc. This is thus a matter of priority,

[18] The introduction to Appendix II discusses how the methodology applied here could also be used to estimate the catches taken from other marine World Heritage Sites for which limited fisheries data are available.

[19] Chiriquí and Veraguas Provinces have over 70 fishing communities, located mainly in the Gulf of Montijo and the Gulf of Chiriquí. Almost each town has its own landing site, but only Puerto Armuelles, Puerto Pedregal and Puerto Mutis keep some sort of statistics (Maté, 2006). According to H. Guzmán, this situation makes it difficult for ARAP to gather high-quality data. "*You would need a battalion of ARAP officers to gather this information and this is convenient for the fishing sector because they know that they can ravage Panama's oceans with impunity because it is impossible for the authority to control them*." (Smithsonian Trop. Res. Inst., pers. comm. 11 June 2018). This may be true, but it begs the question how big countries, such as, e.g., India, are able to produce statistics from tens or hundreds of thousands of fishing communities, as they do year after year since 1950 (Bhathal and Pauly 2008). This however, is not secret: they use since decades stratified random sampling (see Bazigos 1974, Caddy and Bazigos 1985, and other FAO documents on this topic, most of them are available in Spanish).

[20] The astute reader will understand that it is not because we lack examples that we do not provide references to document this claim.

as a knowledge of *fish biology* (as opposed to *fisheries research*) cannot answer questions of fisheries management.

Coiba National Park and surrounding areas are typical of tropical shelves in that they harbor a slowly declining marine biodiversity and declining resource abundance (Vega *et al.* 2016) as invariably occurs where massive fisheries operate, be they artisanal, recreational or industrial (Pauly *et al.* 2002). The decay around Coiba National Park is not surprising; in fact, it would be surprising if it were not occurring. This decay is not due to illegal fishing by artisanal or recreational or industrial bad actors, although this will always be asserted by representatives of competing fisheries. The problem is that *any* fishing is permitted in a UNESCO World Heritage Site, and that not even 15% of the coastal area exploited by the fisheries of Chiriquí and Veraguas Province (i.e., the fractional area of the CNP), can be fully protected from their onslaught.

We are aware that the argument for closing Coiba National Park to any fishing will be felt by Panamanian authorities as an unrealistic in view of the perceived needs of the local fisheries, and for local employment and seafood. However, the province of Chiriquí and Veraguas, except for the 1 nm around islands in the CNP and 2 nm around Montuosa Island, lack no-take marine reserves and hence have no refuge where large and long-lived individuals of various species could survive, and produce the eggs and larvae that can replenish the surrounding area (Barneche *et al*. 2018; Cinner *et al*. 2018; Edgar *et al.* 2014). We believe that the best way to prevent further erosion of the biodiversity of the CNP, and the fisheries of Chiriquí and Veraguas Province would be for the Panamanian Government to declare the CNP as a no-take area and to devote more resources to the enforcement of its rules and regulations.

Finally, we would recommend that the Panamanian authorities commission a serious, comprehensive study of the fisheries in and around Coiba National Park that would use state-of-the-art methods to gather catch and effort data. Also, this should include systematic collection of length-frequency data for major species caught by the 'artisanal plus' and the recreational fisheries. Such length-frequency data can be used, if properly sampled, to straightforwardly estimate the value of a key indicator of the status of fisheries, B/B_{MSY}, i.e., the ratio of the current biomass of a fish population to the biomass that generates Maximum Sustainable Yield (see Figure 3), without catch time series from earlier years being available (Froese *et al*. 2018).

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APPENDIX I: SCIENTIFIC AND COMMON NAMES OF ORGANISMS IN THIS REPORT

IA. Fishes

Table IA Scientific and common names of the fishes mentioned in this report; based on FishBase (Froese and Pauly 2018; www.fishbase.org), and their status on the IUCN Red List of Threatened Species. LC = Least Concern; DD = Data Deficient; VU = Vulnerable; NT = Near Threatened.

English	Spanish	Scientific name	IUCN
Black marlin	Aguja negra / marlin negro	*Istiompax indica*	DD
Blacktip shark	Tiburón aletinegro	*Carcharhinus limbatus*	NT
Blue Marlin	Aguja azul	*Makaira nigricans*	VU
Broomtail grouper	Mero/cherna escoba	*Mycteroperca xenarcha*	LC
Colorado snapper	Pargo achotillo	*Lutjanus colorado*	LC
Dolphinfish	Dorado/mahi-mahi	*Coryphaena hippurus*	LC
Oceanic whitetip shark	Tiburón oceánico	*Carcharhinus longimanus*	VU
Olive grouper	Mero/cherna mantequilla	*Epinephelus cifuentesi*	NT
Pacific anchoveta	Anchoveta	*Cetengraulis mysticetus*	LC
Pacific dog snapper	Pargo dientón	*Lutjanus novemfasciatus*	LC
Pacific goliath grouper	Mero guasa/goliath	*Epinephelus quinquefasciatus*	DD
Pacific red snapper	Pargo seda	*Lutjanus peru*	LC
Parrot sand bass	Cabrilla	*Paralabrax loro*	DD
Rivulated mutton hamlet	Cabrilla	*Alphestes multiguttatus*	LC
Rooster hind	Mero/cherna roja	*Hyporthodus acanthistius*	LC
Sailfish	Pez vela del Indo-Pacífico	*Istiophorus platypterus*	LC
Scalloped hammerhead	Tiburón martillo	*Sphyrna lewini*	EN
Sicklefin smooth-hound	Tiburón mamón	*Mustelus lunatus*	LC
Silky shark	Tiburón jaquetón/cazón	*Carcharhinus falciformis*	NT
Smalltail shark	Tollo	*Carcharhinus porosus*	DD
Spotted grouper	Mero/cherna cabrilla	*Epinephelus analogus*	LC
Spotted rose snapper	Pargo mancha	*Lutjanus guttatus*	LC
Star-studded grouper	Mero/cherna gris	*Epinephelus niphobles*	DD
Striped marlin	Marlin rayado	*Kajikia audax*	NT
Tenspine grouper	Cherna pechi blanca/ gris	*Hyporthodus exsul*	DD
Whitenose shark	Tiburón pico blanco	*Nasolamia velox*	DD
Yellow snapper	Pargo amarillo	*Lutjanus argentiventris*	LC
Yellowfin tuna	Atún aleta amarilla	*Thunnus albacares*	NT

IB. Other marine organisms and terrestrial plants

Table IB. Scientific and common names of non-fish marine organisms and terrestrial plants mentioned in this report; based on SeaLifeBase (Palomares and Pauly 2018; www.sealifebase.org), and their status on the IUCN Red List of Threatened Species. LC = Least Concern; DD = Data Deficient; VU = Vulnerable; NT = Near Threatened.

