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ECOSYSTEM CONSIDERATIONS

CONTENTS

1. INTRODUCTION

Over the past two decades, the scope of management of many fisheries worldwide has broadened to take into account the impacts of fishing on non-target species in particular, and the ecosystem generally. This ecosystem approach to fisheries management (EAFM) is important for maintaining the integrity and productivity of ecosystems while maximizing the utilization of commercially-important fisheries resources, but also ecosystem services that provide social, cultural and economic benefits to human society.

EAFM was first formalized in the 1995 FAO *Code of Conduct for Responsible Fisheries*, which stipulates that "*States and users of living aquatic resources should conserve aquatic ecosystems*" and that "*management measures should not only ensure the conservation of target species, but also of species belonging to the same ecosystem or associated with or dependent upon the target species*". In 2001, the Reykjavik

Declaration on Responsible Fisheries in the Marine Ecosystem elaborated these principles with a commitment to incorporate an ecosystem approach into fisheries management.

The IATTC's Antigua Convention, which entered into force in 2010, is consistent with these instruments and principles. Article VII (f) establishes that one of the functions of the IATTC is to "*adopt, as necessary, conservation and management measures and recommendations for species belonging to the same ecosystem and that are affected by fishing for, or dependent on or associated with, the fish stocks covered by this Convention, with a view to maintaining or restoring populations of such species above levels at which their reproduction may become seriously threatened*". Prior to that, the 1999 Agreement on the International Dolphin Conservation Program (AIDCP) introduced ecosystem considerations into the management of the tuna fisheries in the EPO. Consequently, for over twenty years the IATTC has been aware of ecosystem issues, and has moved towards EAFM in many of its management decisions (e.g., SAC-10 INF-B; Juan-Jorda et al. 2018). Within the framework of the Strategic Science Plan (SSP), the IATTC staff is conducting novel and innovative ecological research aimed at obtaining the data and developing the tools required to implement EAFM in the tuna fisheries of the EPO. Current and planned ecosystem-related activities by the staff is summarized in the SSP (IATTC-93-06a; SAC-14-01a) and the Staff Activities and Research report (SAC-14-01b).

Determining the ecological sustainability of EPO tuna fisheries is a significant challenge, given the wide range of species with differing life histories with which those fisheries interact. While relatively good information is available for catches of tunas and billfishes across the entire fishery, this is not the case for most non-target (i.e. "bycatch") species, especially those that are discarded at sea or have low economic value (see section 2 and IATTC Special Report 25). Furthermore, environmental processes that operate on a variety of time and spatial scales (e.g., El Niño-Southern Oscillation, Pacific Decadal Oscillation, ocean warming, anoxia and acidification) can influence the abundance and horizontal and vertical distribution of species to different degrees, which in turn affects their potential to interact with tuna fisheries.

Biological reference points, based on estimates of fishing mortality, spawning stock biomass, recruitment, and other biological parameters, have been used for traditional single-species management of target species, but the reliable catch and/or biological data required for determining such reference points, or alternative performance measures, are unavailable for most bycatch species. Similarly, given the complexity of marine ecosystems, there is no single indicator that can holistically represent their structure and internal dynamics and thus be used to monitor and detect the impacts of fishing and the environment.

The staff has presented an *Ecosystem Considerations* report since 2003, but in recent years this report has continued to evolve in content, structure, and purpose. Its primary purpose is to complement the annual report on the fishery (SAC-14-03) with information on non-target species and on the effect of the fishery on the ecosystem, and to describe how ecosystem research can contribute to management advice and the decision-making process. It also describes some important recent advances in research related to assessing ecological impacts of fishing and the environment on the EPO ecosystem and its associated species.

2. DATA SOURCES

In this report, estimated total catches of bycatch species were obtained from observer data for the large-vessel purse-seine fishery[1], nominal catches reported by the limited observer coverage onboard the small-vessel purse-seine fishery[2], and gross annual removals by the longline fishery were obtained from annual summary reports (TASK I data, see SAC-12-09, WSDAT-01-01) submitted to the IATTC by CPCs. Minimum catches in 2021 reported by observers on longline vessels are also included as an interim measure until observer coverage increases to at least 20% that may allow total annual catches for some bycatch species

[1] Size class 6 purse-seine vessels with a carrying capacity > 363 t

[2] Vessels with a carrying capacity ≤363 t

to be reliably estimated. Currently, observer coverage for some CPCs is about or less than the mandated 5% and are not considered by staff to be representative of the activities of their longline fleets (see section 2.2. below and BYC-10 INF-D). Additionally, a previously undetected error in longline observer data submitted to the IATTC resulted in over-reporting of sharks and large fishes published in SAC-13-10. These values were corrected in April 2023 (see SAC-13-10_CORR), and the data quality control procedures were modified to catch a possible repeat of this issue. Longline data were available through 2021 as the deadline for data reporting for the previous year occurs after the annual SAC meeting (see Resolutions C-03-05; C-19-08). However, some CPCs have temporarily suspended their longline observer programs due to the COVID-19 pandemic and these have not resumed to date. Therefore, 2021 data from these programs is not available. Purse-seine data were available through 2022, with data from the last 2 years considered preliminary as of March 2023. Each data source and associated data gaps is described in detail below. Additional information on bycatch data available by fishery can be found in documents SAC-07-INF-C(d) and SAC-12-09.

2.1. Purse-seine

Data from the purse-seine fishery is compiled from 3 data sources: 1) IATTC and National Program observer data, 2) vessel logbook data extracted by staff at the Commission's field offices in Latin American tuna ports, and 3) cannery data. The observer data from the large-vessel (Class 6) fishery are the most comprehensive in terms of bycatch species, since the 1992 Agreement on the Conservation of Dolphins (the La Jolla Agreement) has required an observer be placed on all trips for Class- 6 vssels since 1993. An historical perspective of bycatch data collection from the observer programs was recently published and is described in IATTC Special Report 25. Observers of the IATTC and the various National Programs provide detailed bycatch data by species, catch, disposition and effort for the exact fishing position (i.e., the latitude and longitude of the purse-seine set). Both the fisher-completed logbook and cannery datasets contain very limited data on bycatch species as reporting is primarily focused on commercially important tuna species. The logbook data, like the observer data, includes the exact fishing position, but limited effort data are recorded with only one entry per day, regardless of the number of sets made. The cannery (or "unloading") data do not have an exact fishing position but rather a broad geographic region where fish were caught (e.g., the eastern Pacific or western Pacific Ocean). These data contain bycatch species only if they were retained in a purse-seine well during the fishing operation.

Smaller (Class 1-5) purse-seine vessels are not systematically required to carry observers, except under specific circumstances (e.g., certification purposes, fishing during closure periods). The primary sources of unobserved data are logbook records, cannery unloading records, and port sampling by IATTC field office staff, all of which focus on tuna species. The FAD form, a logbook designed in late 2018 to be used by skippers of small vessels fishing on FADs, is also a source of unobserved data for tunas and sensitive species groups, but bycatch data is currently of little use for the purposes of this report as data are aggregated into broad taxonomic groups and data quality is uncertain. As such, there is limited information recorded on interactions with bycatch species by smaller vessels. In recent years there has been an increase in the number of smaller vessels that have carried observers. This is due to AIDCP requirements for fishing during closure periods for Class 6 purse-seine vessels, a desire for dolphin-safe fishery certification, an IATTC pilot project trialing the efficacy of electronic monitoring methodologies (SAC-11-11), and a voluntary observer program for smaller vessels established by the Tuna Conservation Group (TUNACONS)–a consortium of Ecuadorian tuna fishing companies–that began in 2018. The minimum observer-derived catch reported by observers for bycatch species by small vessel trips are included in this report (Table J-8) to provide the basic information currently available for this fishery, with a view to expanding reporting on this fishery as data provision is hoped to improve in future. In 2022, most trips (66%) made by smaller vessels were unobserved, 27% were from the voluntary TUNACONS observer program, 5% from the Ecuadorian National Observer program, 2% from the IATTC observer program and 1% from the Colombian National Observer program.

Therefore, in this report we primarily focus on the comprehensive observer dataset from large purse-seine vessels to provide catch estimates for bycatch species. The bycatch data provided by the observers is used to estimate total catches, by set type (i.e., floating objects (OBJ), unassociated tunas (NOA), and dolphins (DEL))[3]. The numbers of sets of each type made in the EPO during 2007–2022 are shown in Table A-7 of Document SAC-14-03.

Despite the observer requirement on all Class-6 trips, some sets are known to have taken place, based on logbooks and other sources, but were not observed. For example, at the start of bycatch data collection in 1993, about 46% of sets were observed, increasing to 70% in 1994. From 1994 to 2008, the average percent of sets observed was around 80%. From 2009 onwards, nearly 100% of sets were observed. Catch-per-day data for both target and non-target bycatch species are extrapolated[3] to account for such instances.

2.2. Longline

The considerable variability in reporting formats of longline data has hindered the staff's ability to estimate EPO-wide catches for bycatch species (SAC-08-07b, SAC-08-07d, SAC-08-07e, BYC-10 INF-D). Bycatch data for longline fisheries reported here were obtained using data of gross annual removals estimated by each CPC and reported to the IATTC in summarized form annually (i.e., termed "TASK I" data). Because there is uncertainty in whether the IATTC is receiving all bycatch data from the longline fishery of each CPC and considerable variability has been observed in the reported data by taxa, these data are considered incomplete, or 'sample data', and are therefore regarded as minimum annual reported catch estimates for 1993–2021. A staff-wide collaboration is underway to update the data provision Resolution C-03-05 to improve the quality of data collection, reporting, and analysis to align with IATTC's responsibilities set forth in the Antigua Convention and the SSP (SAC-12-09). A preliminary objective of this work is to initiate a series of collaborative workshops between the staff and CPCs to assess the feasibility of collecting desirable data types and develop data collection templates for each gear type, with clear standards and procedures for data submission that will explicitly include interactions with bycatch species. The first workshop in the series—focused on the industrial longline fishery—was held by videoconference on 09-10 January 2023 and garnered nearly 100 participants. A background document detailing the need for improving longline data, along with case examples, and staff recommendations was prepared by the staff (WSDAT-01-01); a series of presentations on this document, as well as a presentation by an invited speaker, were discussed during the workshop. Staff recommendations for updating Resolution C-03-05, pertaining to industrial longline data, were further revised based on input from workshop participants and consultations with individual CPCs (see SAC-14-14). The workshop report has also been posted to the IATTC website (WSDAT-01-RPT).

As part of the data-review process for gathering information on data reported to the IATTC under Resolution C-03-05, the staff were able to determine that the longline catches of sharks, reported by CPCs

[3] The observed data is aggregated by species, year, flag and set type. The number of known unobserved sets is taken from logbooks and other sources. Additionally, there are known EPO trips for which the staff do not know the number and type of sets made. Therefore, known bycatch-per-day from observer data is calculated by species, year, flag and set type, and applied to the number of days-at-sea for each trip to estimate the bycatch.
In some instances, there may be unobserved sets or days-at-sea data by a flag that have no equivalent observer data for that year to facilitate a reliable estimation of catch. For these trips, yearly data from a proxy flag is used. The proxy flag is determined by subsequent 5 trips made by the vessel where an observer was onboard, and adopting the predominant flag used for those trips as the proxy flag. Then the bycatch-per-set or day of the known proxy flag for the year in question is applied to the data for the unrepresented flag.

were several times higher than previously reported catches for the longline fishery. A review of the data revealed that a high proportion of shark catches were assigned to "other gears" in the annual Fishery Status Reports since 2006 but were in fact taken by longline by coastal CPCs. Therefore, the resulting transfer of catch data from "other gears" to "longline" significantly increased the longline catches of sharks from 2006 onwards (see Table A2c in SAC-11-03).

Longline observer data reporting for longline vessels >20 m has been improving since Resolution C-19-08 was adopted in 2019, updating the previous longline observer measure, C-11-08. The staff has received detailed set-by-set operational level observer data for several CPCs, although the level of observer coverage achieved by some CPCs has been less than the current mandated coverage of 5% of effort measured as either the total number of hooks or "effective days fishing" (see e.g., SAC-14 INF-B). This was further exacerbated by the challenges many CPCs had in placing observers during the COVID19 pandemic, which continued to impact at least one longline observer program in 2022. And while some challenges in meeting the 5% requirement persist, the IATTC staff, the Working Group on Bycatch and the Scientific Advisory Committee have recommended that the longline observer coverage requirement should be increased to at least 20%. IATTC staff discussed the insufficieny of 5% coverage, as well as concerns about whether the existing observer coverage is representative of the activities of longline fleets in the EPO in BYC-10 INF-D. Although CPCs have made a tremendous effort in improving their reporting of longline observer data, results from the analysis showed that 5% observer coverage is insufficient for estimating the total catch of the relatively data-rich yellowfin and bigeye tunas, and so catch estimates for bycatch species are likely to be less reliable given that less data are available for these species. Additionally, the COVID-19 pandemic has in some cases hindered progress in the reporting of longline observer data. The challenges to observer placement and reporting of observer data necessarily implies that the datasets presented in this report are provided for transparency and show only minimum estimates of interactions and mortalities submitted to the IATTC. IATTC staff will seek to provide fleet estimates of longline catches in the EPO based on observer data in the future, but the results of the aforementioned analyses highlight a clear need for data reporting of bycatch species to improve (see SAC-12-09, WSDAT-01-01) prior to data expansion attempts.

3. FISHERY INTERACTIONS WITH SPECIES GROUPS

3.1. Tunas and billfishes

Data on catches of the principal species of tunas and bonitos of the genera *Thunnus*, *Katsuwonis*, *Euthynnus*, and *Sarda*, and of billfishes in the Istiophoridae and Xiphiidae families, are reported in Document SAC-14-03. An investigation on the effects of the COVID-19 pandemic on the catches of tropical tunas is provided in SAC-14 INF-D. The staff has developed stock assessments and/or stock status indicators (SSIs) for tropical tunas (SAC-14-04), exploratory analyses for bigeye (SAC-14-05) and yellowfin (SAC-14-06) tunas, and skipjack tuna assessment (SAC-14-08), proposed target and limit reference points for skipjack (SAC-14-09), and developed a fisheries independent abundance index for skipjack using echosounder buoy data for the OBJ fishery (e.g., FAD-06-03, FAD-07-03), which was included in the interim skipjack assessment (SAC-13-07). The staff has also collaborated in the assessments of Pacific bluefin and albacore tunas led by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), the assessment of south Pacific albacore tuna led by the Western and Central Pacific Fisheries Commission (WCPFC), and collaborated on the ISC assessments for north Pacific swordfish (2018), blue marlin (2021), striped marlin (2019) and shortfin mako (2022–2023). A southern EPO swordfish benchmark assessment is provided in SAC-14-15.

3.2. Marine mammals

Marine mammals, especially spotted dolphins (*Stenella attenuata*), spinner dolphins (*S. longirostris*), and common dolphins (*Delphinus delphis*), are frequently associated with yellowfin tuna in the EPO. Purse-seine fishers commonly set their nets around herds of dolphins and the associated yellowfin tuna, and then release the dolphins while retaining the tunas. The incidental mortality of dolphins was high during the early years of the fishery, but declined dramatically in the early 1990s, and has remained at low levels thereafter (AIDCP-43-02; Figure J-1). The IATTC staff is collaborating on two research projects on dolphins focused on improving current understanding of the potential impacts of tuna fisheries on dolphin populations (SAC-14 INF-K), including a cow-calf separation study and an abundance survey.

Estimates of incidental mortality of dolphins in the purse-seine fishery of large vessels during 1993–2022 are shown in Table J-1a. In 2022, the stock of dolphins with the highest incidental mortality was the whitebelly spinner (n=300), followed by the eastern spinner (n=271), the western-southern spotted (n=197), and northeastern spotted dolphins (n=147). Common dolphins were least impacted by the fishery, with mortalities of 2 central, 20 southern, and 23 northern common dolphins. The staff plans to analyze available reported and observed marine mammal interaction data for the purse-seine fisheries in the near future.

In recent years significant improvements have been made to the minimum data standards of longline observer data submitted to the IATTC, which now require submission of operational level data under Resolution C-19-08. However, as discussed in section 2.2 the low level of observer coverage (at least 5%) currently mandated for these vessels is not representative of the different fleet components and hinders the extrapolation of observed data to generate fleet totals (see BYC-10 INF-D). For the time being, only the minimum number of observed interactions and mortalities reported for marine mammals is presented for 2021 (Table J-1b). Interactions and mortalities were defined by subjective classification of fate (injured, released, or not reported) and release condition (alive and healthy or not reported) as recorded by observers. Dispositions not reported were precautionarily assumed to represent mortalities. Under these assumptions, all 11 marine mammals reported by observers in 2021 were considered to be mortalities. The staff reiterates that the level of observer coverage should be increased to at least the recommended 20% to help facilitate expansion of the number of interactions and mortalities to the total fleet activities for marine mammals and other vulnerable bycatch species.

3.3. Sea turtles

Sea turtles are occasionally caught in the purse-seine fishery in the EPO, usually when associated with floating objects that are encircled, although they are sometimes also caught by happenstance in sets on unassociated tunas or tunas associated with dolphins. They can also become entangled in the webbing of fish-aggregating devices (FADs) or other floating objects (FAD-07-04) and drown or be injured or killed by fishing gear.

The number of estimated sea turtle mortalities and interactions recorded by observers on large purse-seine vessels, by set type, from 1993–2022 is shown in Figure J-2a and b, respectively. Interactions were defined from observer information recorded as fate on the dedicated turtle form as: entangled, released unharmed, light injuries, escaped from net, observed but not involved in the set and other/unknown, while mortalities were defined as those with fates recorded as: grave injuries, killed, or consumed. The olive Ridley turtle (*Lepidochelys olivacea*) is, by far, the species of sea turtle most frequently caught, with a total of 21,850 interactions and 951 mortalities (~4%) during 1993–2022, but only 168 interactions and no mortalities occurred in 2022 (Table J-2a). In 2022, there were 44 interactions recorded with eastern Pacific green, 28 loggerhead, 11 hawksbill, 4 leatherback, and 116 unidentified turtles and no mortalities.