English	Spanish	Scientific name	IUCN
Spinner dolphin	Delfín tornillo	*Stenella longirostris*	DD
Humpback whale	Ballena jorobada	*Megaptera novaeangliae*	LC
Olive ridley sea turtle	Tortuga golfina	*Lepidochelys olivacea*	VU
Green sea turtle	Tortuga verde	*Chelonia mydas*	EN
Brown pelican	Pelícano pardo	*Pelecanus occidentalis*	LC
Blue shrimp	Camarón blanco/langostino	*Litopenaeus stylirostris*	--
Crystal shrimp	Camarón rojo	*Farfantepenaeus brevirostris*	--
Seabob	Camarón blanco	*Xiphopenaeus kroyeri*	--
Titi shrimp	Tití	*Protrachypene precipua*	--
Western white shrimp	Langostino	*Litopenaeus occidentalis*	--
Whiteleg shrimp	Camarón patiblanco	*Litopenaeus vannamei*	--
Green spiny lobster	Langosta barbona	*Panulirus gracilis*	DD
Shield fan lobster	Langosta china	*Evibacus princeps*	LC
Coiba spinetail	Curutié Coiba	*Cranioleuca dissita*	NT
Camibar	Camibar	*Prioria copaifera*	--
Wild cashew	Espavé	*Anacardium excelsum*	--

APPENDIX II: MARINE WORLD HERITAGE SITES

The methodological approach used in this report to estimate the fisheries catches taken from Coiba National Park could be applied – with suitable modifications dictated by data availability – to all other marine World Heritage sites. Indeed, all of them are part of Exclusive Economic Zones (EEZs) whose fisheries have already been studied by the *Sea Around Us* in the context of the global 'catch reconstruction' project whose major results were published in Pauly and Zeller (2016).

The Working Papers, book or report chapters, or peer-reviewed publications documenting this work are listed, by marine World Heritage site in Table II below, and are available as PDFs from the website of the *Sea Around Us* (www.seaaroundus.org). As can be assessed, each of these documents has features in common, e.g., they all (*i*) cover the years 1950 to 2010 (and often beyond), (*ii*) distinguish industrial, artisanal, subsistence and recreational catches, and (*iii*) include discarded catches.

However, they widely differ in the assumptions that had to be made to elevate all national accounts to the same level. For example, while some countries had detailed accounts of their recreational fisheries and corresponding catch estimates, others had no such information. In such cases, recreational fisheries catches had to be inferred, e.g., from the number of foreign tourist visits, their presumed participation rates, and reports of their catch on Facebook.

Overall, however, the *Sea Around Us* would be able to infer, based on the documents cited below and other information sources (notably local boat counts from (AIS) satellite data, the catch taken from the other 48 Marine World Heritage sites, and to improve on the catch estimate of Coiba National Park presented in this report (which had to be completed in less time that would have been appropriate).

Table IIA. The 49 marine World Heritage Site and the Sea Around Us contribution describing the fisheries of the Exclusive Economic Zones surrounding the sites.

Site	Pertinent contribution of the *Sea Around Us*
Península Valdés (Argentina)	Villasante, S., G. Macho, J. Isusu de Rivero, E. Divovich, K. Zylich, D. Zeller and D. Pauly. 2015. Reconstruction of Argentina's marine fisheries catches (1950-2010). Fisheries Centre Working Paper #2015-50, 6 p.
Great Barrier Reef (Australia)	Kleisner, K.M., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly and D. Zeller. 2015. Australia: reconstructing estimates of total fisheries removals 1950-2010. Fisheries Centre Working Paper #2015-02, 26 p.
Lord Howe Island Group (Australia)	Kleisner, K.M., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly and D. Zeller. 2016. Australia (Lord Howe Island). P. 195 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts.* Island Press, Washington, DC.
Ningaloo Coast (Australia)	Kleisner, K.M., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly and D. Zeller. 2015. Australia: reconstructing estimates of total fisheries removals 1950-2010. Fisheries Centre Working Paper #2015-02, 26 p.

Table IIA. The 49 marine World Heritage Site and the Sea Around Us contribution describing the fisheries of the Exclusive Economic Zones surrounding the sites.

Site	Pertinent contribution of the *Sea Around Us*
Shark Bay, Western Australia	Kleisner, K.M., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly and D. Zeller. 2015. Australia: reconstructing estimates of total fisheries removals 1950-2010. Fisheries Centre Working Paper #2015-02, 26 p.
Macquarie Island (Australia)	Kleisner, K.M., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly and D. Zeller. 2016. Australia (Macquarie Island). P. 196 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts.* Island Press, Washington, DC.
Heard and McDonald Islands (Australia)	Kleisner, K.M., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly and D. Zeller. 2016. Australia (Heard and MacDonald Islands) P. 194 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
The Sundarbans (Bangladesh)	Ullah, H. D., Knip, D. Gibson, K. Zylich, and D. Zeller. 2014. Reconstruction of total marine fisheries catches for Bangladesh: 1950-2010. Fisheries Centre Working Paper #2014-15, Vancouver. 10 p.
Belize Barrier Reef Reserve System	Zeller, D., R. Graham, and S. Harper. 2011. Reconstruction of total marine fisheries catches from Belize, 1950-2008. pp. 142-151 in MLD. Palomares and D. Pauly D (eds.), Too Precious to Drill: The Marine Biodiversity of Belize. Fisheries Centre Research Reports 19(6).
Brazilian Atlantic Islands: Fernando de Noronha and Atol das Rocas Reserves	Divovich, E. and D. Pauly. 2016. Brazil (Fernando de Noronha). P. 207 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Kluane / Wrangell-St. Elias / Glacier Bay / Tatshenshini-Alsek (Canada / USA)	Doherty,B., D. Gibson, Y. Zhai, A. McCrea-Strub, K. Zylich, D. Zeller and D. Pauly. 2015. Reconstruction of marine fisheries catches for Subarctic Alaska, 1950-2010. Fisheries Centre Working Paper #2015-82, University of British Columbia, Vancouver, 34 p.
Malpelo Fauna and Flora Sanctuary (Colombia)	Wielgus, J., D. Caicedo-Herrera, A. Lindop, T. Chen, K. Zylich, and D. Zeller. 2016. Colombia (Pacific). P. 224 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Área de Conservación Guanacaste (Costa Rica)	Trujillo, P., A. Cisneros-Montemayor, S. Harper, K. Zylich, and D. Zeller. 2016. Costa Rica (Pacific). P. 230 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Cocos Island National Park (Costa Rica)	Trujillo, P., A. Cisneros-Montemayor, S. Harper, K. Zylich, and D. Zeller. 2016. Costa Rica (Pacific). P. 230 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Wadden Sea (Denmark)	Gibson, D., B. Ueberschär, K. Zylich, and D. Zeller. 2016. Denmark (North Sea). P. 237 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts.* Island Press, Washington, DC.

Table IIA. The 49 marine World Heritage Site and the Sea Around Us contribution describing the fisheries of the Exclusive Economic Zones surrounding the sites.