In the longline fishery, sea turtles are caught when they swallow a baited hook, are accidentally hooked, or drown after becoming entangled in the mainline, floatlines or branchlines and cannot reach the surface to breathe. They are also caught in coastal pelagic and bottom-set gillnet fisheries, where they become enmeshed in the net or entangled in the floatlines or headrope. Although very few data are available on incidental mortality of turtles by longline and gillnet fishing, the mortality rates in the EPO industrial longline fishery are likely to be lowest in "deep" sets (around 200–300 m) targeting bigeye tuna and albacore, and highest in "shallow" sets (<150 m) targeting swordfish. There is also a sizeable fleet of artisanal longline and gillnet fleets from coastal nations that are known to catch sea turtles, but limited data are available (see BYC-11-02).

Data on sea turtle interactions and mortalities in the longline fishery have not been available (SAC-08-07b), although they are beginning to improve with the submission of operational-level observer data since 2019 pursuant to Resolution C-19-08. Recalling the observer coverage for most longline vessels is 5% or less (see BYC-10 INF-D), compared to 100% of observed trips in the large-vessel purse-seine fishery, the observer data provided by CPCs for 2021 are considered minimum numbers of interactions and mortalities (Table J-2b) that have been reported to the IATTC (see section 2.2). Here interactions and mortalities were defined by fate (discarded, injured, grave injuries, released, released with hook, or not reported) and/or release condition (alive and healthy, alive and injured, dead, unknown, or not reported) as recorded by observers. Only 8 interactions of sea turtles (5 olive Ridley turtles and 3 loggerhead turtles) were reported for 2021 and these all resulted in mortalities. The staff hopes to use the new operational observer data submissions required under C-19-08 to report the first total longline fleet catch estimate for sea turtle species in the future, although BYC-10 INF-D cautions that the current 5% observer coverage is insufficient for producing reliable estimates of total catch.

Various IATTC resolutions, most recently C-19-04, have been intended to mitigate fishing impacts on sea turtles and establish safe handling and release procedures for sea turtles caught by purse-seine and longline gears. Additionally, a "circle hook" workshop was held prior to the 13th SAC meeting to discuss a) the effects of different sizes of circle hooks on mitigating bycatch of sea turtles and other vulnerable species in the longline fishery and b) the minimum hook size to satisfy the requirements outlined in Resolution C-19-04. The workshop participants discussed the use of different circle hooks in longline fisheries to satisfy C-19-04, with minimum width of the hook defined on a fishery-specific basis and dependent upon the target species. However, no definitive conclusions or recommendation were made (WSHKS-01), although discussions on this topic resumed during the 11th Bycatch Working Group meeting, in May 2022 and are expected to continue at the 1st Ecosystem and Bycatch Working Group meeting in May 2023.

A preliminary vulnerability assessment was conducted in collaboration with the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) for the eastern Pacific stock of leatherback turtles for 2018, using the Ecological Assessment of Sustainable Impacts of Fisheries (EASI-Fish) approach (see section 5) (BYC-10 INF-B). The vulnerability status of the stock was determined to be "most vulnerable" in 2018. The staff continued to collaborate with IAC in 2020–2023 to improve the species distribution model (BYC-11-01) and vulnerability assessment using updated fisheries data from coastal CPCs (BYC-11-02). The final assessment showed that the vulnerability status of the stock remained as "most vulnerable" in 2019. Modelling of 70 management scenarios showed that the implementation of improved handling and release practices by industrial and artisanal fleets, or use of circle hooks, or use of fish bait by longline fleets could reduce at-vessel and/or post-release mortality to an extent where the vulnerability status of the population could improve to "least vulnerable", assuming fishing effort levels of all EPO fisheries do not increase. The use of these three measures in concert was predicted to reduce vulnerability even further. Detailed results from this work were presented in 2022 at the Bycatch Working Group meeting (BYC-11-01, BYC-11-02) and will be presented at the Ecosystem and Bycatch Working Group of ICCAT in May 2023 as an example of successful collaboration between organizations.

3.4. Seabirds

There are approximately 100 species of seabirds in the tropical EPO. Some of them associate with epipelagic predators, such as fishes (especially tunas) and marine mammals, near the ocean surface; for some, feeding opportunities are dependent on the presence of tuna schools feeding near the surface. Some seabirds, especially albatrosses and petrels, are caught on baited hooks in pelagic longline fisheries.

The IATTC has adopted one resolution on seabirds (C-11-02); also, the Agreement on the Conservation of Albatrosses and Petrels (ACAP) and BirdLife International have updated their maps of seabird distribution in the EPO, and have recommended guidelines for seabird identification, reporting, handling, and mitigation measures (SAC-05 INF-E, SAC-07-INF-C(d), SAC-08-INF-D(a), SAC-08-INF-D(b), BYC-08 INF J(b)). Additionally, ACAP has reported on the conservation status of albatrosses and large petrels (SAC-08-INF-D(c); BYC-08 INF J(a)). Guidelines on fisheries electronic monitoring systems have also been reported by ACAP. Participants in the circle hook workshop, held in March 2022 (WSHKS-01), discussed the influence of circle hooks on seabird capture and mortality. The available data seem to be inconclusive to comment on any conservation value of circle hooks over other hook shapes or sizes to seabirds given a lack of empirical studies.

As with sea turtles, data on seabird interactions and mortalities in the longline fishery have been unavailable (SAC-08-07b), but with the submission of operational-level observer data for longline vessels >20 m beginning in 2019 some minimum estimates for 2021 are available for reporting (Table J-3) (but see section 2.2 for uncertainties and data gaps in reported data).

The observer data submitted by CPCs for 2021 contained 340 interactions with seabirds—all recorded as "discarded" or precautionarily presumed dead due to incomplete disposition data. With these limited data, the white-chinned petrel, *Procellaria aequinoctialis*, was reported to have interacted the most with the gear (n=63; 19% of all interactions), followed by the wandering albatross, *Diomedea exulans* (n=58; 17%), and the black-browed albatross, *Thalassarche melanophrys* (n=53; 16%). The staff hopes to report the first total longline fleet catch estimate for seabird species in the future using the operational observer data as improvements in data collection continue—but see BYC-10 INF-D for a discussion on the current inadequacy of longline observer data for expanding data to the activities of the longline fleet to provide estimates of total catch.

3.5. Sharks

Sharks are caught as bycatch in EPO tuna purse-seine fisheries and as either bycatch or a target in longline and multi-species and multi-gear fisheries of the coastal nations.

Stock assessments or stock status indicators (SSIs) are available for only 4 shark species in the EPO: silky (*Carcharhinus falciformis*) (Lennert-Cody *et al*. 2018; BYC-10 INF-A, BYC-11 INF-A, EBWG-01 INF-A), blue (*Prionace glauca*) (ISC Shark Working Group), shortfin mako (*Isurus oxyrinchus*) (ISC Shark Working Group), and common thresher (*Alopias vulpinus*) (NMFS). As part of the FAO Common Oceans Tuna Project, Pacific-wide assessments of the porbeagle shark (*Lamna nasus*) in the southern hemisphere (Clarke 2017) and the bigeye thresher shark (*Alopias superciliosus*) (Fu *et al*. 2018) were completed in 2017, and for the silky shark (Clarke 2018a) in 2018, as well as a risk assessment for the Indo-Pacific whale shark population (Clarke 2018b) also in 2018. Whale shark interactions with the tuna purse-seine fishery in the EPO are summarized in document BYC-08 INF-A. The impacts of tuna fisheries on the stocks of other shark species, not previously mentioned, in the EPO are unknown.

The first quantitative vulnerability assessment of sharks for EPO industrial and artisanal fisheries—using the EASI-Fish methodology (section 5)—was completed in 2022 and was presented at SAC-13 (SAC-13-11). Briefly, a total of 49 shark species were recorded to interact with EPO tuna fisheries, of which 32 species were formally assessed using EASI-Fish for 2019. Overall, 20 species were classified as "most vulnerable", including hammerhead sharks (4 species), requiem sharks (10 species), threshers (*Alopias superciliosus* and *A. pelagicus*), mesopelagic sharks (3 species) and the commercially important blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*). The remaining 12 species were classified as "least vulnerable" (9 species) or "increasingly vulnerable" (3 species). The report recommended further analysis to explore a range of potential hypothetical conservation and management measures (CMMs) that may be implemented—in isolation or in combination—within the EPO to reduce fishery impacts on particularly vulnerable shark species identified, including silky, thresher and hammerhead sharks. The EASI-Fish approach was applied to silky shark and hammerhead sharks during 2022–2023 to determine the relative benefits of alternative management scenarios on species' vulnerability (SAC-14-12).

Catches (t) of sharks in the large-vessel purse-seine fishery (1993–2022) and minimum reported catch estimates[4] by longline fisheries (1993–2021) are provided in Table J-4a, while catches of the most frequently caught species, discussed below, are shown in Figure J-3a. Reporting of many shark species by longline gear began in 2006 (but see section 2 for data gaps, including high variability in this dataset). The majority of the shark catch is from floating object sets. The silky shark (family Carcharhinidae) is the species of shark most commonly caught in the purse-seine fishery with annual catches averaging 557 t—primarily from sets on floating objects (Figure J-3a)—and being 645 t in 2022. In contrast, minimum reported annual catch in the longline sample data for 2006–2021 averaged 10,683 t while only 12 t were reported in 2021. Annual catch for the oceanic whitetip shark (Carcharhinidae) in the purse-seine fishery averaged 56 t (also primarily from sets on floating objects) and was 12 t in 2022. The minimum reported annual catch in the longline fishery from 2006–2018 averaged 165 t and none were reported in 2019–2021. Catches of oceanic whitetip have declined in the purse-seine fishery since the early 2000s, while minimum reported catches have been variable in the longline fishery (Figure J-3). Minimum annual reported catch of blue shark in the longline fishery from 1993–2021 averaged 6,220 t and was 8,323 t in 2021. By contrast, the annual catch in the purse-seine fishery averaged only 2 t, with 1 t caught in 2022. Anomalies in the reporting of longline data are likely related to the COVID-19 pandemic, although it's important to note the reporting of bycatch data is not compulsory according to the data provision resolution (C-03-05) and the corresponding memorandum of technical guidelines (see SAC-12-09, WSDAT-01-01) which contributes to the variability.

Other important species of sharks caught in the purse-seine and longline fisheries include the smooth hammerhead (*Sphyrna zygaena*), the pelagic thresher (*Alopias pelagicus*), and mako sharks (*Isurus* spp.) (Table J-4a, Figure J-3a). Catch estimates for the smooth hammerhead shark in the purse-seine fishery averaged 26 t (primarily caught in floating-object sets) and was 12 t in 2022, while in the longline fishery minimum annual reported catch averaged 900 t (2006–2021) and was 37 t in 2021. In contrast, the pelagic thresher was caught primarily in unassociated tuna school sets in the purse-seine fishery with the estimated annual catch averaging 4 t and was 1 t in 2022. Minimum annual reported catch of the pelagic thresher in the longline fishery averaged 1,928 t (2007–2021) and only 1 t was reported in 2021. Catch estimates for the mako sharks in the purse-seine fishery were lower than the aforementioned shark species averaging 3 t and was 2 t in 2022. However, in the longline fishery the minimum annual reported catch averaged 1,436 t (1993–2021) and was 1,399 t in 2021.

Complementary to the shark catches presented in Figure J-3a and similar to the purse-seine based SSIs reported by set type for the tropical tunas (SAC-14-04), catch by set type was scaled so that their average equals 1 during the 1993–2022 time period (i.e., the start of bycatch data collection) for 3 species of sharks with the highest annual nominal catches by large purse-seine vessels (i.e., silky shark, oceanic whitetip shark and smooth hammerhead shark). This relative catch in weight (t), which helps to better understand anomalies in species catch, is presented in Figure J-3b. In the earlier years (pre-2000), the silky shark relative catch was 3–3.5 times greater than the mean for those caught in dolphin sets, and about 4.5 times greater than the mean (1993) for those caught in unassociated sets, while relative catches were less variable in the floating-object set fishery. For the oceanic white tip shark, a decreasing trend in relative

[4] Sharks caught by longline vessels are recorded using different weight metrics (e.g., round, trunk or whole weight) and thus, total annual reported catch estimates may contain a mix of these weight metrics. The staff is working on harmonizing shark data collection to improve the reliability of total catch estimates (e.g., SAC-11-13).

catches was observed for all set types with the greatest relative catches occurring prior to 2000. The relative catches of smooth hammerhead sharks were variable in all set types with relative catches about 5 times greater than the mean in unassociated sets in 2004.

The spatial distribution by 5°x5° grid cells of the catch of the same 3 shark species by set type for the large-vessel purse-seine fishery is presented in Figure J-4b to provide an indication of current (i.e., 2022) and past (average of the last 5 years; 2017–2021) spatial catch dynamics. Catches of silky shark were widely distributed across the EPO, occurred primarily in floating-object sets and were slightly greater in 2022 compared to the 5-year average between the equator and 10°N. Catches of oceanic whitetip shark and smooth hammerhead shark were minimal in both time periods (i.e., primarily <1 t) and the distribution was limited in 2022 compared to the 5-year average (floating-object sets only). Minimal catches of oceanic whitetip were observed around the equator and west of 140°W in 2022 with no catches > 1 t in the 5-year average. For the smooth hammerhead shark, minimal catches were observed east of 100°W in 2022 while only 1 location (10°S and 90°W) had catches slightly >1 t during the 5-year average.

The limited observer data from small purse-seine vessels showed 29 t of silky shark and 4 t of scalloped hammerhead were caught in floating-object sets in 2022, while those of other shark species or species groups were minimal (≤2 t) (Table J-8).

The minimum catches—derived only from observer data—for sharks caught by longline in 2021 are presented in Table J-4b (see section 2.2 and BYC-10 INF-D for uncertainties and data gaps in longline data). Blue shark was by far the most frequently caught shark species in this dataset with over 11,000 animals reported to have interacted with the gear in 2021, followed by the shortfin mako shark with nearly 1,000 animals. Under the disposition criteria described in Table J-4b, nearly all interactions resulted in mortalities for most of the shark species and species groups reported by observers.

The artisanal longline fisheries of the coastal CPCs seasonally target sharks, tunas, billfishes and dorado (*Coryphaena hippurus*), and some of these vessels are similar to industrial longline fisheries in that they operate in areas beyond national jurisdictions (Martínez-Ortiz *et al.* 2015). However, essential shark data from these longline fisheries are often lacking, and therefore conventional stock assessments and/or stock status indicators cannot be produced (see data challenges outlined in SAC-07-06b(iii)).

Since 2014, the IATTC staff has carried out extensive collaborative research with Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (OSPESCA) and IATTC's Central American CPCs to develop a robust sampling methodology to improve data collection for shark fisheries in Central American EPO states. After approximately 7 years (2015–2021), this work—funded by the Food and Agriculture Organization of the United Nations (FAO) and the Global Environmental Facility (GEF) under the framework of the ABNJ Common Oceans program, the IATTC capacity building fund, and the European Union—was completed in December 2021. The project's final results will be presented at SAC-14 (SAC-14 INF-L), but there is a great need to maintain continuity of data collection to generate key fisheries data to assess and manage shark species in the EPO. Meanwhile, a second phase of the FAO-GEG ABNJ project is underway and the IATTC is receiving support to expand the previous work conducted in Central America to other EPO coastal States (SAC-14 INF-M). Data obtained from these projects may be included in future iterations of this report to provide improved catch estimates, albeit minimum estimates, for sharks by the various longline, gillnet and mixed gear fleets.

3.6. RAYS

To better represent estimated annual catches of manta rays (Mobulidae) and stingrays (Dasyatidae), these animals are now reported in numbers of individuals by the large-vessel purse-seine fishery (1993–2022) in Table J-5a, while catches of key species are shown in Figure J-4a. Rays have rarely been reported in the annual summary reports for the longline fishery, although data have been available in the more recently obtained observer data (see Table J-5b). The largest average catches in the purse-seine fishery were observed for unidentified mobulid rays (Mobulidae spp., average 1993–2022: 1,231 individuals; number of individuals in 2022: 246), followed by the pelagic stingray (average: 885; 2022: 684), the smoothtail manta (average: 348; 2022: 103), the spinetail manta (average: 249; 2022: 74), unidentified stingrays (Dasyatidae spp., average: 214; 50) and the giant manta ray (average: 119; 2022: 11 individuals). Although catches of these rays can be variable by set type, they have been highest in unassociated sets, followed by dolphin sets, and lowest in floating-object sets (Figure J-4a).

Similar to the sharks, relative catches of rays in numbers of individuals (i.e., scaled catch with the average equal to 1) by set type for large purse-seine vessels is provided in Figure J-4b. As with the reported observed catch (Figure J-4a), ray relative catches were highly variable with no apparent trends, and peaks of relatively high catches were not consistent between species and set type. The spatial distribution of catches (5°x5° grid cell) was greatest for pelagic stingray with most catches occurring in floating-object sets east of 120°W for 2022 and the 5-year average (2017–2021) (Figure J-4c). Catches from unassociated sets occurred coastally off Baja California and South America, while catches from dolphin sets primarily occurred north of the equator. Minimal catches of the spinetail manta, smoothtail manta and giant manta were observed across space and time with most catches <5 individuals per spatial area.

For the small purse-seine vessel fishery, the limited available observer data for 2022 was minimal with the largest number of individuals caught in floating-object sets corresponding to the pelagic stingray (n=36), followed by the spinetail manta (n=18), the smoothtail manta (n=11) and unidentified manta rays (Mobulidae spp., n=10), while the number of other rays were <10 (Table J-8).

The minimal data available from the reported longline observer dataset for 2021 (see section 2.2. for data gaps and BYC-10 INF-D) showed that the most interactions were with the pelagic stingray (*Pteroplatytrygon violacea*) and 95% of these interactions (3,909 individuals) resulted in mortalities (3,703) (Table J-5b).

The vulnerability status and efficacy of potential conservation and management measures (CMMs) for the spinetail devil ray (*Mobula mobular*) impacted by industrial purse-seine and longline fisheries in the EPO was determined using the EASI-Fish methodology (section 5). In the assessment year of 2018, the estimated fishing mortality exceeded the $F_{/F4}$0% and SBR/S_{BR4}0% biological reference point, leading to a vulnerability status classification of "most vulnerable". A retrospective analysis of vulnerability from 1979–2018 showed the species to be classified as "least vulnerable" between 1979 and 1993, but became "most vulnerable" from 1994, which coincided with the rapid spatial expansion of the industrial purse-seine fishery. Vulnerability increased significantly from 2011 following the rapid increase in the number of purse-seine sets made on floating objects to 2018. Simulating the CMMs in place in 2018 for EPO tuna fisheries (i.e., an EPO-wide closure) and for mobulids specifically (i.e., use of best handling and release practices under C-15-04) resulted in 31 of the 45 scenarios changing the classification of the species from "most vulnerable" to "least vulnerable", which primarily involved a reduction of post-capture mortality by as little as 20%. Implementing appropriate best handling and release practices can be a reasonably simple, rapid and cost-effective conservation measure, but a recommendation from the work was to extend the EASI-Fish analysis to all species of mobulids impacted by EPO tuna fisheries, improve estimates of post-release mortality for these species through dedicated tagging studies, and improve species-specific catch reporting, especially in artisanal fisheries, to improve the reliability of outputs from EASI-Fish assessments.

3.7. Other large fishes

Species composition varies between purse-seine and longline fisheries. Large pelagic fishes caught by the large-vessel purse-seine, primarily on floating-object sets, (1993–2022) and longline (1993–2021) fisheries are shown in Table J-6a, with time series of catches of key species presented in Figure J-5. The most commonly-caught pelagic fishes in both fisheries is dorado (Coryphaenidae) with the estimated average annual catch for the purse-seine fishery being 1,356 t (2,334 t in 2022) and the minimum reported annual catch for the longline fishery averaging 5,812 t (1,413 t in 2021). Dorado is also one of the most important species caught in the artisanal fisheries of the coastal nations of the EPO (SAC-07-06a(i)). Recommendations for potential reference points and harvest control rules for dorado in the EPO were presented at SAC-10 (SAC-10-11).

Other key species caught by the purse-seine fishery include wahoo (Scombridae) and rainbow runner (Carangidae). Wahoo had an estimated average annual catch of 362 t for the purse-seine fishery, although catches have declined from a peak of 1,025 t in 2001 to 164 t in 2022 (Figure J-5). Minimum reported annual catch of wahoo by the longline fishery have averaged 170 t and was 211 t in 2021. No catches of rainbow runner have been reported by the longline fishery. However, in the purse-seine fishery, estimated average annual catches of rainbow runner were 47 t, with the peak catch in 2007 at 158 t and declining thereafter to 36 t in 2022 (Figure J-5).

Pelagic fishes commonly reported by the longline fishery include opah (Lampridae), snake mackerels (Gempylidae) and pomfrets (Bramidae). Minimum reported annual catches for these species averaged 369 t (1993–2021), 369 t (2006–2021), and 53 t (1993–2021), respectively. Catches of all these taxa have increased after the mid-2000s (Figure J-5) but note the uncertainty and data gaps in this dataset (section 2.2). For the most recent year (2021), there were 449 t, 277 t, and 50 t of opah, snake mackerels, and pomfrets reported, respectively (Table J-5a).

The limited observer data available for 2022 for the small purse-seine fishery included 289 t of dorado and 26 t of wahoo caught in floating-object sets, while the remaining species or species groups of large fishes had ≤2 t reported (Table J-8).

For 2021, the minimal available data from longline observers (see section 2.2. and BYC-10 INF-D) is provided in Table J-6b and shows the most frequently caught species in this dataset was the long snouted lancetfish (*Alepisaurus ferox*) with about 11,000 interactions. Most interactions with large fishes resulted in mortalities.

3.8. Forage species

A large number of taxa occupying the middle trophic levels in the EPO ecosystem—generically referred to as “forage” species—play a key role in providing a trophic link between primary producers at the base of the food web and the upper-trophic-level predators, such as tunas and billfishes. Some small forage fishes are incidentally caught in the EPO by purse-seine vessels on the high seas, mostly in sets on floating objects, and by coastal artisanal fisheries, but are generally discarded at sea. Catches of these species are presented in Table J-7 with key species as identified by catch data presented in Figure J-6 for the large-vessel purse-seine fishery, with the majority of catches coming from floating object sets.

Bullet and frigate tunas (Scombridae) are by far the most commonly reported forage species with estimated annual catches averaging 1,021 t from 1993–2022. However, their catches have declined from 1,921 in 2005 to 699 t in 2022 (Figure J-6). Triggerfishes (Balistidae) and filefishes (Monacanthidae) are the second most commonly reported forage group with annual estimated catches averaging 262 t and totaling 545 t in 2022. Catches for this group peaked in 2004 at 922 t but have otherwise been variable. Annual catches of sea chubs (Kyphosidae) have averaged 17 t, and have remained minimal with 22 t in 2022. Lastly, annual catches of the various species in the category ‘epipelagic forage fishes’ averaged 7 t with 15 t estimated to be caught in 2022. A total of 128 t of bullet and frigate tunas and 84 t of triggerfishes and filefishes caught in floating-object sets were reported by observers on the limited number of trips on small purse-seine vessels that carried an observer in 2022. Catches of all other species or species groups of small fishes were minimal (≤3 t) (Table J-8).

4. PHYSICAL ENVIRONMENT

Environmental conditions affect marine ecosystems, the dynamics and catchability of target and bycatch species, and the activities of fishers, and biophysical factors can have important effects on the distribution and abundance of marine species[5] (e.g., SAC-10 INF-D). The following summary of the biophysical environment covers: 1) short- and long-term environmental indicators, and 2) environmental conditions and their potential effect on the fishery during the previous year, in this case, 2022.

4.1. Environmental indicators

The ocean environment changes on a variety of time scales, from seasonal to inter-annual, decadal, and longer. Longer-term climate-induced changes, typically decadal (at intervals of 10–30 years) and characterized by relatively stable average conditions and patterns in physical and biological variables, are called "regimes". However, the dominant source of variability in the upper layers of the EPO is the El Niño-Southern Oscillation (ENSO), an irregular fluctuation involving the entire tropical Pacific Ocean and the world's atmosphere (Fiedler 2002). El Niño events occur at two- to seven-year intervals, and are characterized by weaker trade winds, deeper thermoclines, and higher sea-surface temperatures (SSTs) in the equatorial EPO. El Niño's opposite phase, commonly called La Niña, is characterized by stronger trade winds, shallower thermoclines, and lower SSTs. The changes in the biogeochemical environment caused by ENSO have an impact on the biological productivity, feeding, and reproduction of fishes, seabirds, and marine mammals (Fiedler 2002).

ENSO is thought to cause considerable variability in the availability for capture of commercially-important tunas and billfishes in the EPO (Bayliff 1989). For example, the shallow thermocline during a La Niña event can increase purse-seine catch rates for tunas by compressing the preferred thermal habitat of small tunas near the sea surface, while the deeper thermocline during an El Niño event likely could make tunas less vulnerable to capture, and thus reduce catch rates. Furthermore, warmer- or cooler-than-average SSTs can also cause the fish to move to more favorable habitats, which may also affect catch rates as fishers expend more effort on locating the fish.

Recruitment of tropical tunas in the EPO may also be affected by ENSO events. For example, strong La Niña events in 2007–2008 may have been partly responsible for the subsequent lower recruitment of bigeye tuna, while the largest recruitments corresponded to the extreme El Niño events in 1982–1983 and 1998 (SAC-09-05). Yellowfin recruitment was also low in 2007, but high during 2015–2016, after the extreme El Niño event in 2014–2016 (SAC-09-06).

The Climate Diagnostics Bulletin of the US National Weather Service reported that in 2022 anomalies—defined in the Bulletin as a departure from the monthly mean—in oceanic and atmospheric characteristics (e.g., surface and sub-surface temperatures, thermocline depth, wind, and convection) were consistent with La Niña conditions for the entire year.

Indices of variability in such conditions are commonly used to monitor the direction and magnitude of ENSO events in the Pacific Ocean. In this report, the Oceanic Niño Index (ONI), used by the US National Oceanic and Atmospheric Administration (NOAA) as the primary indicator of warm El Niño and cool La Niña conditions within the Niño 3.4 region in the east-central tropical Pacific Ocean (Dahlman 2016) (Figure J-7a), is used to characterize inter-annual variability in SST anomalies. The ONI is a measure of El Niño defined by NOAA as "a phenomenon in the equatorial Pacific Ocean characterized by a five consecutive 3-month running mean of SST anomalies in the Niño 3.4 region that is above (below) the threshold of +0.5°C (-0.5°C)." The ONI categorizes ENSO events from "extreme" to "weak" (Figure J-7b). For example, the "extreme" El Niño event in 1997–1998 was followed by a "very strong" La Niña event in 1998–2000. "Strong" La Niña events were also observed in 2007–2008 and 2010–2011. The highest ONI values (>2.5) were recorded during the 2015–2016 "extreme" El Niño event. Moderate La Niña conditions persisted

[5] See SAC-04-08, *Physical Environment*, and SAC-06 INF-C for a comprehensive description of the effects of physical and biological oceanography on tunas, prey communities, and fisheries in the EPO.

throughout 2022 with values ranging from -1.1 to -0.8 (Figure J-7b).

The Pacific Decadal Oscillation (PDO; Figure J-8) index is used to describe longer-term fluctuations in the Pacific Ocean, and has also been used to explain, for example, the influence of environmental drivers on the vulnerability of silky sharks to fisheries in the EPO (Lennert-Cody *et al.* 2018). The PDO—a long-lived El Niño-like pattern of Pacific climate variability, with events persisting 20–30 years—tracks large-scale interdecadal patterns of environmental and biotic changes, primarily in the North Pacific Ocean (Mantua 1997), with secondary patterns observed in the tropical Pacific, the opposite of ENSO (Hare and Mantua 2000). As with ENSO, PDO phases are classified as "warm" or "cool". PDO values peaked at 2.79 in August 1997 and at 2.62 in April 2016, both of which coincided with the extreme El Niño events indicated by the ONI. The PDO has been in a "cool" phase since early 2020. During 2022, cool conditions persisted with values ranging from -2.22 to -1.35 (see ERSST V5 PDO Time series data).

4.2. Spatio-temporal exploration of environmental conditions

A time series of SST and chlorophyll-a concentration (CHL-a; an indicator of primary productivity biomass) (Figure J-9) in the eastern tropical Pacific (ETP) from 5°N to 5°S—the same latitudinal band used in the ONI—was explored to show the variability in these variables across space and time using time-longitude Hovmöller diagrams. The SST time series show mean monthly values from 1993–2022, while that for CHL-a concentrations covers data for 2003–2022 due limitations with data availability. The SST plot (Figure J-9, top panel) clearly shows the extension of warmer waters during the extreme El Niño events of 1997–1998 and 2015–2016 and cooler waters during the strong La Niña events in 1999–2000, 2007–2008 and 2010–2011 across the ETP. The CHL-a plot (Figure J-9, bottom panel), although the pattern is less clear than the SST plot, shows an increase in CHL-a concentrations following the strong La Niña events particularly in 2010–2011, likely due to increases in nutrient availability.

4.3. Environmental conditions and distribution of catches

The availability of fish, and thus catches, are strongly related to environmental conditions and processes, particularly in pelagic waters (Fiedler and Lavín 2017; Chassot *et al*. 2011). ENSO conditions are influenced by many oceanic and atmospheric factors, but both SST and CHL-a levels are known to be good explanatory variables to describe and predict the habitat and distributions of oceanic animals (Hobday and Hartog 2014).

Figures J-10 and J-11 show quarterly mean SSTs and CHL-a concentrations, respectively, to: 1) provide a general indication of seasonal environmental variability for 2022, and 2) overlay the distribution of tropical tuna catches, as a first step, to illustrate the potential influence of environmental conditions on catches across the EPO during 2022. In future, the staff plans to incorporate the catch distribution of key bycatch species and develop species distribution models (SDMs) to better describe potential relationships between environment and species. In 2021–2022, SDMs were developed for the leatherback sea turtle (BYC-11-01) and 32 species of sharks (SAC-13-11) and several high-resolution SDMs are underway for other sensitive bycatch species, including oceanic whitetip, silky and hammerhead sharks.

Cooler waters occurred off northern Mexico and the southwestern United States north of 20°N and off South America, south of the equator and east of 100°W (Figure J-10). These cool waters extended westwards during quarters 1 (January–March) and 2 (April–June), and 3 (July–September) and 4 (October–December), respectively. Warmer waters developed off Central America and extended westwards during quarters 2 and 3 but retracted in quarter 4. A secondary, less intense, warm pool was observed in the southwestern EPO (10–20°S, 140°–150°W) during quarters 1 and 2.

Figure J-11 shows CHL-a concentrations were highest along the equator and the coast of the Americas year-round. The oligotrophic[6] South Pacific Gyre—located between around 20°–40°S and extending from

[6] An area of low productivity, nutrients, and surface chlorophyll, often referred to as an "oceanic desert".

150°–90°W—was present in quarter 1, slightly retracted in quarters 2 and 3, and returned in quarter 4.

During quarters 1 and 2, skipjack predominated in the catches in waters ~25°C off the coast of South America (Fig. J-10), where CHL-a concentration was high (Fig. J-11). Yellowfin tuna was the predominant tuna species in the catch primarily north of the equator during these same quarters; yellowfin catches were relatively minimal in the warmer waters (~28°–29°C) present off central America in quarter 2. During quarters 3 and 4, the tuna catches along the coast of South America decreased as cooler waters expanded throughout the region. Bigeye tuna catches mostly occurred south of 10°N with larger catches taken west of ~110°W, particularly in quarters 2 and 3. No tuna catches occurred in the oligotrophic gyre located approximately south of 20°S and the western boundary of the EPO (150°W) to about 100°W.

5. IDENTIFICATION OF SPECIES AT RISK

The primary goal of EAFM is to ensure the long-term sustainability of all species impacted—directly or indirectly—by fishing. However, this is a significant challenge for fisheries that interact with many non-target species with diverse life histories, for which reliable catch and biological data for single-species assessments are lacking. An alternative for such data-limited situations, reflected in Goal L of the SSP, are Ecological Risk Assessments (ERAs), vulnerability assessments that are designed to identify and prioritize at-risk species for data collection, research and management.

'Vulnerability' is defined as the potential for the productivity of a stock to be diminished by the direct and indirect impacts of fishing activities. The IATTC staff has applied qualitative assessments, using Productivity-Susceptibility Analysis (PSA) to estimate the relative vulnerability of data-limited, non-target species caught in the EPO by large purse-seine vessels (Duffy *et al*. 2019) and by the longline fishery (SAC-08-07d).

Because PSA is unable to quantitatively estimate the cumulative effects of multiple fisheries on data-poor bycatch species, a new approach—Ecological Assessment of Sustainable Impacts of Fisheries (EASI-Fish)—was developed by the IATTC staff in 2018 (SAC-09-12) to overcome this issue. This flexible, spatially-explicit method uses a smaller set of parameters than PSA to first produce a proxy for the fishing mortality rate (*F*) of each species, based on the 'volumetric overlap' of each fishery on the geographic distribution of these species. The estimate of *F* is then used in length-structured yield and spawning biomass per-recruit models to assess the vulnerability of each species using conventional biological reference points (e.g., F_{MSY}, $SPR_{40\%}$).

EASI-Fish was successfully applied to 24 species representing a range of life histories, including tunas, billfishes, tuna-like species, elasmobranchs, sea turtles and cetaceans caught in EPO tuna fisheries as a 'proof of concept' in 2018 (SAC-09-12). It was subsequently used to assess the vulnerability status of the spinetail devil ray (*Mobula mobular*), caught by all industrial tuna fisheries in the EPO (BYC-09-01), and the EPO stock of the critically-endangered leatherback turtle (*Dermochelys coriacea*) (BYC-10 INF-B, BYC-11-02). Therefore, it was decided in the SSP that EASI-Fish will be used in future to assess the vulnerability of all species groups (e.g., elasmobranchs, sea turtles, teleosts) impacted by EPO tuna fisheries. In 2022, EASI-Fish was used to assess the vulnerability of the eastern Pacific leatherback turtle and shark bycatch species in EPO tuna fisheries and the results were presented at BYC-11 (BYC-11-02) and SAC-13, respectively (SAC-13-11). An EASI-Fish assessment for silky shark and hammerheads will be presented at SAC-14, where the effect of different conservation and management measures will be simulated (SAC-14-12).

6. ECOSYSTEM DYNAMICS

Although vulnerability assessments (e.g., EASI-Fish) are useful for assessing the ecological impacts of fishing by assessing the populations of individual species, ecosystem models are required to detect changes in the structure and internal dynamics of an ecosystem. These models are generally data- and labor-intensive to construct, and consequently, few fisheries worldwide have access to a reliable ecosystem model to guide conservation and management measures. These models require a good understanding of ecosystem components and the direction and magnitude of the trophic flows between them, which require detailed ecological studies involving stomach contents and/or stable isotope studies. Purposefully, IATTC staff have had a long history of undertaking such trophic studies, including the experimental determination of consumption estimates of yellowfin tuna at the NMFS Kewalo Basin facility on Oahu, HI in the 1980s, to more recent analyses of stomach content and stable isotope analysis of a range of top-level predators.

In 2003, the IATTC staff compiled the trophic data to complete the development of a model of the pelagic ecosystem in the tropical EPO (IATTC Bulletin, Vol. 22, No. 3)—named "ETP7"—to explore how fishing and climate variation might affect target species (e.g., tunas), byproduct species (e.g., wahoo, dorado), elasmobranchs (e.g., sharks), forage groups (e.g., flyingfishes, squids) and species of conservation importance (e.g., sea turtles, cetaceans). A simplified food-web diagram, with approximate trophic levels (TLs), from the model is shown in Figure J-12.