Site	Pertinent contribution of the *Sea Around Us*
Galápagos Islands (Ecuador)	Schiller, L., J. Alava, J. Grove, G. Reck, G. and D. Pauly. 2016. Ecuador (Galápagos). P. 242 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Gulf of Porto: Calanche of Piana, Gulf of Girolata, Scandola Reserve (France)	Le Manach, F., D. Dura, A. Pere, J.J. Riutor, P. Lejeune, M.C. Santoni, J.M. Culioli, and D. Pauly. 2016. France (Corsica). P. 254 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Lagoons of New Caledonia: Reef Diversity and Associated Ecosystems (France)	Harper, S., L. Frotté, S. Bale, S. Booth and D. Zeller. 2016. New Caledonia. P. 264 in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Surtsey (Iceland)	Valtýsson, H. 2016. Reconstructing Icelandic catches from 1950-2010. pp. 73-88. In K. Zylich, D. Zeller, M. Ang and D. Pauly (eds) *Fisheries Catch Reconstructions: Islands, Part IV*. Fisheries Centre Research Reports 22(2).
Sundarbans National Park (India)	Hornby, C., B. Bhathal, D. Pauly and D. Zeller. 2015. Reconstruction of India's marine fish catch from 1950-2010. Fisheries Centre Working Paper #2015-77, 42 p.
Ujung Kulon National Park (Indonesia)	Budimartono, V., M. Badrudin and D. Pauly. 2015. Indonesian marine fisheries catches in the Western Indonesia (FAO area 57) and in the Bay of Bengal large marine ecosystem project (BOBLME) area: a tentative reconstruction, 1950-2010. pp. 27-51. In D. Pauly and V. Budimartono (eds.) *Marine Fisheries Catches of Western, Central and Eastern Indonesia, 1950-2010*. Fisheries Centre Working Paper #2015-61.
Komodo National Park (Indonesia)	Budimartono, V., M. Badrudin, E. Divovich and D. Pauly. 2015. A reconstruction of marine fisheries catches of Indonesia, with emphasis on Central and Eastern Indonesia, 1950-2010. pp. 2-26 In D. Pauly and V. Budimartono (eds.) *Marine Fisheries Catches of Western, Central and Eastern Indonesia, 1950-2010*. Fisheries Centre Working Paper #2015-61.
Shiretoko (Japan)	Swartz, W. and G. Ishimura. 2014. Baseline assessment of total fisheries-related biomass removals from Japan's Exclusive Economic Zone: 1950 – 2010. *Fisheries Science* 80(4): 643-651.
Ogasawara Islands (Japan)	Swartz, W. 2016. Japan (Ogasawara Islands). P. 308 in in D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Phoenix Islands Protected Area (Kiribati)	Zylich, K., S. Harper, D. Zeller and D. Pauly. 2016. Kiribati (Phoenix Islands). P. 313 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Banc d'Arguin National Park (Mauritania)	Belhabib, D., D. Gascuel, E. Abou Kane, S. Harper, D. Zeller and D. Pauly. 2012. Preliminary estimation of realistic fisheries removals from Mauritania: 1950-2010. pp.61-78 In Belhabib, D., D. Zeller, S. Harper and D. Pauly (eds.) *Marine fisheries catches in West Africa, Part 1*. Fisheries Centre Research Reports 20(3).

Table IIA. The 49 marine World Heritage Site and the Sea Around Us contribution describing the fisheries of the Exclusive Economic Zones surrounding the sites.

Site	Pertinent contribution of the *Sea Around Us*
Sian Ka'an (Mexico)	Cisneros-Montemayor, A.M., M.A. Cisneros-Mata, S. Harper and D. Pauly. 2016. Mexico (Atlantic). P. 331 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Archipiélago de Revillagigedo (Mexico)	Cisneros-Montemayor, A.M., M.A. Cisneros-Mata, S. Harper and D. Pauly. 2016. Mexico (Pacific). P. 332 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Islands and Protected Areas of the Gulf of California (Mexico)	Cisneros-Montemayor, A.M., M.A. Cisneros-Mata, S. Harper and D. Pauly. 2016. Mexico (Pacific). P. 332 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Whale Sanctuary of El Vizcaíno (Mexico)	Cisneros-Montemayor, A.M., M.A. Cisneros-Mata, S. Harper and D. Pauly. 2016. Mexico (Pacific). P. 332 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
New Zealand Sub-Antarctic Islands	Simmons, G., G. Bremmer, H. Whittaker, P. Clarke, L. Teh, K. Zylich, D. Zeller, D. Pauly, C. Stringer, B. Torkington, and N. Haworth. 2015. Preliminary reconstruction of marine fisheries catches for New Zealand (1950-2010). Fisheries Centre Working Paper #2015-87, 33 p.
West Norwegian Fjords – Geirangerfjord and Nærøyfjord	Nedreaas, K., S. Iversen, and G. Kuhnle. 2015. Preliminary estimates of total removals by the Norwegian marine fisheries, 1950-2010. Fisheries Centre Working Paper #2015-94, 15 p.
Rock Islands Southern Lagoon (Palau)	Lingard, S., S. Harper, Y. Ota and D. Zeller. 2015. Fisheries of Palau, 1950-2008: Total reconstructed catch. pp. 73-84. In S. Harper and D. Zeller (eds.) Fisheries catch reconstruction: Islands, Part II. Fisheries Centre Research Reports 19(4) [updated to 2010].
Coiba National Park and its Special Zone of Marine Protection (Panama)	Harper, S., H.M. Guzmán, K. Zylich and D. Zeller. 2016. Panama (Pacific). P. 364 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC. **[also: thus study]**
Puerto-Princesa Subterranean River National Park (Philippines)	Palomares, M.L.D., and D. Pauly. 2014. Philippine marine fisheries catches: A bottom-up reconstruction, 1950-2010. Fisheries Centre Research Reports 22(1), 171 p.
Tubbataha Reefs Natural Park (Philippines)	Palomares, M.L.D., and D. Pauly. 2014. Philippine marine fisheries catches: A bottom-up reconstruction, 1950-2010. Fisheries Centre Research Reports 22(1), 171 p.
Natural System of Wrangel Island Reserve (Russia)	Pauly, D., W. Swartz, E. Pakhomov and D. Zeller. 2016. Russia (Laptev to Chukchi Seas). P. 379 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Aldabra Atoll (Seychelles)	Le Manach, F., P. Bach, L. Boistol, J. Robinson and D. Pauly. 2015. Artisanal fisheries in the world's second largest tuna fishing ground: Reconstruction of the Seychelles' marine fisheries catch, 1950-2010. pp. 99-109 In F, Le Manach and D. Pauly (eds.) *Fisheries catch reconstructions in the Western Indian Ocean, 1950-2010*. Fisheries Centre Research Reports 23(2).

Table IIA. The 49 marine World Heritage Site and the Sea Around Us contribution describing the fisheries of the Exclusive Economic Zones surrounding the sites.

Site	Pertinent contribution of the *Sea Around Us*
East Rennell (Solomon Islands)	Doyle, B., S. Harper, J. Jacquet, and Z. Zeller. 2012. Reconstructing marine fisheries catches in the Solomon Islands: 1950-2009. pp. 119-134 In S. Harper, K. Zylich, L. Boonzaier, F. Le Manach, D. Pauly and D. Zeller (eds.) *Fisheries catch reconstructions: Islands, Part III*. Fisheries Centre Research Report 20(5). [Including on p. 129 and addendum which updates the dataset to 2010]
iSimangaliso Wetland Park (South Africa)	Baust, S., L.C.L. Teh, S. Harper, and D. Zeller. 2016. South Africa (Indian Ocean Coast). P. 392 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Ibiza, Biodiversity and Culture (Spain)	Carreras, M., M. Coll, A. Quetglas, R. Goñi, X. Pastor, M. Cornax, M. Iglesias, E Massutí, P. Oliver, R. Aguilar, A. Au, K. Zylich and D. Pauly. 2016. Spain (Balearic Islands). P. 394 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
Sanganeb Marine National Park and Dungonab Bay – Mukkawar Island Marine National Park (Sudan)	Tesfamichael, D. and A. Nasser Elawad. 2012. Reconstructing the Red Sea fisheries of Sudan: foreign aid and fisheries. pp. 51-70 In D. Tesfamichael and D. Pauly (eds.) Catch reconstruction for the Red Sea. *Ecology and Society* 19(1): 18.
High Coast / Kvarken Archipelago (Sweden / Finland)	Persson, L. 2016. Sweden (Baltic Sea). P. 404 In D. Pauly and D. Zeller (eds.) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, DC.
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APPENDIX III: FIELD QUESTIONNAIRE[21]

Introductory questions

1. Do you currently fish full time or part-time?
2. For how many years have you been fishing?
3. Year started fishing?
4. How old were you when you first started fishing?
5. Is fishing your primary source of income?
6. IF NO: Was fishing ever your primary income?
7. Was your father a fisherman?
8. How many generations of your family are fishermen?
9. Do you have children?
10. IF YES: Would you like them to be fishermen?
11. Why or why not?

Boat questions

12. Do you own a boat?
13. Are you currently using your boat for fishing?
14. IF NO: Is your boat currently functioning?
15. How many feet long is it?
16. What horsepower is the engine?

General catch questions

On a typical fishing day…

17. What time do you leave?
18. What port do you leave from?
19. How long to travel to fishing location?
20. In what areas do you most often fish? (map)
21. How many other people do you fish with?
22. Are you the captain or an assistant?
23. How many kilograms of fish do you catch?
24. How many liters of fuel do you use in one day?
25. What time do you return?
26. Total fishing hours?
27. On a normal fishing day, how much do you spend on: Boat Fuel? Bait? Assistants? Ice? Other Expenses? Total?
28. To whom do you sell your catch? Middlemen? Individual persons? Lodges? Restaurants? Supermarkets?
29. What is the smallest fish you are able to sell?
30. Do you eat some of the fish you catch
31. IF YES: In how many meals per week do you eat fish you catch?
32. What is your favorite fish to eat?
33. Which species do you throw back if you catch them?

[21] The UBC Ethics Certificate of Approval # H18-00929 on May 24, 2018, authorized a much wider range of questions, but the list below covers the questions actually asked by the first author in the Panama June 2018 field sampling.

Fishing income questions

34. On a normal day, how many kilograms of fish do you sell?
35. How much money do you make from selling those?
36. Average Fl./kg?
37. In a normal week, how many days do you fish?
38. In a normal week, how much money do you earn from selling fish?
39. In a good week, how much money do you earn from selling fish?
40. In a bad week, how much money do you earn from selling fish?
41. Out of 52 weeks in a year, about how many weeks do you fish?

Shifting baseline questions

42. Do you think you catch more fish or less fish than previous generations?
43. Do you think you catch bigger or smaller fish than previous generations?
44. Did you catch more fish this year or last year?
45. In the last 5 years, each year are you generally catching:
46. Have you stopped fishing in some areas because the catch there is no longer good?
47. Have you stopped fishing in some areas due to the establishment of Coiba National Park as a marine protected area?
48. Are there any species of fish that you used to catch commonly and now don't catch or catch rarely?
49. Do you think there are fewer fish in the ocean than there were 10 years ago?
50. IF WORSENED: What do you think has caused the decline in fish catch?
51. Pollution? Or: Too much fishing? Or: Climate change? Or: SCUBA diving? Or Change in currents? Or God's will? Or: Small mesh nets? Or: Spear fishing? Or: Coastal development? Ore: Other causes?

Gear questions

52. What type of fishing gear to do you most often fish with?
53. Of all the types of gear, which is the most profitable type of fishing gear to use?
54. Do you ever use more than one type of gear in a single fishing trip?
55. Do you fish with hook and line?
56. Do you hook and line fish on reefs?
57. What types of fish do you aim to catch with line?
58. What types fish do you most often catch with line?
59. Do you fish with a trammel net?
60. What types of fish do you aim to catch by trammel net?
61. Do you fish with other types of gear?
62. IF YES: What type of gear?
63. What types of fish do you most often catch with this gear?

Entry/exit and demographic questions

64. Why did you originally start fishing?
65. Is it profitable to be a full time fisherman?
66. What is your age?
67. Are you married?
68. IF YES: How many family members do you support?

APPENDIX IV: CATCH PER EFFORT OF SMALL ARTISANAL BOATS (*PANGA*)

IVA. Small boat catch (kg) per month by the 22 members of the Hicaco Association, Veraguas Province[22]

Month/year	1	2	3	4	5	6	7	8	9	10	11
05/2018	117.0	315.4	350.9	389.4	132.0	333.5	825.3	227.5	316.9	144.4	477.2
04/2018	329.3	617.0	387.5	387.8	325.5	236.3	892.3	314.6	528.8	355.4	861.9
03/2018	319.3	708.5	410.0	316.2	313.0	-	1072.7	850.0	430.0	181.9	451.3
02/2018	184.2	714.9	368.3	929.0	60.8	349.7	873.6	377.8	142.9	459.5	379.7
01/2018	212.7	304.8	513.6	1237.9	182.0	265.0	1766.7	518.1	271.6	470.4	355.3
12/2016	492.1	565.5	413.0	1562.2	314.5	166.3	1106.8	254.4	938.4	156.7	345.1
11/2016	131.8	382.8	424.6	705.5	181.0	137.0	1061.0	167.2	601.1	176.2	252.2
10/2016	249.6	712.7	250.2	1478.2	239.4	105.7	1086.3	357.9	838.1	299.8	468.4
09/2016	86.7	715.5	300.1	1801.0	331.4	28.1	935.2	240.6	852.6	96.2	591.6
08/2016	153.1	348.3	272.1	1809.2	353.7	253.7	1122.7	392.7	431.8	189.1	448.1
07/2016	147.2	560.2	173.8	2087.5	429.6	292.6	1133.6	568.4	409.1	376.8	392.5
06/2016	229.3	684.0	135.0	173.2	295.6	315.8	1525.3	414.2	55.7	605.5	710.2
05/2016	156.6	696.4	15.4	1921.3	398.6	659.2	1107.8	408.6	76.7	642.4	747.3
04/2016	282.8	563.4	391.3	2842.5	495.8	413.6	1552.7	450.8	135.3	325.5	523.0
03/2016	347.8	429.0	211.6	1061.9	232.4	291.9	1421.5	380.0	154.8	360.0	499.4
02/2016	129.8	376.4	183.9	16.3	35.0	75.4	877.6	327.3	129.8	216.1	175.7
01/2016	276.0	447.6	241.9	77.3	223.3	235.6	886.5	279.2	114.5	268.7	320.0
Mean	226.2	537.8	296.6	1105.7	267.3	260.0	1132.2	384.1	378.1	313.2	470.5