The model was calibrated to time series of biomass and catch data for a number of target species for 1961–1998. There have been significant improvements in data collection programs in the EPO since 1998, that has allowed the model to be updated with these new data up to 2018 ("ETP8"). The model required a further update in 2021 due to a significant change in how the IATTC staff have reclassified the catch data submitted by the CPCs for "other gears" into longline and other gear types following an internal review of the data. This resulted in a dramatic increase in reported longline catches of high trophic level predators (sharks), which can have a strong influence on ecosystem dynamics. Therefore, annual catch estimates by species for 1993–2018 were assigned to the relevant functional groups in the ETP-21 model, which was then rebalanced and recalibrated to time series data to provide an updated ecosystem status for 2021 and to undertake simulations to assess potential impacts of the FAD fishery on the structure of the ecosystem (SAC-12-13).

6.1. Ecological indicators

Since 2017, the most recent Ecopath model has been used in the *Ecosystem Considerations* report to provide annual values for seven ecological indicators that, together, can identify changes in the structure and internal dynamics of the ETP ecosystem. These indicators are: mean trophic level of the catch (TL_c), the Marine Trophic Index (MTI), the Fishing in Balance (FIB) index, Shannon's index, and the mean trophic level of the modelled community for trophic levels 2.0–3.25 ($TL_{2.0}$), ≥3.25–4.0 ($TL_{3.5}$), and >4.0 ($TL_{4.0}$). A full description of these indicators is provided in SAC-10-14.

Following no update to the model in 2022, ETP-21 was updated in 2023 (named ETP-23) using annual catch estimates by species for 1993–2021 assigned to the relevant functional groups, which was then rebalanced to provide an updated ecosystem status for 2021.

Ecological indicators showed that values for TL_c and MTI decreased from their peak of 4.77 and 4.83 in 1991 to 4.62 and 4.65 in 2019 and 2018, respectively, as the purse-seine fishing effort on floating objects (OBJ) significantly increased (Figure J-13), where there was increasing catches of high trophic level bycatch species that tend to aggregate around floating objects (e.g., sharks, billfish, wahoo and dorado). Since its peak in 1991, TL_c declined by 0.05 of a trophic level in the subsequent 30 years, or 0.04 trophic levels per decade. The increasing number of OBJ sets is also seen in the FIB index that exceeds zero after 1990, as well as the continual change in the evenness of biomass of the community indicated by Shannon's index.

The above indicators generally describe the change in the exploited components of the ecosystem, whereas community biomass indicators describe changes in the structure of the ecosystem once biomass has been removed due to fishing. The biomass of the $TL_{MC\mathit{4.0}}$ community was at one of its highest values

(4.493) in 1986 but has continued to decline to 4.459 in 2021 (Figure J-13). As a result of changes in predation pressure on lower trophic levels, between 1993 and 2021 the biomass of the $TL_{MC3.25}$ community increased from 3.801 to 3.816, while interestingly, the biomass of the $TL_{MC2.0}$ community also increased from 3.092 to 3.114.

Together, these indicators show that the ecosystem structure has likely changed over the 42-year analysis period. The consistent patterns of change in each ecological indicator, particularly in the mean trophic level of the communities since 1993, certainly warrant the continuation, and ideally an expansion, of monitoring programs for fisheries in the EPO. The COVID-19 pandemic in 2020 allowed staff to examine the direct effects of reduced fishing effort on the ecosystem through use of ecological indicators. The most notable change was a 23% decrease in the number of purse-seine OBJ sets from 14,987 sets in 2019 to 11,543 sets in 2020. This decrease in effort resulted in abrupt changes in most ecological indicators for 2020 and mostly returning to pre-pandemic levels in 2021 when the number of OBJ sets increased to 14,865 (Figure J-13). These results suggest that the increase in OBJ sets are likely primarily responsible for the continued change in ecosystem structure over the past two decades .

7. FUTURE DEVELOPMENTS

It is unlikely, in the near future at least, that there will be stock assessments for most of the bycatch species. Therefore, the IATTC must continue to undertake ecological research and assessments that can provide managers with reliable information to guide the development of science-based conservation and management measures, where required, to ensure the IATTC continues to fulfil its responsibilities under the Antigua Convention and the objectives of the SSP. The priority research areas that have been identified by the scientific staff that require further development are detailed below:

- Following the development of the EASI-Fish approach, analysis of the full suite of over 100 impacted bycatch species will be conducted in stages, by taxonomic group (e.g., sharks, rays, teleosts, turtles and cetaceans). All pelagic shark species and the critically endangered eastern Pacific leatherback turtle stock were assessed in 2022.
- Given the high number of species classified as "most vulnerable" in the 2022 shark EASI-Fish assessment, a high priority is to develop a strategy for future conservation and management of these vulnerable species. As a first step EASI-Fish will be used to explore the potential efficacy of hypothetical conservation and management measures for silky and hammerhead sharks in 2023 (SAC-14-12).
- Significant knowledge gaps identified for sharks in the EASI-Fish assessment pertained to the fundamental parameter values required to characterize the population dynamics of several species in the EPO, even those that have been commonly recorded as bycatch for decades. Therefore, significant efforts are required by the IATTC and its Members to establish a strategy for undertaking cost-effective studies to collect data to develop morphometric relationships (e.g., length-weight and length-length), growth curves, and maturity ogives. In addition to the GEF-FAO ABNJ shark fishery data collection work recently completed in Central America and about to expand to other IATTC Members in 2023, which could be seen as an opportunity to achieve such a strategy (SAC-13-12, SAC-14 INF-L, SAC-14 INF-M), the IATTC staff has prepared a document identifying data gaps and potential opportunities for a phase-based approach to obtaining morphometric measurements and biological sampling of tunas, billfishes, and priority bycatch species on purse seiners and longliners (SAC-14 INF-J).
- A shortcoming of the ETP-23 ecosystem model, from which the ecological indicators are derived, is that its structure is based on stomach content data from fish collected in 1992–1994. Given the significant environmental and fishery changes that have been observed in the EPO over the past decade, there is a critical need to collect updated trophic information. There have been proposals

made by the staff in 2018–2023 to establish an ecological monitoring program to collect stomach content data to update the ecosystem model. Given the emerging requirements for biological data on sharks, such a monitoring program could incorporate all biological and ecological requirements of the IATTC. Again, the GEF-FAO ABNJ project which continues to expand among IATTC Members offers some opportunities for integrating such a sampling program, especially if the ABNJ pilot project continues in perpetuity as recommended by the staff. In addition, the proposed morphometric and biological sampling study (SAC-14 INF-J) aims to opportunistically collect biological samples, including stomachs, to obtain updated diet data for future use in a spatially-explicit ecosystem model.

- A second limitation of the ETP-23 model is that it describes only the tropical component of the EPO ecosystem, and results cannot be reliably extrapolated to other regions of the EPO. Therefore, after updated diet information is collected, future work will aim to develop a spatially-explicit model that covers the entire EPO and calibrate the model with available time series of catches, ideally for species representing different trophic levels, and effort data for key fisheries in the EPO.
- Environmental variables can have a profound influence on the catches of target and bycatch species, as has been shown previously by IATTC staff and now undertaken annually in this report. However, the staff's research to investigate the impact of environmental conditions on the fishery could be greatly improved with the availability of high-resolution operational level data for the longline fishery. Although IATTC Members and CPCs are now required to submit operational level observer data to the IATTC that covers at least 5% of their fleets, analyses conducted by the staff provide conclusive evidence that these data are not representative of the fleet (BYC-10 INF-D) and therefore brings into question the validity of using submitted longline data for future environmental analyses until the observer coverage reaches at least 20%.
- The task of disentangling the spatial and temporal overlap of multiple target and non-target species requires an in-depth exploration of risk and trade-offs across management scenarios and species groups. Although the scientific community has argued for the importance of exploring dynamic spatial management over the past 20 years, there are currently few examples of dynamic or adaptive spatial management measures being implemented in tuna fisheries to reduce bycatch. In fact, no spatial management measures have been implemented to date to specifically reduce the catch of non-target species in tuna RFMOs. The identification of areas of potential interest for spatial management in the open ocean is directly dependent on the everchanging species-environment relationship, which can be modeled to estimate and predict species' distributions and relative abundance across space and time and inform the design of adaptive management measures. Although the IATTC staff has started to investigate this issue in the EPO for both target and non-target species (e.g. SAC-10 INF-D, Pons et al 2022, BYC-11-04, Druon et al 2022), the potential implementation and operationalization of adaptive management options should be explored in the coming years.
- The quality of ecological analyses and the annual reporting of EPO-wide catch estimates for bycatch species is currently hampered by IATTC's existing resolution on data provision (C-03-05), which no longer aligns with IATTC's evolving responsibilities under the Antigua Convention (see SAC-12-09). Such responsibilities include ensuring the sustainable impacts of EPO fisheries on associated and dependent species, which is the primary reason for the creation, and annual updates of, this *Ecosystem Considerations* report. Presently, the only reliable source of bycatch data is from observers onboard large, size Class-6, purse-seine vessels. Limited to no data on bycatch exists for other pelagic fisheries in the EPO. Proposed capacity building opportunities and a series of workshops involving IATTC staff and CPCs to develop clear data reporting standards are expected to facilitate improved data submission, catch estimates and reporting, which in turn will improve ecological analyses to allow the IATTC to meet its obligations under the Antigua Convention. Discussions commenced during the first workshop on

improving data collection for the industrial longline fisheries (WSDAT-01, WSDAT-01-RPT) and a series of staff recommendations, which culminated from workshop participation and individual consultation with CPCs, will be presented at this SAC (see SAC-14-14).

- The IATTC staff is collaborating on two research projects on dolphins focused on improving current understanding of the potential impacts of tuna fisheries on dolphin populations (SAC-14 INF-K), including a cow-calf separation study and an abundance survey.

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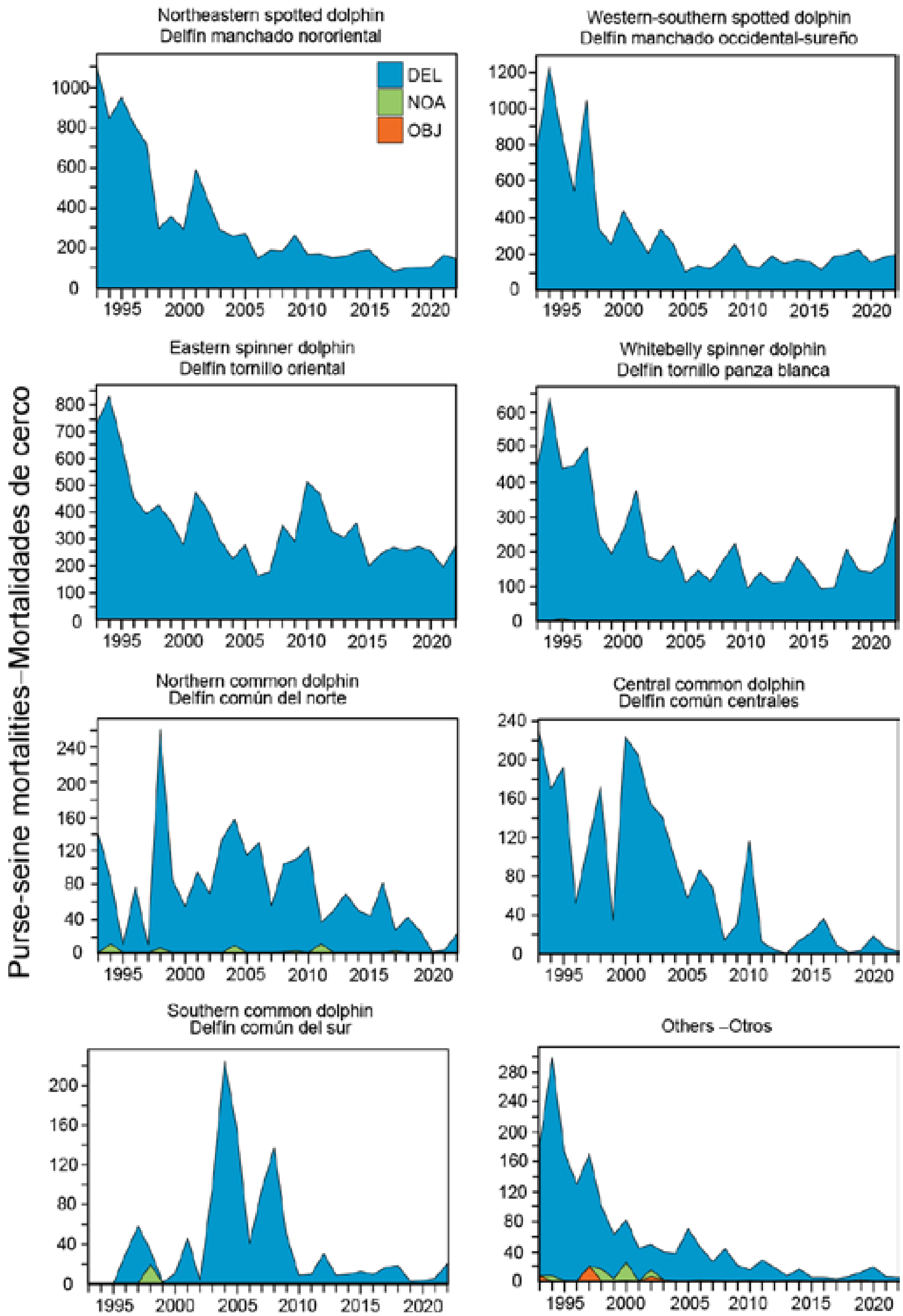
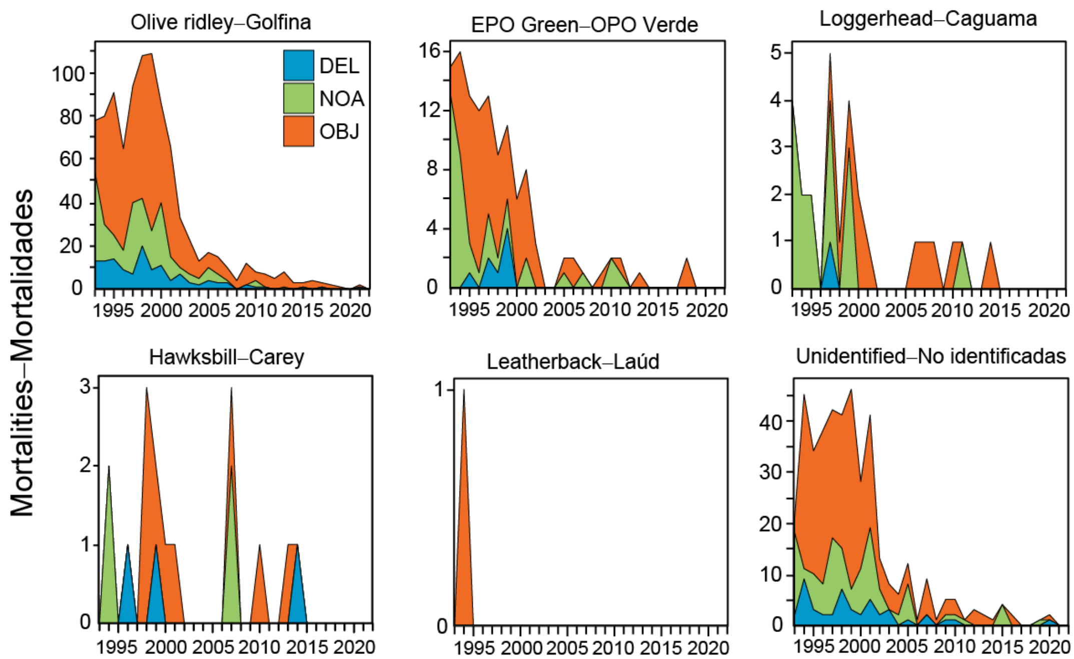


FIGURE J-1. Estimated number of incidental dolphin mortalities by observers onboard purse-seine vessels, 1993–2022.
FIGURA J-1. Número estimado de mortalidades incidentales de delfines por observadores a bordo de buques cerqueros grandes, 1993–2022.

a.



b.

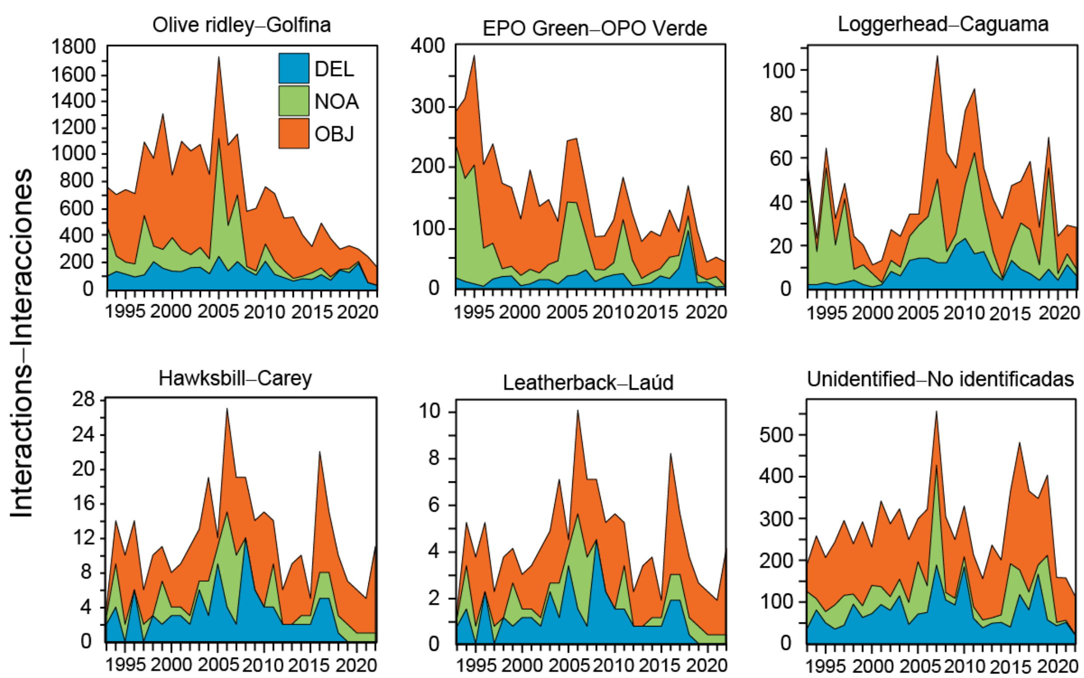


FIGURE J-2. Estimated number of sea turtle a) mortalities and b) interactions by observers onboard large purse-seine vessels, 1993–2022, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)).
FIGURA J-2. Número estimado de a) mortalidades y b) interacciones de tortugas marinas por observadores a bordo de buques cerqueros grandes, 1993-2022, por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)).