Month/year	12	13	14	15	16	17	18	19	20	21	22
05/2018	275.9	396.0	253.1	507.7	361.3	651.4	189.7	107.4	194.7	271.6	176.2
04/2018	361.7	984.7	838.2	657.6	225.0	493.2	703.9	280.9	237.8	140.4	188.0
03/2018	140.2	546.6	606.9	411.4	198.2	215.5	456.8	100.2	285.3	188.7	-
02/2018	494.9	961.6	770.2	730.7	475.4	708.5	975.2	314.8	221.4	110.2	-
01/2018	391.6	499.0	1179.3	406.6	989.3	633.2	408.3	343.9	330.0	132.6	75.4
12/2016	206.8	1933.1	400.2	197.5	-	297.1	-	201.6	-	145.7	156.7
11/2016	77.0	719.1	165.6	146.9	-	250.6	-	149.7	-	177.2	54.6
10/2016	91.8	1079.2	231.0	366.9	-	311.7	-	234.9	-	174.8	87.5
09/2016	206.6	483.1	237.9	284.7	-	274.2	-	28.1	-	64.5	-
08/2016	147.1	235.7	314.6	186.0	-	301.7	-	254.9	-	180.2	215.0
07/2016	231.5	319.4	321.2	268.4	-	452.1	-	314.7	-	185.3	127.6
06/2016	368.4	515.6	491.1	391.9	-	54.7	-	448.1	-	310.8	319.6
05/2016	380.9	284.7	503.0	427.2	-	221.6	-	300.1	-	180.2	177.5
04/2016	279.7	249.2	525.7	352.8	-	503.9	-	293.3	-	86.5	89.4
03/2016	253.8	258.8	206.1	501.7	-	108.1	-	311.4	-	-	-
02/2016	308.3	99.9	138.5	89.0	-	207.5	-	232.9	-	-	-
01/2016	185.7	151.2	129.5	140.9	-	322.0	-	218.1	-	-	-
Mean	258.9	571.6	430.1	356.9	449.8	353.3	546.8	243.2	253.8	167.8	151.6

[22] Based on about 17 day trips per month. Source: Internal records of and interviews with the Association of Artisanal Fishers of Hicaco.

IVB. Small boat catch (kg) per trip by members by members of the Guarumal Association, Veraguas Province[23]

Trip #	Month/Year	1	2	3	4	5	6	7	8	9	10
Trip 1	04/2018	3.2	1.8	-	1.4	-	-	-	-	-	-
Trip 2	04/2018	30.4	-	33.3	-	-	-	-	-	-	-
Trip 3	04/2018	-	16.1	68.7	17.5	-	-	-	-	-	-
Trip 4	04/2018	20.1	18.5	7.9	11.9	-	-	-	-	-	-
Trip 5	04/2018	-	14.2	-	-	14.5	-	-	-	-	-
Trip 6	04/2018	-	-	-	-	-	31.5	-	-	-	-
Trip 7	04/2018	65.8	20.6	-	-	-	-	-	-	-	-
Trip 8	04/2018	-	-	-	-	-	-	-	-	-	-
Trip 9	04/2018	-	-	-	-	-	-	-	-	-	-
Trip 10	04/2018	-	-	-	-	-	-	-	-	-	-
Trip 11	04/2018	44.9	24.7	-	-	46.3	-	-	-	-	-
Trip 1	04/2017	-	-	-	-	-	-	20.0	20.0	10.0	-
Trip 2	04/2017	-	-	-	-	-	-	28.6	36.7	43.1	-
Trip 3	04/2017	-	-	-	-	-	-	17.2	20.9	44.0	-
Trip 4	04/2017	-	-	-	-	-	-	9.5	35.4	12.2	-
Trip 5	04/2017	-	-	-	-	-	-	17.2	26.8	21.8	-
Trip 6	04/2017	-	-	-	-	-	-	39.4	16.9	14.5	-
Trip 7	04/2017	-	-	-	-	-	-	11.3	9.2	9.1	-
Trip 8	04/2017	-	-	-	-	-	-	9.8	9.1	20.0	-
Trip 9	04/2017	-	-	-	-	-	-	13.4	10.4	12.5	-
Trip 10	04/2017	-	-	-	-	-	-	22.6	-	19.3	-
Trip 11	04/2017	-	-	-	-	-	-	7.7	-	14.1	-
Trip 12	04/2017	-	-	-	-	-	-	24.9	-	22.2	-
Trip 13	04/2017	-	-	-	-	-	-	9.1	-	16.8	-
Trip 14	04/2017	-	-	-	-	-	-	11.7	-	8.2	-
Trip 15	04/2017	-	-	-	-	-	-	10.8	-	-	-
Trip 16	04/2017	-	-	-	-	-	-	18.1	-	-	-
Trip 17	04/2017	-	-	-	-	-	-	9.1	-	-	-
Trip 18	04/2017	-	-	-	-	-	-	-	18.8	8.6	43.1
Trip 1	04/2016	-	-	-	-	-	-	-	18.4	23.4	83.0
Trip 2	04/2016	-	-	-	-	-	-	-	7.3	8.5	21.2
Trip 3	04/2016	-	-	-	-	-	-	-	38.1	7.7	17.8
Trip 4	04/2016	-	-	-	-	-	-	-	45.8	29.0	17.1
Trip 5	04/2016	-	-	-	-	-	-	-	26.8	39.9	27.7
Trip 6	04/2016	-	-	-	-	-	-	-	33.8	24.5	19.1
Trip 7	04/2016	-	-	-	-	-	-	-	11.8	10.9	20.4
Trip 8	04/2016	-	-	-	-	-	-	-	-	22.2	28.3
Trip 9	04/2016	-	-	-	-	-	-	-	-	15.0	15.0
Trip 10	04/2016	-	-	-	-	-	-	-	-	34.9	10.4
Trip 11	04/2016	-	-	-	-	-	-	-	-	12.5	-
Trip 12	04/2016	-	-	-	-	-	-	-	-	56.7	-
Trip 1	04/2015	12.7	40.8	-	34.9	-	-	20.0	-	6.8	38.1
Trip 2	04/2015	13.2	4.0	-	14.5	-	-	11.8	-	6.8	20.6
Trip 3	04/2015	22.7	26.3	-	15.4	-	-	11.3	-	10.9	10.4

[23] This association has 22 members. They undertake 3 one-day trips per week. Source: Internal records of and interviews with the Association of Artisanal Fishers of Guarumal.