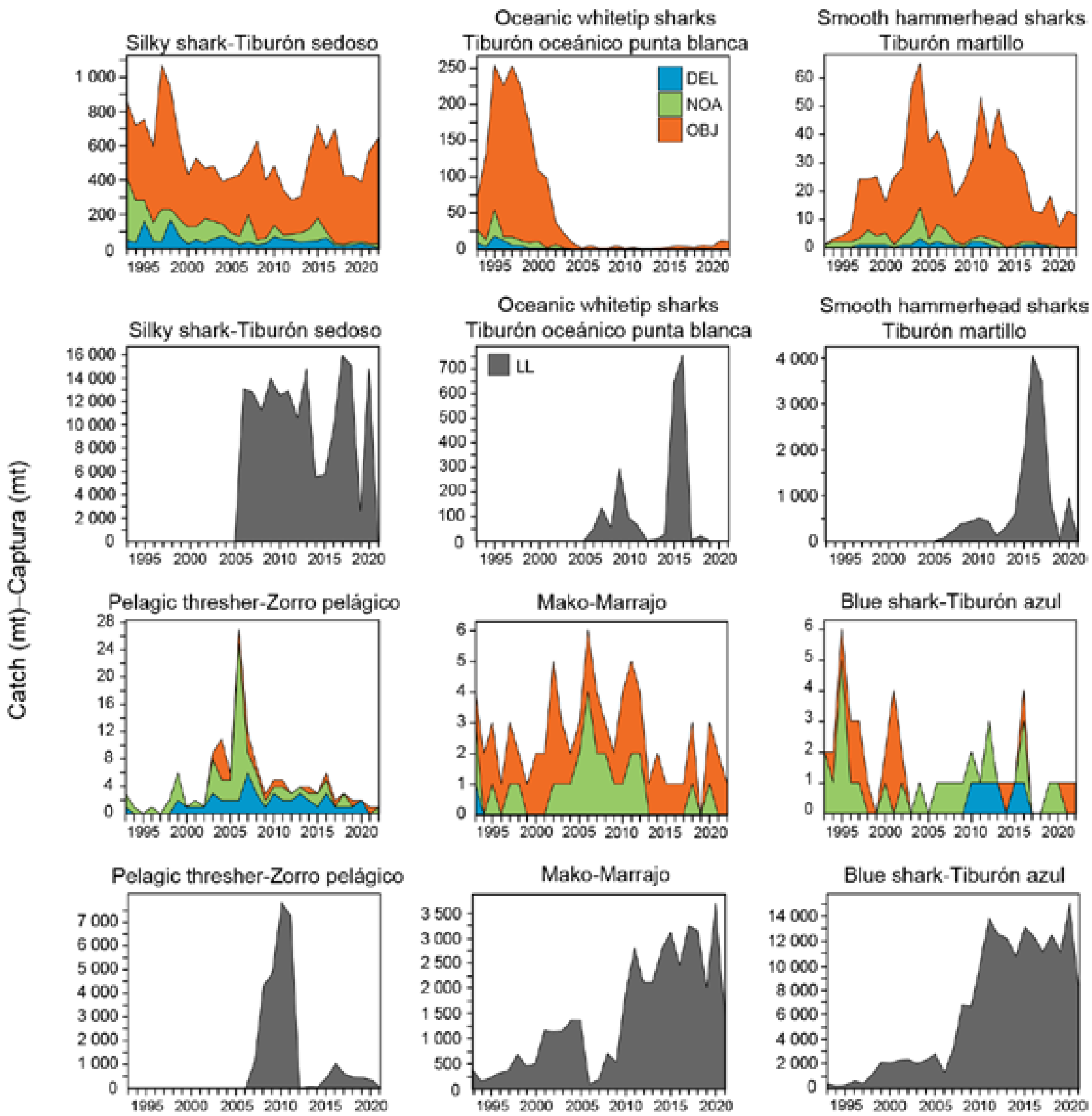


FIGURE J-3a. Estimated catches in metric tons (t) of key shark species in the eastern Pacific Ocean recorded by observers onboard large purse-seine vessels and minimum longline (LL) estimates of gross annual removals reported by CPCs (see section 2.2. for uncertainty and data gaps in reporting of bycatch species caught by longline). Purse-seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2022) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Longline catches (1993–2021) are minimum reported gross-annual removals that may have been estimated using a mixture of different weight metrics (see footnote in section 3.5).

FIGURA J-3a. Capturas estimadas en toneladas (t) de especies clave de tiburones en el Océano Pacífico oriental registradas por observadores a bordo de buques cerqueros grandes y estimaciones mínimas de palangre (LL) de extracciones anuales brutas reportadas por los CPC (ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos en la notificación de especies capturadas incidentalmente con palangre). Se presentan las capturas cerqueras para buques de clase 6 con una capacidad de acarreo >363 t (1993-2022) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las capturas palangreras (1993–2021) son extracciones anuales brutas mínimas reportadas que pueden haber sido estimadas usando una mezcla de diferentes métricas de peso (ver nota al pie de página en la sección 3.5).

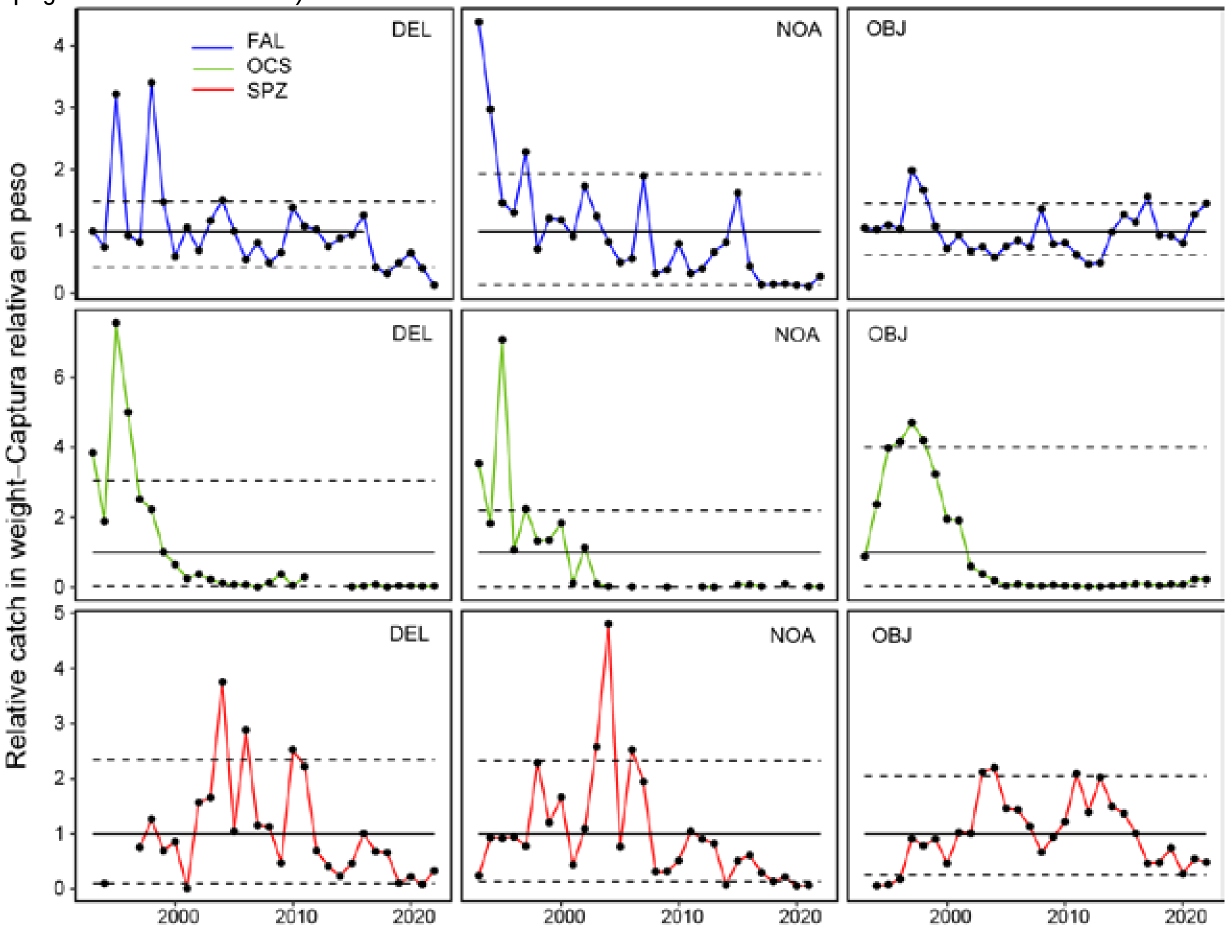


FIGURE J-3b. Indicators of relative catch of key shark species reported by observers onboard large purse-seine vessels (Class 6, carrying capacity > 363 t) by set type: dolphins (DEL), unassociated tuna schools (NOA) and floating object (OBJ). The solid line is the average equal to 1 and the dashed lines represent the 10th and 90th percentiles. FAL: silky shark (*Carcharhinus falciformis*), OCS: oceanic whitetip shark (*Carcharhinus longimanus*), SPZ: smooth hammerhead shark (*Sphyrna zygaena*).

FIGURA J-3b. Indicadores de captura relativa de especies clave de tiburones notificada por observadores a bordo de buques cerqueros grandes (clase 6, capacidad de acarreo > 363 t) por tipo de lance: sobre delfines (DEL), no asociados (NOA) y sobre objetos flotantes (OBJ). La línea continua es el promedio igual a 1 y las líneas punteadas representan los percentiles de 10 y 90%. FAL: tiburón sedoso (*Carcharhinus falciformis*), OCS: tiburón oceánico punta blanca (*Carcharhinus longimanus*), SPZ: cornuda cruz (*Sphyrna zygaena*).

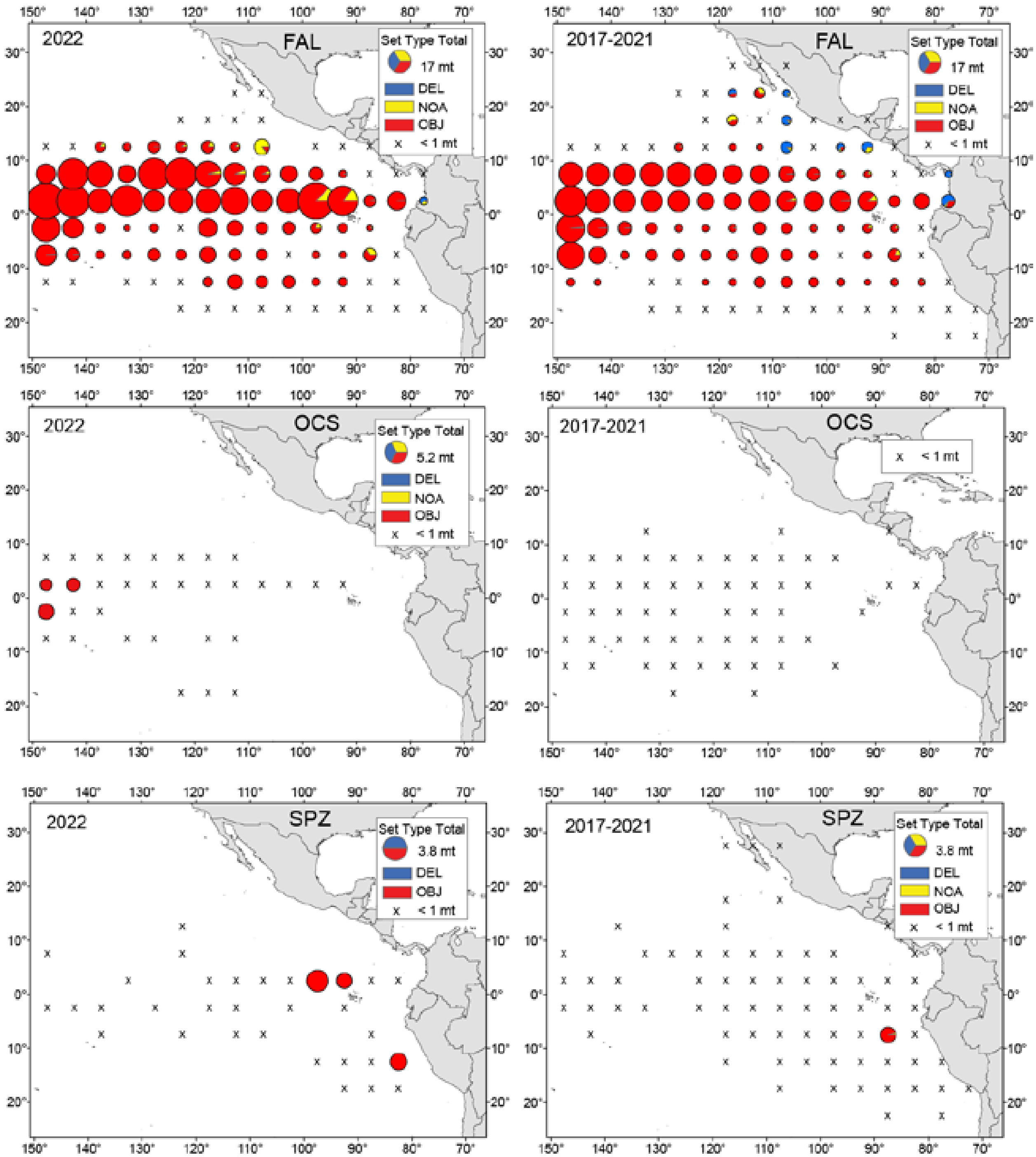


FIGURE 3c. Purse-seine catches (Class 6, carrying capacity > 363 t) (at 5°x5° resolution) of key species of sharks by set type: floating object (OBJ) unassociated tuna schools (NOA) and dolphins (DEL), for 2022 (left panel) and the 2017-2021 averages (right panel). FAL: silky shark (*Carcharhinus falciformis*), OCS: oceanic whitetip shark (*Carcharhinus longimanus*), SPZ: smooth hammerhead shark (*Sphyrna zygaena*).

FIGURA 3c. Capturas cerqueras (clase 6, capacidad de acarreo > 363 t) (resolución de 5°x5°) de especies clave de tiburones por tipo de lance: sobre objetos flotantes (OBJ), no asociados (NOA) y sobre delfines (DEL), para 2022 (panel izquierdo) y los promedios de 2017-2021 (panel derecho). FAL: tiburón sedoso (*Carcharhinus falciformis*), OCS: tiburón oceánico punta blanca (*Carcharhinus longimanus*), SPZ: cornuda cruz (*Sphyrna zygaena*).

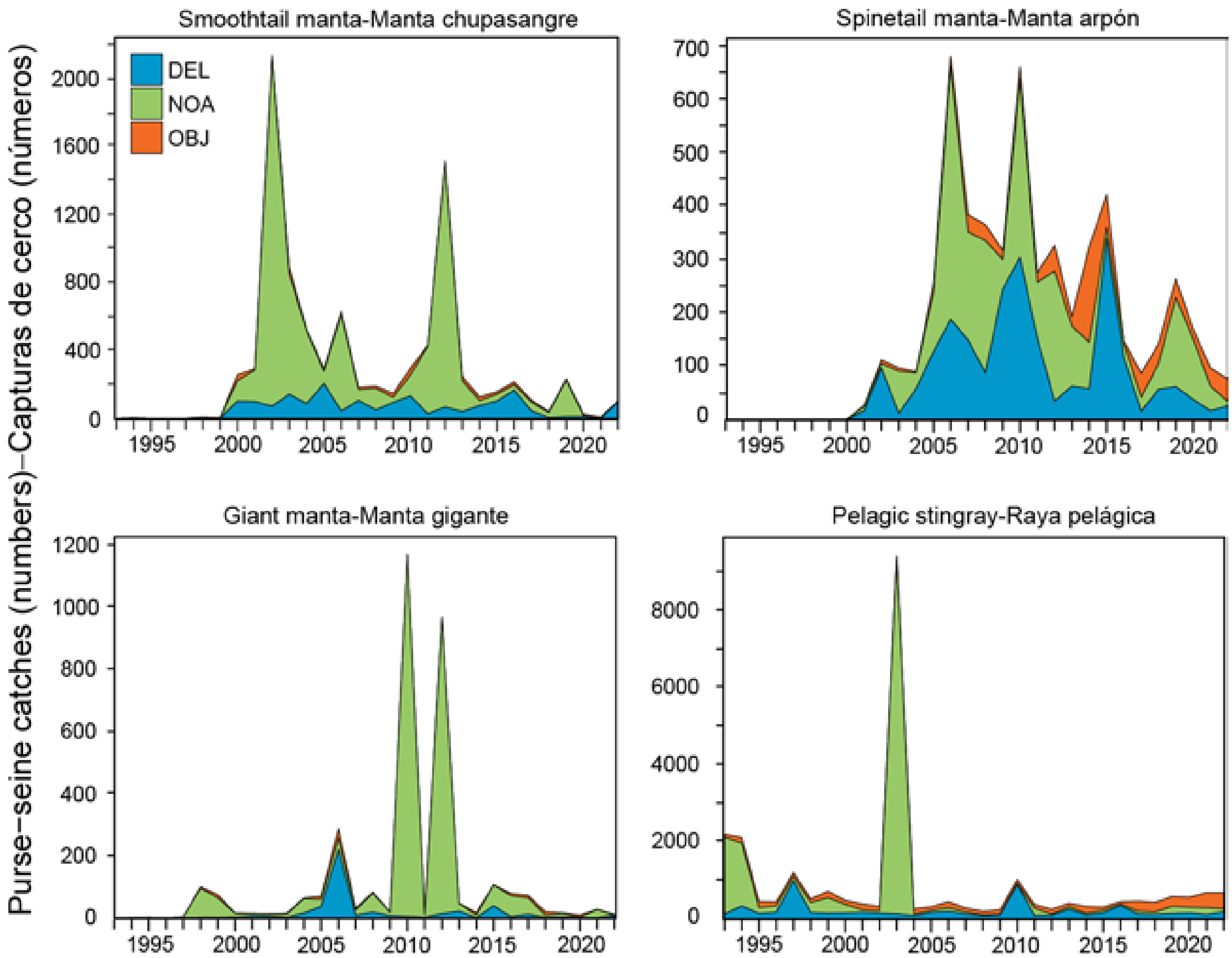


FIGURE J-4a. Estimated purse-seine catches in numbers of individuals of key species of rays in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2022) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL).