Trip #	Month/Year	1	2	3	4	5	6	7	8	9	10
Trip 4	04/2015	14.5	1.8	-	6.4	-	-	12.0	-	6.9	29.5
Trip 5	04/2015	14.5	37.0	-	27.2	-	-	6.6	-	5.7	22.7
Trip 6	04/2015	24.9	8.6	-	3.2	-	-	20.9	-	2.8	24.5
Trip 7	04/2015	12.7	13.4	-	1.6	-	-	17.2	-	31.3	-
Trip 8	04/2015	14.5	4.8	-	4.3	-	-	7.7	-	11.8	-
Trip 9	04/2015	12.2	18.4	-	-	-	-	5.9	-	19.5	-
Trip 10	04/2015	-	13.5	-	-	-	-	-	-	6.1	-
Trip 11	04/2015	-	2.5	-	-	-	-	-	-	14.1	-
Trip 12	04/2015	-	-	-	-	-	-	-	-	15.6	-
Trip 13	04/2015	-	-	-	-	-	-	-	-	15.6	-
Trip 14	04/2015	-	-	-	-	-	-	-	-	16.8	-
Trip 15	04/2015	-	-	-	-	-	-	-	-	26.9	-
Trip 1	04/2014	20.3	-	-	8.2	-	-	3.6	20.9	9.3	14.5
Trip 2	04/2014	24.7	-	-	12.2	-	-	4.0	20.0	11.0	26.2
Trip 3	04/2014	24.0	-	-	17.7	-	-	8.6	0.7	3.2	8.4
Trip 4	04/2014	4.1	-	-	15.9	-	-	8.2	29.6	12.9	7.7
Trip 5	04/2014	14.1	-	-	9.4	-	-	-	7.7	37.2	-
Trip 6	04/2014	12.1	-	-	17.0	-	-	-	7.0	26.6	-
Trip 7	04/2014	-	-	-	-	-	-	-	-	34.2	-
Trip 8	04/2014	-	-	-	-	-	-	-	-	20.0	-
Trip 9	04/2014	-	-	-	-	-	-	-	-	3.2	-
Trip 10	04/2014	-	-	-	-	-	-	-	-	22.2	-
Trip 11	04/2014	-	-	-	-	-	-	-	-	20.6	-
Trip 12	04/2014	-	-	-	-	-	-	-	-	7.7	-
Trip 13	04/2014	-	-	-	-	-	-	-	-	7.3	-
Trip 1	04/2011	24.0	-	-	21.8	-	-	-	13.6	8.2	-
Trip 2	04/2011	20.4	-	-	35.8	-	-	-	6.8	2.7	-
Trip 3	04/2011	34.0	-	-	20.9	-	-	-	2.9	20.4	-
Trip 4	04/2011	15.9	-	-	15.9	-	-	-	-	10.4	-
Trip 5	04/2011	1.6	-	-	-	-	-	-	-	2.3	-
Trip 6	04/2011	16.3	-	-	-	-	-	-	-	22.2	-
Trip 7	04/2011	16.3	-	-	-	-	-	-	-	19.5	-
Trip 8	04/2011	15.4	-	-	-	-	-	-	-	11.3	-
Trip 9	04/2011	-	-	-	-	-	-	-	-	22.7	-
Trip 10	04/2011	-	-	-	-	-	-	-	-	13.4	-
	Mean	19.6	15.7	36.7	14.9	30.4	31.5	13.9	19.0	17.0	24.1

IVC. Small boats catch (kg) per trip by members of the El Pito, and per month by members of the Guarumalito Associations, Veraguas Province, Panama

El Pito: Member #1 of the El Pito Association additionally provided data for 13 trips in March 2018, 1 trip in May 2018, 10 trips in March 2017, 11 trips in March 2016 and 4 trips in November 2013. The overall mean catch of this fisher was 69.4 kg per trip. The El Pito Association has 20 members. These 6 fishers undertook 3 two-day trips per week. Source: Internal records of and interviews with Association of Artisanal Fishers of El Pito.

Trip #	Month/year	1	2	3	4	5	6
Trip 1	05/2018	40.5	20.2	37.9	28.1	57.2	-
Trip 2	05/2018	16.6	7.3	-	50.1	11.9	-
Trip 3	05/2018	87.3	27.7	-	-	-	-
Trip 4	05/2018	4.3	11.6	-	-	-	-
Trip 5	05/2018	93.0	5.4	-	-	-	-
Trip 6	05/2018	37.2	23.6	-	-	-	-
Trip 7	05/2018	57.8	30.4	-	-	-	-
Trip 8	05/2018	24.5	76.7	-	-	-	-
Trip 9	05/2018	35.4	43.3	-	-	-	-
Trip 10	05/2018	82.1	28.8	-	-	-	-
Trip 12	03/2016	42.2	45.4	-	55.3	-	24.9
Trip 1	11/2013	65.3	64.9	-	115.7	-	32.5
Trip 2	11/2013	54.4	34.4	-	42.2	-	12.9
Trip 3	11/2013	32.2	19.1	-	60.8	-	8.1
Trip 4	11/2013	55.9	63.5	-	26.1	-	54.4
Trip 5	11/2013	46.7	48.5	-	46.7	-	49.0
Trip 6	11/2013	103.4	28.1	-	46.7	-	32.4
Trip 7	11/2013	55.8	-	-	34.5	-	8.7
Trip 8	11/2013	55.3	-	-	47.2	-	-
	Mean	52.1	34.0	37.9	50.3	34.5	27.9

Guarumalito: The Guarumalito Association has 17 members. These 6 fishers undertook 3 two-day trips per week. Source: Internal records of and interviews with the Association of Arisanal Fishers of Guarumalito.

Trip #	Month/year	1	2	3	4	5	6
Trip 1	05/2018	276.7	171.5	254.5	132.0	44.0	218.5
Trip 1	04/2018	-	152.2	9.5	-	-	-
Trip 1	08/2017	335.2	219.9	269.9	-	-	-
	Mean	305.9	181.2	178.0	132.0	44.0	218.5

IVD. Small boat catch (kg) per month by members of the Palo Seco Association, Veraguas Province, Panama[24]

Month/year	1	2	3	4	5	6	7	8	9	10	11	12
05/2018	320	0	713	340	1097	204	130	678	925	706	0	43
04/2018	388	290	929	508	803	229	56	427	1012	625	0	440
03/2018	301	637	882	154	806	237	103	826	797	720	0	286
02/2018	42	0	482	432	291	201	51	237	609	524	16	73
01/2018	1068	223	1416	985	1250	287	76	768	656	427	67	703
03/2016	20	13	54	267	383	396	27	729	257	-	156	53
02/2016	26	0	90	406	0	52	30	411	25	-	78	67
01/2016	269	801	710	0	259	598	31	1163	322	-	37	90
10/2015	116	69	831	-	290	394	108	641	788	449	191	40
10/2013	224	1749	823	891	1032	962	0	-	-	16	73	-
09/2013	231	86	587	986	1191	953	69	-	-	204	0	-
08/2013	570	500	1142	445	781	505	0	-	-	401	61	-
06/2013	360	160	714	187	1142	438	-	-	-	749	297	-
05/2013	390	293	438	765	795	866	-	-	-	631	302	-
04/2013	337	315	419	282	795	114	-	-	-	143	-	-
03/2013	1071	1102	1236	717	1102	922	-	-	-	530	47	-
02/2013	412	852	989	1147	821	946	-	-	-	-	-	-
01/2013	633	933	956	662	864	880	-	-	-	801	835	-
Means	377	446	745	540	761	510	57	653	599	495	135	200

Appendix IVD continued.