FIGURA J-4a. Capturas cerqueras estimadas en número de individuos de especies clave de rayas en el Océano Pacífico oriental. Se presentan las capturas cerqueras para buques de clase 6 con una capacidad de acarreo >363 t (1993-2022) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL).

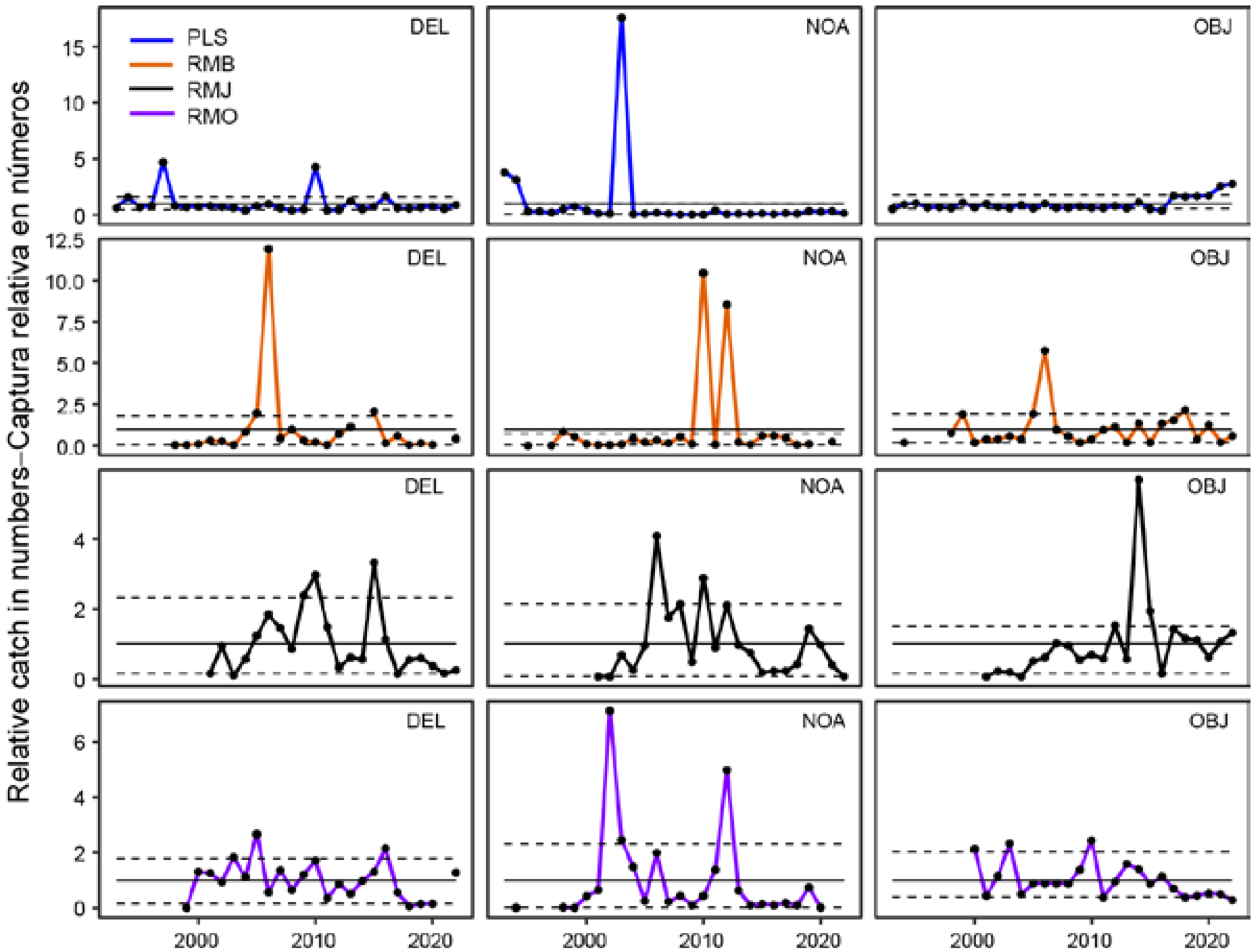


FIGURE J-4b. Indicators of relative number of individuals of rays reported by observers onboard large purse-seine vessels (Class 6, carrying capacity > 363 t) by set type: dolphins (DEL), unassociated tuna schools (NOA) and floating object (OBJ). The solid line is the average equal to 1 and the dashed lines represent the 10th and 90th percentiles. PLS: pelagic stingray (*Pteroplatytrygon violacea*), RMB: giant manta (*Mobula birostris*), RMJ: spinetail manta (*Mobula mobular*), RMO: smoothtail manta (*Mobula thurstoni*).

FIGURA J-4b. Indicadores del número relativo de individuos de rayas notificado por observadores a bordo de buques cerqueros grandes (clase 6, capacidad de acarreo > 363 t) por tipo de lance: sobre delfines (DEL), no asociados (NOA) y sobre objetos flotantes (OBJ). La línea continua es el promedio igual a 1 y las líneas punteadas representan los percentiles de 10 y 90%. PLS: raya pelágica (*Pteroplatytrygon violacea*), RMB: manta gigante (*Mobula birostris*), RMJ: manta mobula (*Mobula mobular*), RMO: manta diablo (*Mobula thurstoni*).

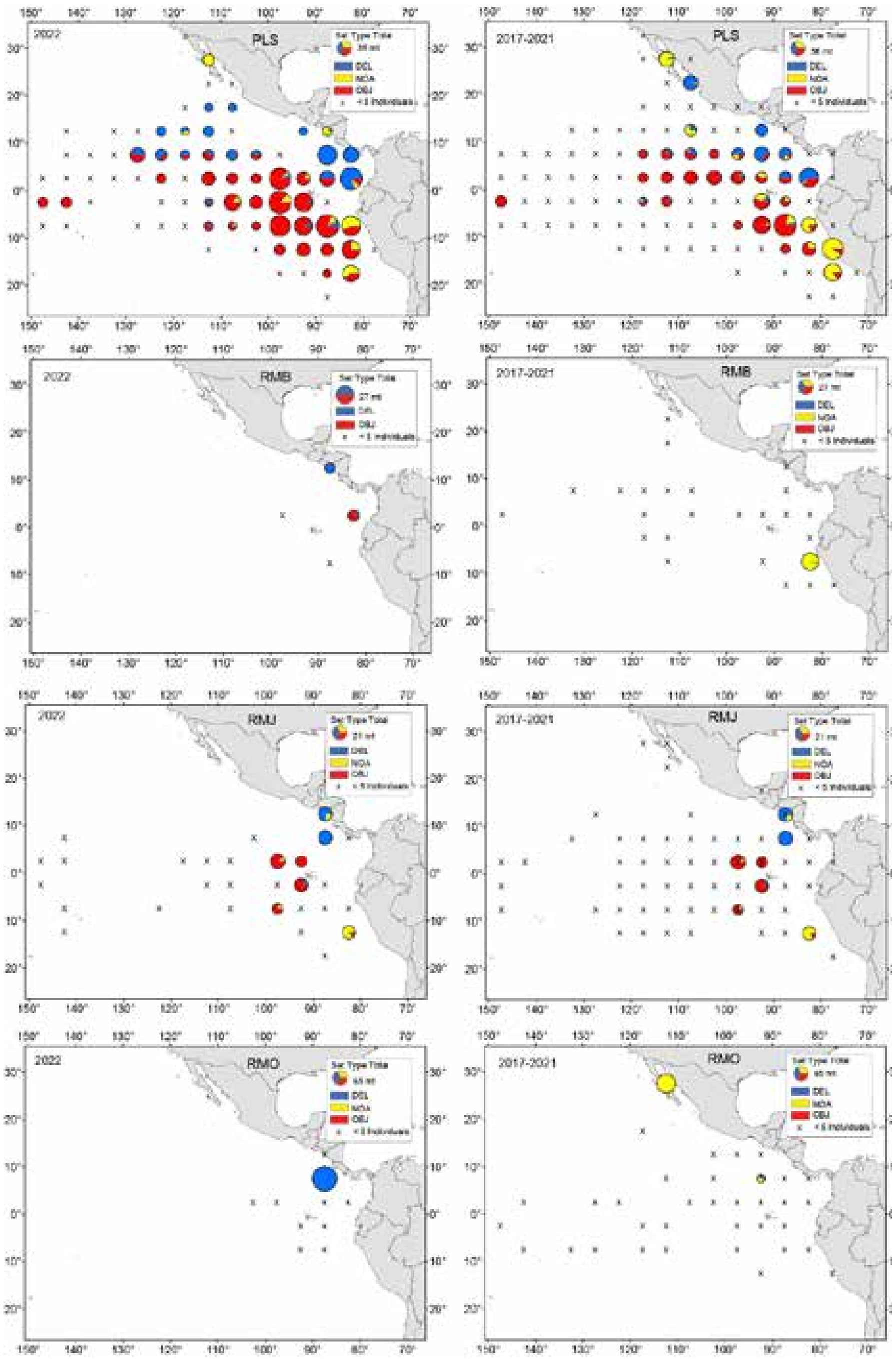


FIGURE J-4c. Purse-seine catches (Class 6, carrying capacity > 363 t) (at 5°x5° resolution) of key species of rays by set type: floating object (OBJ) unassociated tuna schools (NOA) and dolphins (DEL), for 2022 (left panel) and the 2017-2021 averages (right panel). PLS: pelagic stingray (*Pteroplatytrygon violacea*), RMB: giant manta (*Mobula birostris*), RMJ: spinetail manta (*Mobula mobular*), RMO: smoothtail manta (*Mobula thurstoni*).

FIGURA J-4c. Capturas cerqueras (clase 6, capacidad de acarreo > 363 t) (resolución de 5°x5°) de especies clave de rayas por tipo de lance: sobre objetos flotantes (OBJ), no asociados (NOA) y sobre delfines (DEL), para 2022 (panel izquierdo) y los promedios de 2017-2021 (panel derecho). PLS: raya pelágica (*Pteroplatytrygon violacea*), RMB: manta gigante (*Mobula birostris*), RMJ: manta mobula (*Mobula mobular*), RMO: manta diablo (*Mobula thurstoni*).

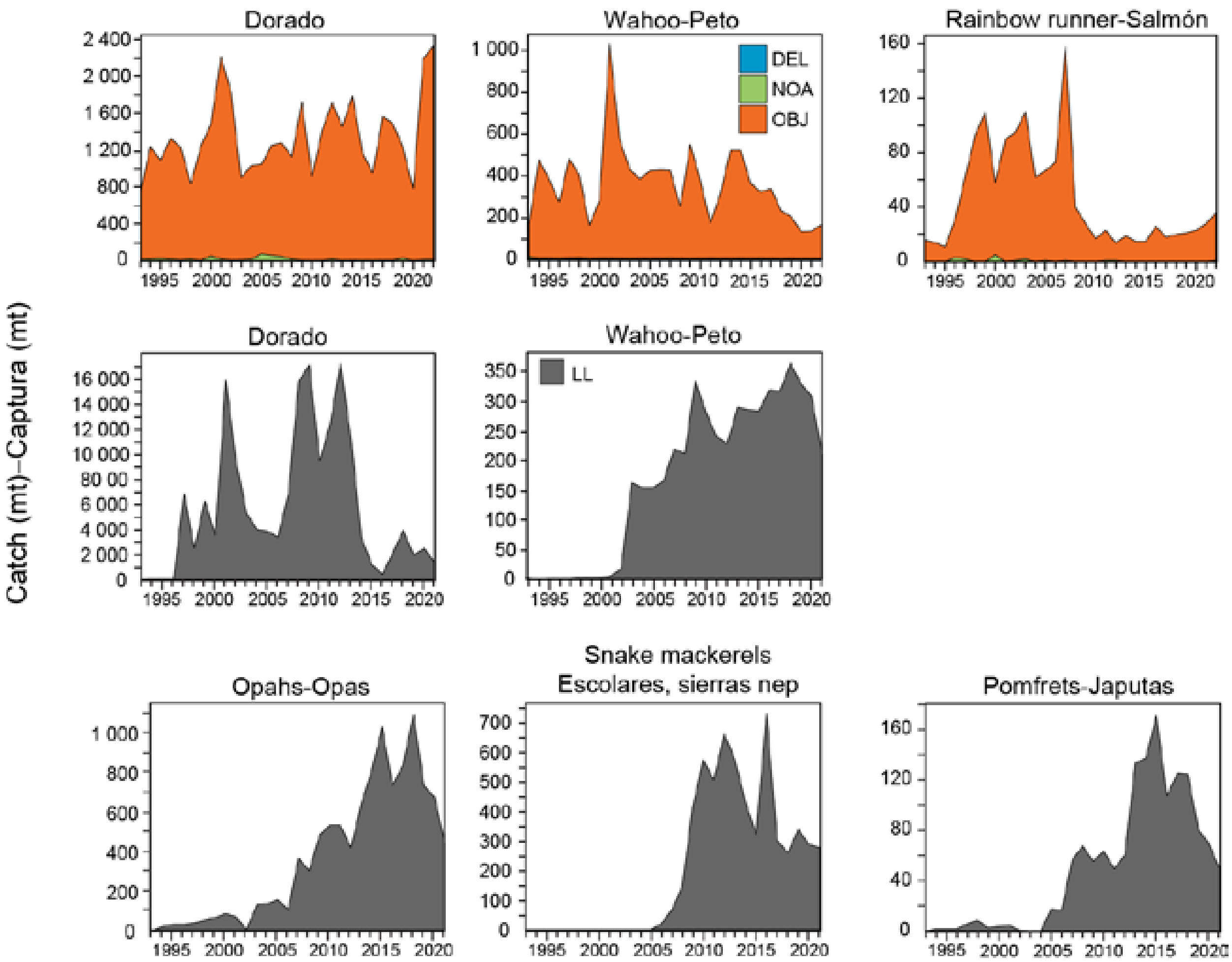


FIGURE J-5. Estimated purse-seine and longline catches in metric tons (t) of key species of large fishes in the eastern Pacific Ocean. Purse-seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2022) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Longline (LL) catches (1993–2021) are minimum reported gross-annual removals (see section 2.2. for uncertainty and data gaps in reporting of bycatch species caught by longline).

FIGURA J-5. Capturas cerqueras y palangreras estimadas en toneladas (t) de especies clave de peces grandes en el Océano Pacífico oriental. Se presentan las capturas cerqueras para buques de clase 6 con una capacidad de acarreo >363 t (1993-2022) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las capturas palangreras (LL) (1993–2021) son extracciones anuales brutas mínimas reportadas (ver la Sección 2.2 para consultar información sobre la incertidumbre y las deficiencias de los datos en la notificación de especies capturadas incidentalmente con palangre).

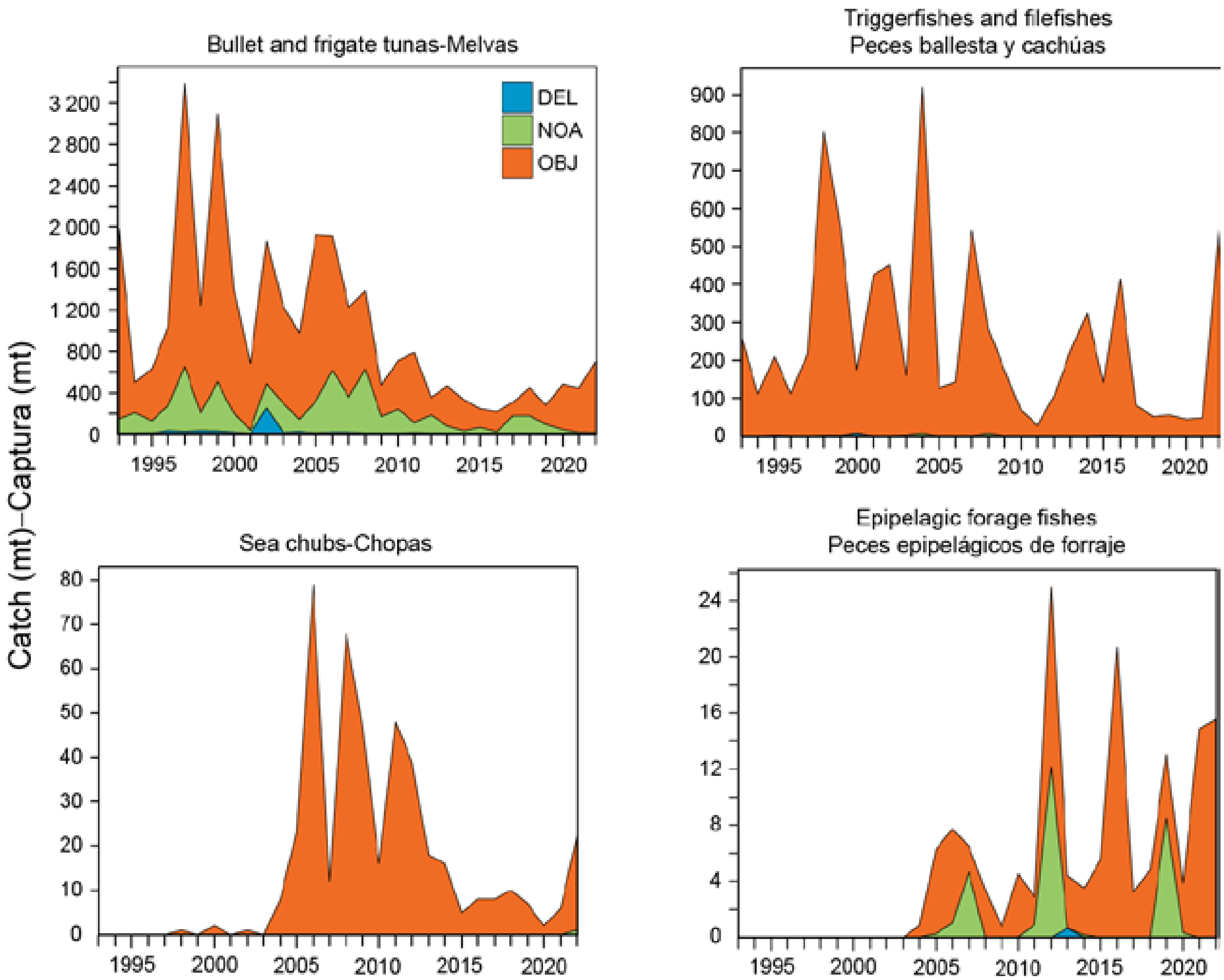


FIGURE J-6. Estimated purse-seine catches in metric tons (t) of key species of small fishes in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2022) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL).
FIGURA J-6. Capturas cerqueras estimadas en toneladas (t) de especies clave de peces pequeños en el Océano Pacífico oriental. Se presentan las capturas cerqueras para buques de clase 6 con una capacidad de acarreo >363 t (1993-2022) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL).