Month/year	13	14	15	16	17	18	19	20	21	22	23	24
05/2018	18	35	797	155	12	14	35	0	0	-	-	-
04/2018	0	25	370	170	28	12	0	4	0	-	-	-
03/2018	0	94	81	124	-	9	-	10	0	-	-	-
02/2018	225	25	55	41	-	0	-	250	6	-	-	-
01/2018	420	507	642	54	-	47	-	1056	-	-	-	-
03/2016	-	33	214	69	-	-	-	37	-	-	-	-
02/2016	-	167	131	31	-	-	-	19	-	-	-	-
01/2016	-	281	142	-	-	-	-	432	-	-	-	-
10/2015	-	147	-	21	-	68	-	112	157	-	-	-
10/2013	-	-	-	17	-	-	-	-	-	2131	14	99
09/2013	-	-	-	-	-	-	-	-	-	0	0	896
08/2013	-	-	-	-	-	-	-	-	-	481	-	0
06/2013	-	-	-	-	-	-	-	-	-	201	-	347
05/2013	-	-	-	-	-	-	-	-	-	412	76	174
04/2013	-	-	-	599	-	-	-	-	-	310	198	44
03/2013	-	-	-	252	-	-	-	-	-	940	-	-
02/2013	-	-	-	-	-	-	-	-	-	1218	-	-
01/2013	-	-	-	101	-	-	-	-	-	871	-	96
Mean	133	146	304	136	20	25	17	213	33	729	72	237

[24] The Palo Seco Association has 24 members, who undertake 4 one-day trips per week. Source: Internal records of and interviews with the Agricultural, Fishing and Eco-touristic Association of Palo Seco.

APPENDIX V: CATCH PER TRIP OF LARGER ARTISANAL BOATS (*PARGUEROS*)

VA. Large boat catches (kg) per trip by boats from Puerto Remedios, Chiriquí Panama allowed to fish inside Coiba National park[25]

Month/Year	1	2	3	4	5	6	7	8	9	10	11	12	13
05/2018	651	1054	749	1170	1065	605	200	1071	1147	842	520	737	-
05/2018	980	-	864	631	961	-	751	834	-	1028	-	1161	-
05/2018	200	-	163	-	-	-	-	-	-	-	-	-	-
04/2018	803	1416	416	-	-	-	-	867	-	-	-	666	-
04/2018	-	-	311	-	-	-	-	1278	-	-	-	-	-
03/2018	472	968	673	686	-	-	-	684	697	84	-	157	360
03/2018	498	-	922	-	-	-	-	664	-	-	-	722	-
02/2018	2220	2292	1862	1475	342	1483	-	834	-	-	-	1081	272
02/2018	1859	913	928	-	-	1219	-	-	-	-	-	1091	341
01/2018	2407	2433	626	2056	937	2734	938	2489	2571	-	-	2018	1214
01/2018	-	-	1199	2002	-	1699	-	1726	-	-	-	-	683
09/2017	1046	1588	229	546	287	291	-	849	-	523	587	925	562
09/2017	636	-	-	-	431	663	529	609	-	-	-	525	406
08/2017	879	1671	713	118	906	738	283	1286	-	676	-	174	784
08/2017	913	750	-	798	898	927	1181	1419	-	1119	-	1118	360
08/2017	-	-	-	-	703	702	-	-	-	-	-	-	484
07/2017	1094	1746	1563	1292	841	1056	1250	1308	-	1005	2104	814	1222
07/2017	1627	-	1393	1323	1439	1730	706	-	-	516	1649	1146	1071
07/2017	891	-	-	1525	-	791	1048	-	-	-	884	-	-
06/2017	977	1081	1147	1045	868	1174	841	-	-	702	1291	1337	755
06/2017	1056	1440	1865	1292	847	1385	1358	-	-	926	730	-	-
06/2017	1338	-	1620	-	-	-	-	-	-	1010	-	-	-
05/2017	862	1736	1320	1479	1064	-	1092	1471	-	499	795	1256	291
05/2017	1317	1872	-	-	1014	-	917	1125	-	-	-	-	-
04/2017	345	604	624	1140	-	-	-	715	-	512	-	606	472
04/2017	1420	-	582	-	-	-	-	714	-	122	-	1180	-
04/2017	-	-	1582	-	-	-	-	897	-	699	-	-	-
03/2017	372	542	458	683	-	-	-	509	-	20	-	370	85
03/2017	652	958	-	834	-	-	-	-	-	116	-	601	117
03/2017	-	526	-	-	-	-	-	-	-	-	-	-	-
Mean	1021	1311	948	1116	840	1147	853	1067	1472	612	1070	884	557

[25] The 13 large boats undertook about 2 eight-day trips per month. Source: Data of and interviews with Maritime Authority of Panama, Puerto Remedios.

VB. Large boat catches (kg) per trip by 50 boats from Puerto Remedios, Chiriquí Panama not allowed to fish in Coiba National park[26]