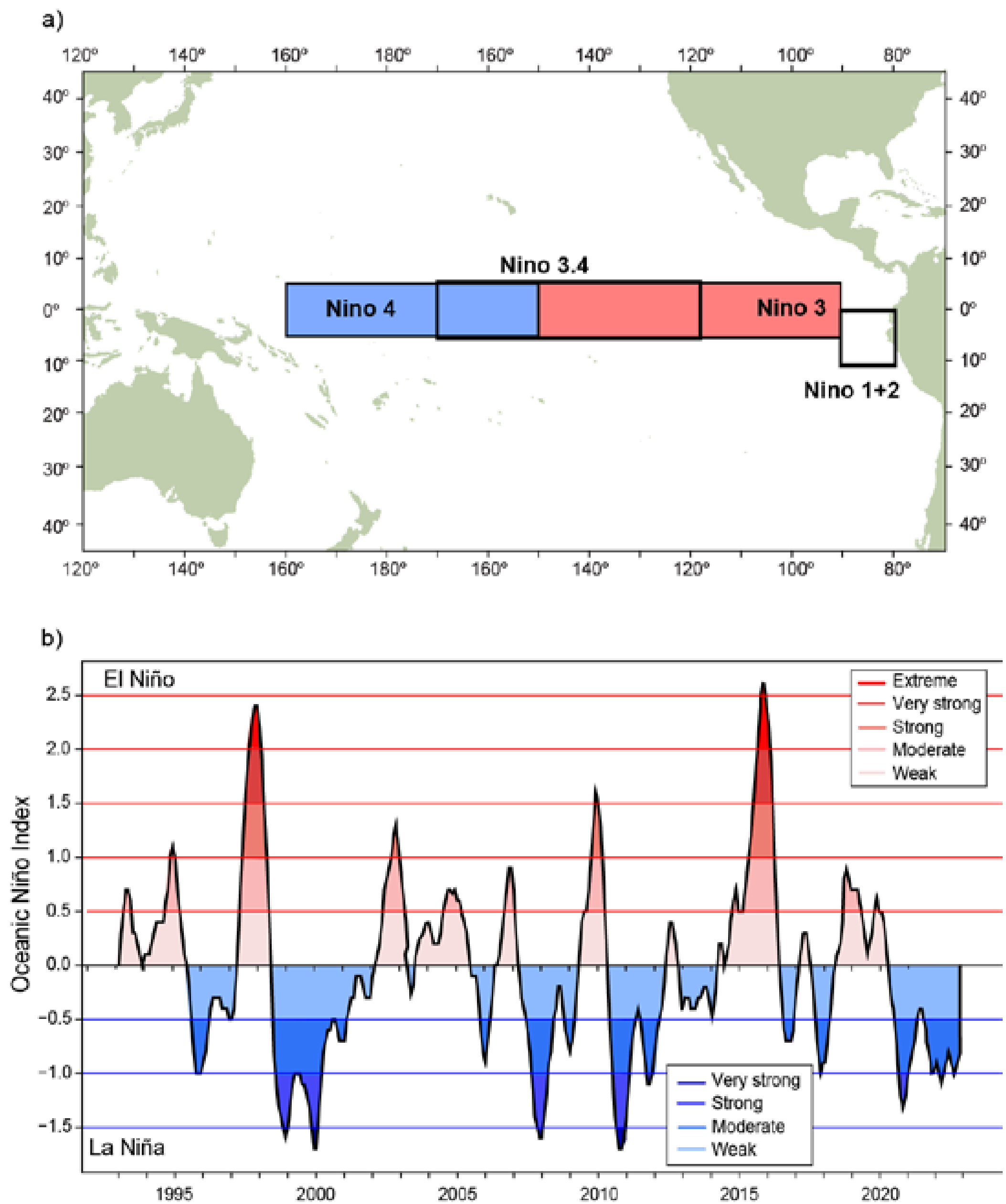


FIGURE J-7. El Niño regions used as indicators of El Niño Southern Oscillation (ENSO) events in the Pacific Ocean (top panel), and the Oceanic Niño Index (ONI) used to monitor ENSO conditions in Niño region 3.4 from 5°N to 5°S and 120°W to 170°W (bottom panel). Time series shows the running 3-month mean ONI values from the start of the IATTC observer program through December 2022. ONI data obtained from: http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

FIGURA J-7. Regiones de El Niño utilizadas como indicadores de los eventos de El Niño-Oscilación del Sur (ENOS) en el Océano Pacífico (panel superior), e Índice de El Niño Oceánico (ONI) usado para dar seguimiento a las condiciones de ENOS en la región Niño 3.4 de 5°N a 5°S y de 120°O a 170°O (panel inferior). Las series de tiempo muestran los valores del promedio móvil de 3 meses del ONI desde el inicio del programa de observadores de la CIAT hasta finales de diciembre de 2022. Datos del ONI obtenidos de: http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

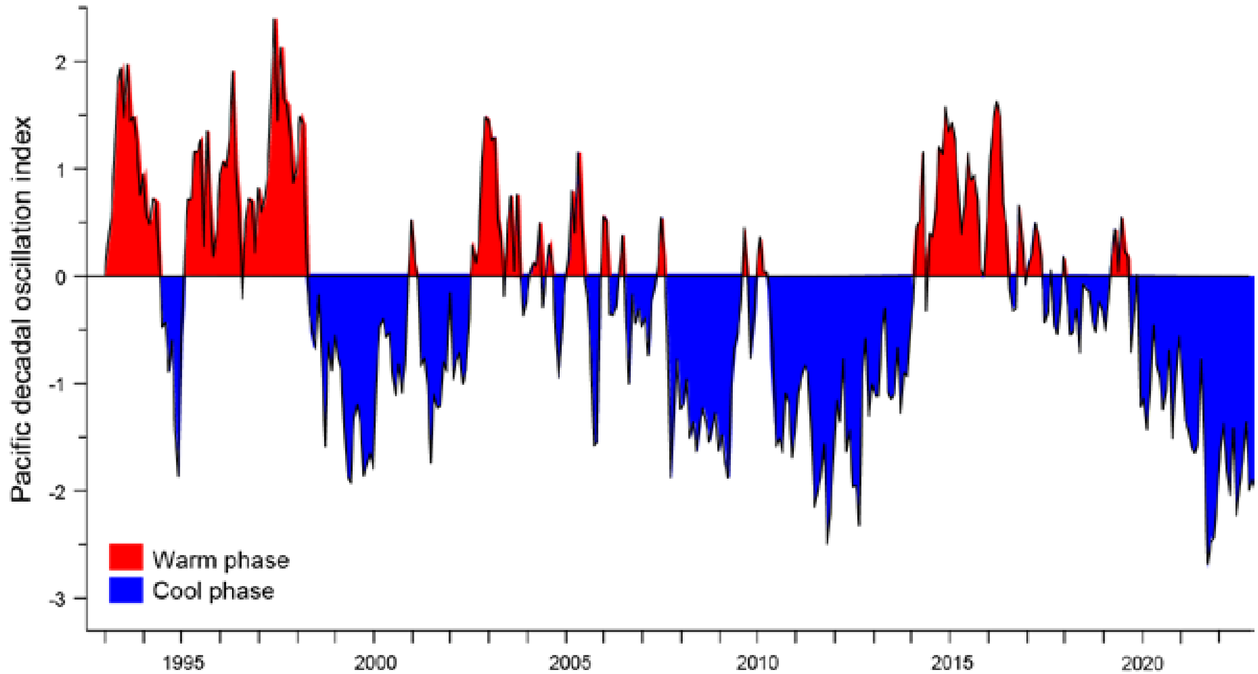


FIGURE J-8. Monthly values of the Pacific Decadal Oscillation (PDO) Index, January 1993–December 2022. ERSST V5 PDO Time Series data obtained from: https://psl.noaa.gov/pdo/

FIGURA J-8. Valores mensuales del índice de Oscilación Decadal del Pacífico (PDO), enero de 1993–diciembre de 2022. Datos de la serie de tiempo ERSST V5 PDO obtenidos de: https://psl.noaa.gov/pdo/

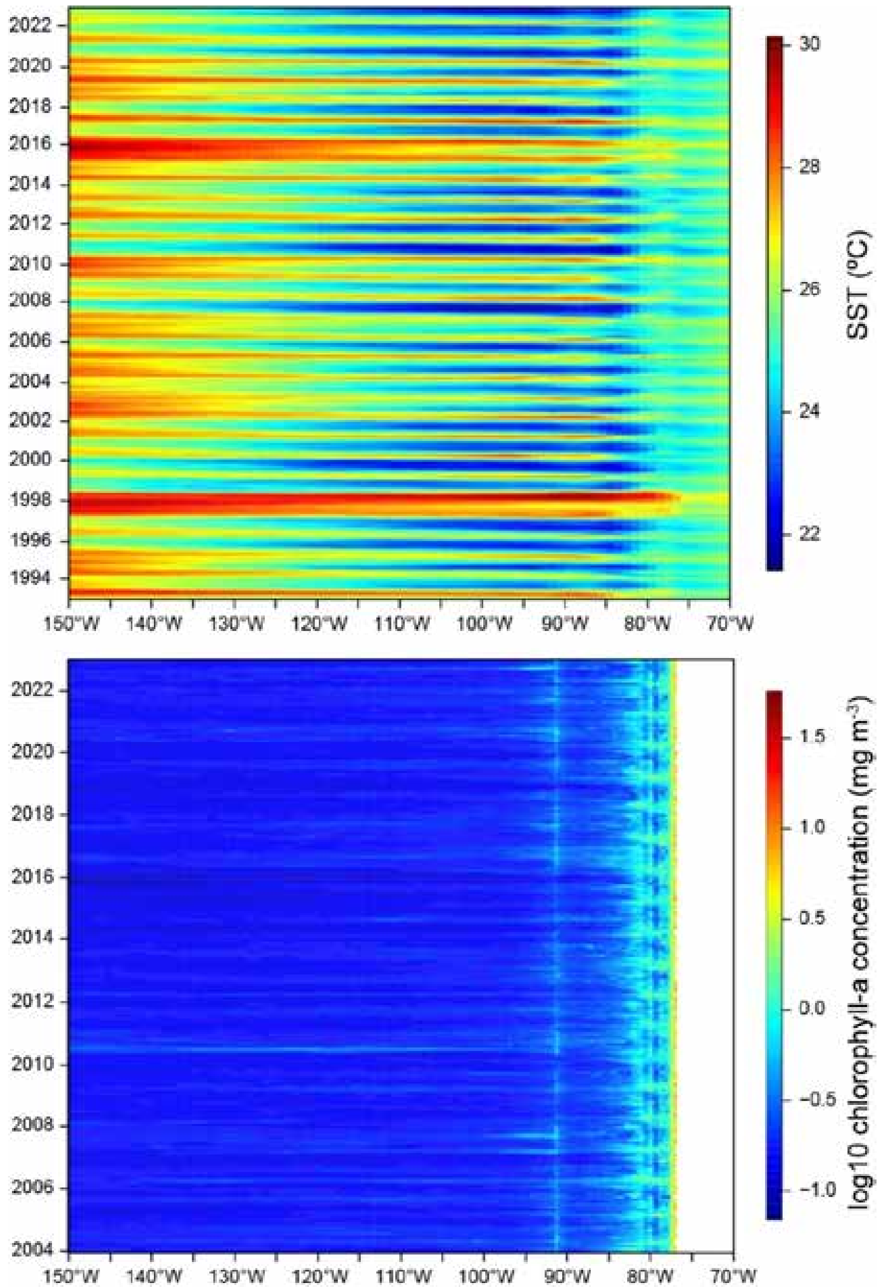


FIGURE J-9. Time-longitude Hovmöller diagram with data averaged across the tropical eastern Pacific Ocean from 5°N to 5°S for mean monthly SST for January 1993–December 2022 (top panel) (https://www.esrl.noaa.gov/psd/) and mean monthly chlorophyll-a concentration for January 2003–December 2022 (bottom panel) (https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday_R2022SQ/index.html)

FIGURA J-9. Diagrama de Hovmöller tiempo-longitud con datos promediados en el Océano Pacífico tropical oriental de 5°N a 5°S para la TSM promedio mensual de enero de 1993 a diciembre de 2022 (panel superior) (https://www.esrl.noaa.gov/psd/) y concentración promedio mensual de clorofila-a de enero de 2003 a diciembre de 2022 (panel inferior) (https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday_R2022SQ/index.html).

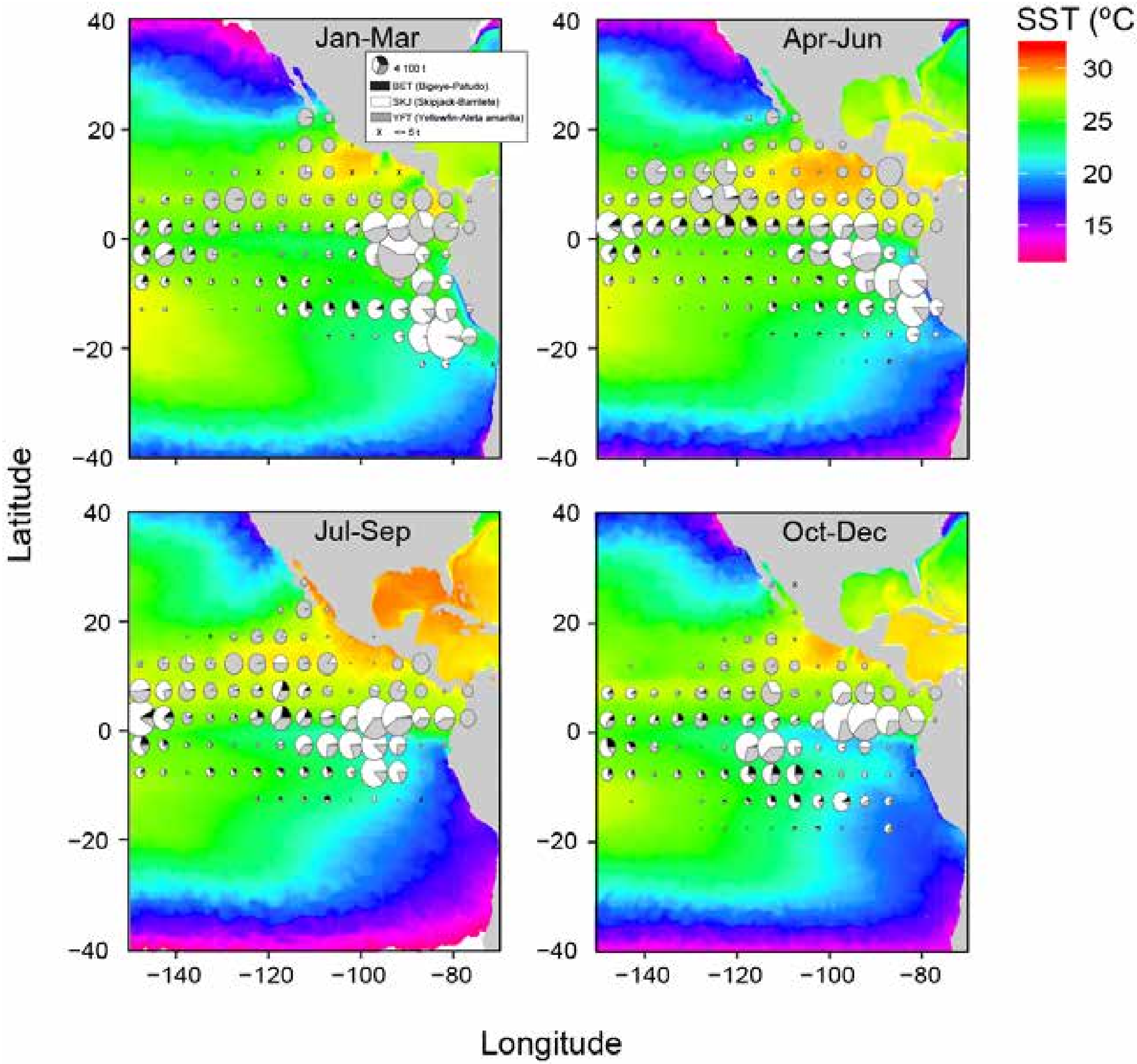


FIGURE J-10. Mean sea surface temperature (SST) for each quarter during 2022 with catches of tropical tunas overlaid. SST data obtained from NOAA NMFS SWFSC ERD on January 19, 2023, "Multi-scale Ultra-high Resolution (MUR) SST Analysis fv04.1, Global, 0.01°, 2002–present, Monthly", https://coastwatch.pfeg.noaa.gov/erddap/info/jplMURSST41mday/index.html.