Month/Year	1	2	3	4	5	6	7	8	9	10	11	12	13
05/2018	307	326	181	182	507	681	817	517	453	855	154	385	5
05/2018	336	-	287	200	696	1055	1257	926	-	-	-	-	129
05/2018	392	-	451	-	727	-	-	-	-	-	-	-	63
05/2018	342	-	-	-	-	-	-	-	-	-	-	-	-
04/2018	218	275	416	308	490	530	242	234	192	-	-	-	359
04/2018	242	210	311	129	374	191	-	62	-	-	398	-	28
04/2018	351	148	-	-	-	-	-	164	-	-	165	-	154
04/2018	-	306	-	-	-	-	-	-	-	-	-	-	-
03/2018	286	223	601	925	-	519	-	249	-	-	-	212	-
03/2018	353	74	371	1078	-	262	-	323	-	-	-	253	-
03/2018	271	322	673	-	-	-	-	164	-	-	-	-	-
03/2018	339	237	251	-	-	-	-	138	-	-	-	-	-
03/2018	-	-	218	-	-	-	-	639	-	-	-	-	-
02/2018	348	104	405	55	1198	1390	-	345	-	-	-	366	16
02/2018	473	181	437	168	-	-	-	482	-	-	-	258	-
02/2018	89	354	490	-	-	-	-	622	-	-	-	-	-
02/2018	556	205	374	-	-	-	-	-	-	-	-	-	-
02/2018	392	-	-	-	-	-	-	-	-	-	-	-	-
01/2018	268	576	153	283	2035	2218	-	415	179	-	-	444	-
01/2018	369	-	261	221	1379	1511	-	348	-	-	-	-	-
01/2018	289	-	148	-	-	-	-	857	-	-	-	-	-
01/2018	417	-	-	-	-	-	-	-	-	-	-	-	-
09/2017	304	113	483	385	793	661	-	396	-	-	-	270	-
09/2017	395	317	65	262	559	245	-	434	-	-	-	173	-
09/2017	600	-	299	-	95	-	-	-	-	-	-	-	-
08/2017	651	328	119	-	1241	496	-	619	15	1039	-	186	87
08/2017	85	123	75	-	1089	547	-	158	-	-	-	426	-
08/2017	92	44	465	-	-	964	-	464	-	-	-	-	-
08/2017	457	-	-	-	-	-	-	-	-	-	-	-	-
07/2017	547	408	404	339	1075	950	-	756	-	2117	-	577	61
07/2017	533	438	479	113	1101	1354	-	204	-	2437	-	575	73
07/2017	362	281	-	-	-	-	-	-	-	1183	-	375	135
07/2017	-	-	-	-	-	-	-	-	-	-	-	-	133
07/2017	-	-	-	-	-	-	-	-	-	-	-	-	262
06/2017	362	721	731	117	1086	540	-	664	-	1745	98	491	159
06/2017	459	297	271	295	1368	877	-	256	-	-	-	445	-
06/2017	405	139	321	-	-	-	-	440	-	-	-	-	-
06/2017	157	-	-	-	-	-	-	680	-	-	-	-	-
05/2017	756	492	89	201	1084	1148	246	453	-	436	128	232	-
05/2017	434	378	-	293	962	-	-	565	-	1550	172	449	-
05/2017	262	162	-	-	781	-	-	501	-	-	-	-	-
05/2017	-	-	-	-	-	-	-	-	-	-	-	-	-
04/2017	651	661	-	301	566	523	-	639	102	817	24	318	147
04/2017	521	615	-	450	575	579	-	285	31	-	48	-	-

[26] The 50 large boats undertook trips totaling about 14 days per month. Source: Data of and interviews with Maritime Authority of Panama, Puerto Remedios.

Month/Year	1	2	3	4	5	6	7	8	9	10	11	12	13
04/2017	670	492	-	-	-	-	-	-	-	-	-	-	-
04/2017	280	292	-	-	-	-	-	-	-	-	-	-	-
04/2017	747	-	-	-	-	-	-	-	-	-	-	-	-
03/2017	838	222	-	409	199	362	-	717	353	626	31	465	136
03/2017	978	364	-	350	117	344	-	997	239	-	27	463	-
03/2017	754	733	-	-	-	-	-	740	-	-	-	-	-
03/2017	1008	480	-	-	-	-	-	851	-	-	-	-	-
03/2017	-	753	-	-	-	-	-	-	-	-	-	-	-
01/2017	-	-	-	-	-	-	145	-	-	-	-	178	141
01/2017	-	-	-	-	-	-	229	-	-	-	-	84	147
01/2017	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	434	335	339	321	837	780	489	481	195	1280	124	347	124

PANAMA (PACIFIC)[1]

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Panama is located in Central America and is bisected, since the early 20th century, by a canal connecting the Atlantic and Pacific. Reconstructed domestic catches for Panama's Pacific coast (figure 1), based on Harper et al. (2014), were about 5,000 t/year in the early 1950s, increasing to an average of 200,000 t/year from the late 1970s to the mid-2000s and later declining. Overall, this is 1.4 times the landings reported to the FAO, the discrepancy being mainly discards (not considered in FAO data) from the shrimp trawl fishery. Overall, fisheries were dominated by the industrial sector, although the artisanal sector increased more recently (figure 2A). Although the majority of catches are taken by Panama, some foreign fishing is occurring (figure 2B). In the mid-1960s, Panama's most lucrative fishery developed: a fishmeal and oil reduction fishery for Pacific anchoveta (*Cetengraulis mysticetus*) and Pacific thread herring (*Opisthonema libertate*; figure 2C), which continues to the present. The artisanal fishery targets snappers (*Lutjanus* spp.) and croakers (Sciaenidae), as well as invertebrates, such as scallops (*Argopecten ventricosus*), conch (*Strombus* spp.), and

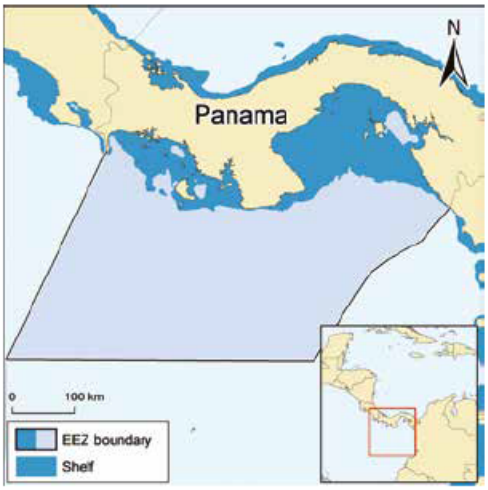

Figure 1. Panama's Pacific coast has a shelf of 40,700 km² and an EEZ of 189,000 km².

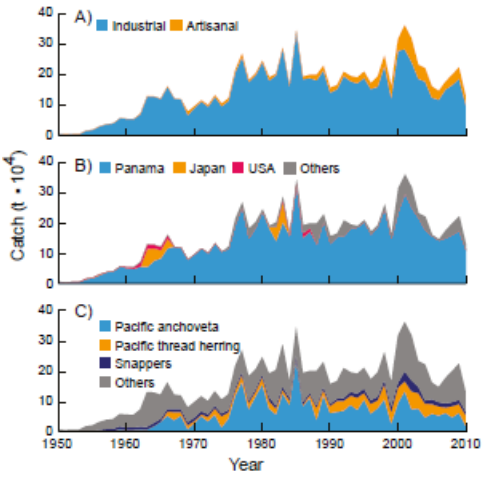

Figure 2. Domestic and foreign catches taken in the Pacific EEZ of Panama: (A) by sector (domestic scores: Ind. 3, 3, 3; Art. 2, 2, 2; Rec. 1, 2, 1; Dis. 1, 1, 2); (B) by fishing country (foreign catches are very uncertain); (C) by taxon.

lobster, notably *Panulirus gracilis* (see Guzman et al. 2008). The economically important trawl fishery has targeted seabob and shrimp (family Penaeidae) since the 1950s, mainly for export, but it has much diminished lately. Although management measures have been implemented to protect overexploited marine resources along Panama's Pacific coast (Harper et al. 2010), more are needed to protect threatened species.

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