FIGURA J-10 Temperatura superficial del mar (TSM) promedio para cada trimestre de 2022 con las capturas de atunes tropicales superpuestas. Datos de TSM obtenidos de NOAA NMFS SWFSC ERD el 19 de enero de 2023, "Multi-scale Ultra-high Resolution (MUR) SST Analysis fv04.1, Global, 0.01°, 2002–present, Monthly", https://coastwatch.pfeg.noaa.gov/erddap/info/jplMURSST41mday/index.html.

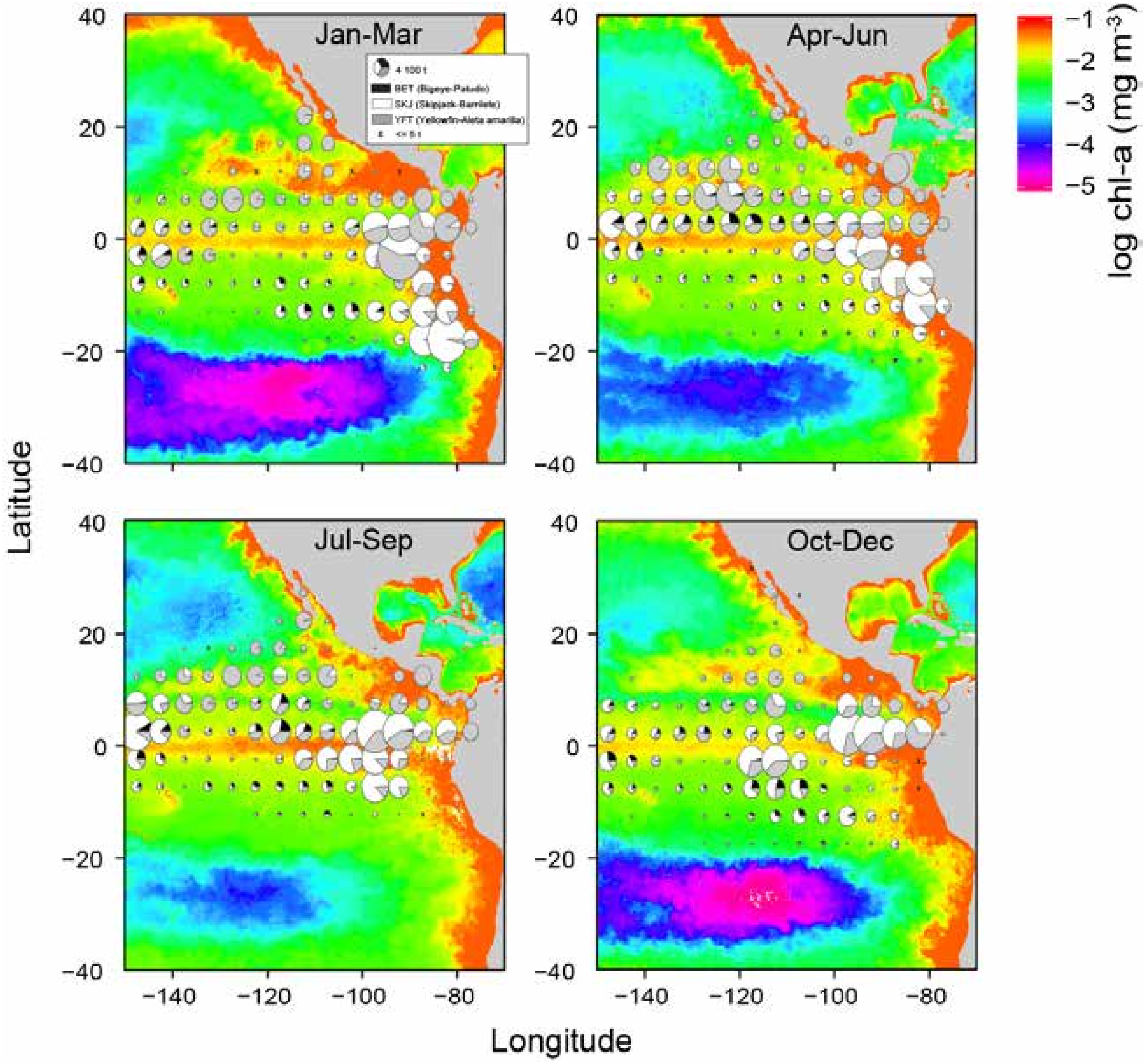


FIGURE J-11. Mean log chlorophyll-a concentration (in mg m^3) for each quarter during 2022 with catches of tropical tunas overlaid. Chlorophyll data obtained from NOAA CoastWatch on March 3, 2023, "Chlorophyll-a, Aqua MODIS, NPP, L3SMI, Global, 4km, R2022 SQ, 2003-present (Monthly Composite)", NOAA NMFS SWFSC ERD, https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday_R2022SQ/index.html.

FIGURA J-11. Concentración promedio de clorofila-a (en mg m^3) para cada trimestre de 20222 con las capturas de atunes tropicales superpuestas. Datos de clorofila obtenidos de NOAA CoastWatch el 3 de marzo de 2023, "Chlorophyll-a, Aqua MODIS, NPP, L3SMI, Global, 4km, R2022 SQ, 2003-present (Monthly Composite)", NOAA NMFS SWFSC ERD, https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday_R2022SQ/index.html.

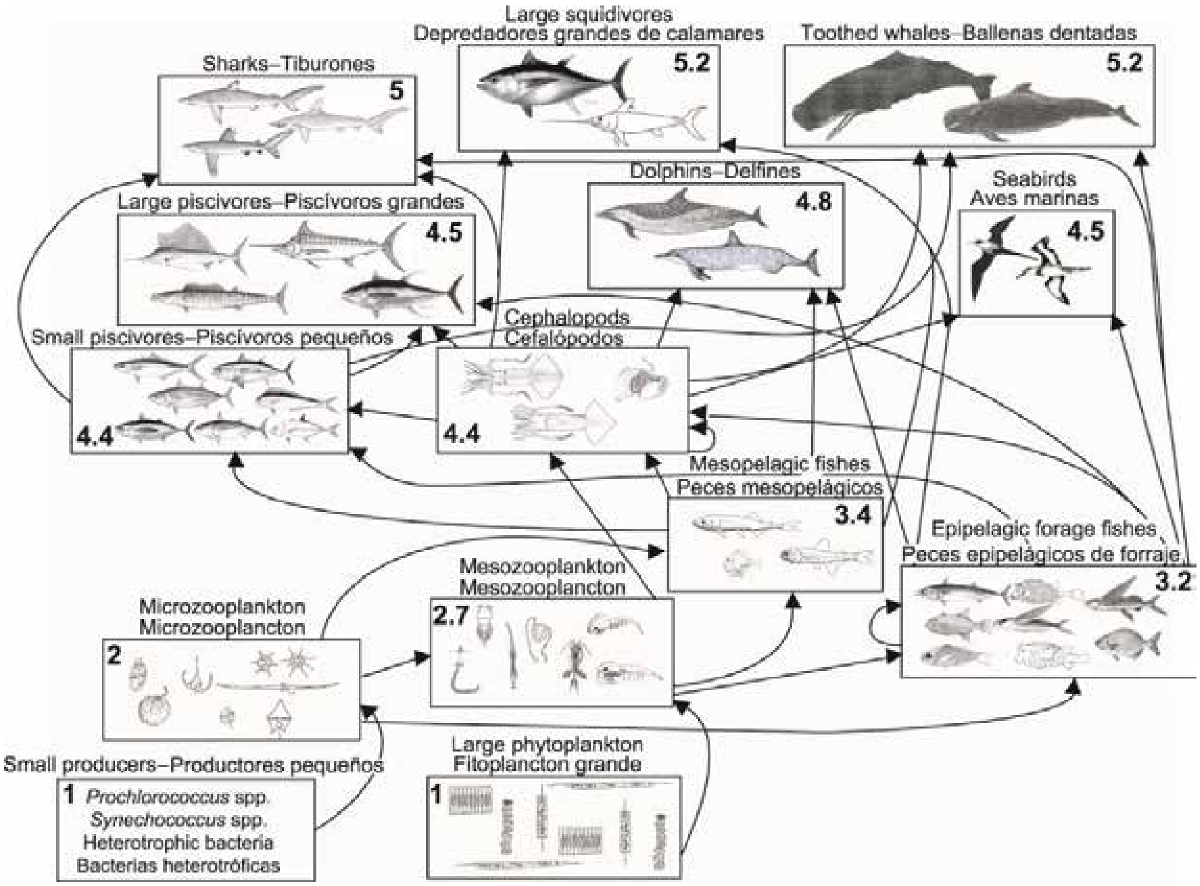


FIGURE J-12. Simplified food-web diagram of the pelagic ecosystem in the tropical EPO. The numbers inside the boxes indicate the approximate trophic level of each group.
FIGURA J-12. Diagrama simplificado de la red trófica del ecosistema pelágico en el OPO tropical. Los números en los recuadros indican el nivel trófico aproximado de cada grupo.

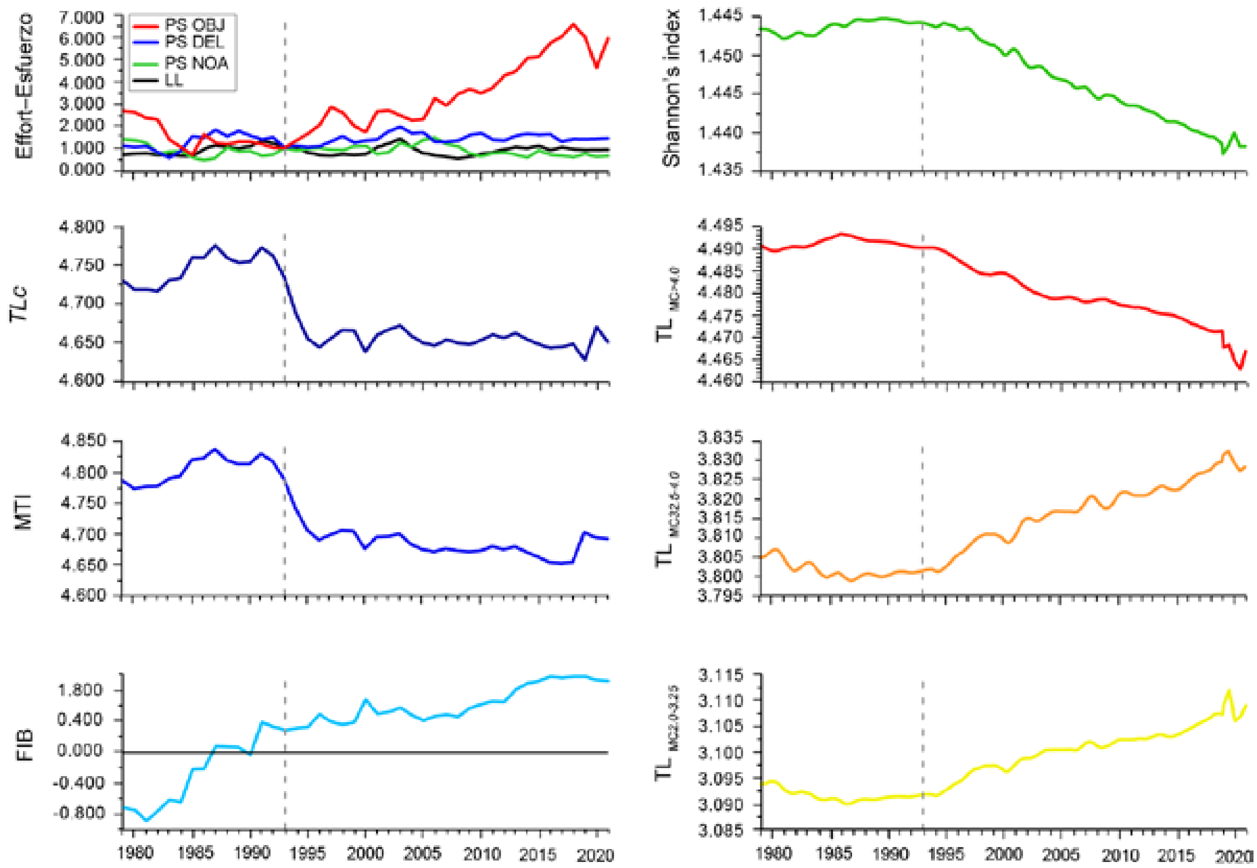


FIGURE J-13. Annual values for seven ecological indicators of changes in different components of the tropical EPO ecosystem, 1979–2021 (see Section 6 of text for details), and an index of longline (LL) and purse-seine (PS) fishing effort, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)), relative to the model start year of 1993 (vertical dashed line), when the expansion of the purse-seine fishery on FADs began.

FIGURA J-13 Valores anuales de siete indicadores ecológicos de cambios en diferentes componentes del ecosistema del OPO tropical, 1979–2021 (ver detalles en la sección 6 del texto), y un índice de esfuerzo palangrero (LL) y cerquero (PS), por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)) relativo al año de inicio del modelo de 1993 (línea de trazos vertical), cuando comenzó la expansión de la pesquería cerquera sobre plantados.

Table J-1a. Estimated number of individuals of incidental dolphin mortalities by set type and stock in the eastern Pacific Ocean by the purse-seine fishery from 1993-2022. Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Data for 2022 are considered preliminary.
Tabla J-1a. Número estimado de individuos de mortalidades incidentales de delfines por la pesquería de cerco durante 1993-2022, por tipo de lance y población en el Océano Pacífico oriental. Tipos de lances de cerco: sobre objetos flotantes (OBJ), no asociados (NOA) y sobre delfines (DEL). Los datos de 2022 se consideran preliminares.

	Northeastern spotted Purse seine			Western-southern spotted Purse seine			Eastern spinner Purse seine			Whitebelly spinner Purse seine		
Year	DEL	NOA	OBJ	DEL	NOA	OBJ	DEL	NOA	OBJ	DEL	NOA	OBJ
1993	1,112	-	-	773	-	-	725	-	-	437	-	-
1994	847	-	-	1,228	-	-	828	-	-	640	-	-
1995	952	-	-	859	-	-	654	-	-	431	5	-
1996	818	-	-	545	-	-	450	-	-	447	-	-
1997	718	3	-	1,044	-	-	391	-	-	498	-	-
1998	298	-	-	341	-	-	422	-	-	249	-	-
1999	358	-	-	253	-	-	363	-	-	192	-	-
2000	295	-	-	435	-	-	275	-	-	262	-	-
2001	592	-	-	315	-	-	470	-	-	374	-	-
2002	435	-	-	203	-	-	403	-	-	182	-	-
2003	288	-	-	335	-	-	290	-	-	170	-	-
2004	261	-	-	256	-	-	223	-	-	214	-	-
2005	273	-	-	100	-	-	275	-	-	108	-	-
2006	147	-	-	135	-	-	160	-	-	144	-	-
2007	189	-	-	116	-	-	175	-	-	113	-	-
2008	184	-	-	167	-	-	349	-	-	171	-	-
2009	266	-	-	254	-	-	288	-	-	222	-	-
2010	170	-	-	135	-	-	510	-	-	92	-	-
2011	172	-	-	124	-	-	467	-	-	139	-	-
2012	151	-	-	187	-	-	324	-	-	107	-	-
2013	158	-	-	145	-	-	303	-	-	111	-	-
2014	181	-	-	168	-	-	356	-	-	183	-	-
2015	191	-	-	158	-	-	196	-	-	139	-	-
2016	127	-	-	111	-	-	243	-	-	89	-	-
2017	85	-	-	183	-	-	266	-	-	95	-	-
2018	99	-	-	197	-	-	252	-	-	205	-	-
2019	104	-	-	220	-	-	269	-	-	143	-	-
2020	106	-	-	153	-	-	251	-	-	138	-	-
2021	166	-	-	173	-	-	194	-	-	172	-	-
2022	147	-	-	197	-	-	271	-	-	300	-	-
Total	9,891	3	-	9,511	-	-	10,644	-	-	6,768	5	-

Table J-1a continued

	Northern common Purse seine			Central common Purse seine			Southern common Purse seine			Other dolphins Purse seine		
Year	DEL	NOA	OBJ	DEL	NOA	OBJ	DEL	NOA	OBJ	DEL	NOA	OBJ
1993	139	-	-	230	-	-	-	-	-	178	-	7
1994	75	10	-	170	-	-	-	-	-	291	7	-
1995	9	-	-	192	-	-	-	-	-	171	1	-
1996	77	-	-	51	-	-	30	-	-	129	-	-
1997	9	-	-	114	-	-	58	-	-	150	-	20
1998	256	5	-	172	-	-	14	19	-	84	16	-
1999	85	-	-	34	-	-	1	-	-	59	3	-
2000	54	-	-	223	-	-	10	-	-	57	24	1
2001	94	-	-	205	-	-	46	-	-	44	-	-
2002	69	-	-	155	-	-	3	-	-	34	9	6
2003	133	-	-	140	-	-	97	-	-	37	-	2
2004	148	8	-	97	-	-	225	-	-	37	-	-
2005	114	-	-	57	-	-	154	-	-	70	-	-
2006	129	-	-	86	-	-	40	-	-	43	2	-
2007	55	-	-	69	-	-	95	-	-	25	1	-
2008	103	1	-	14	-	-	137	-	-	43	-	-
2009	107	2	-	30	-	-	49	-	-	21	-	-
2010	124	-	-	116	-	-	8	-	-	14	-	1
2011	25	10	-	12	-	-	9	-	-	28	-	-
2012	49	-	-	4	-	-	30	-	-	18	-	-
2013	69	-	-	-	-	-	8	-	-	6	1	-
2014	49	-	-	13	-	-	9	-	-	15	-	1
2015	43	-	-	21	-	-	12	-	-	5	-	-
2016	82	-	-	36	-	-	9	-	-	4	-	1
2017	24	2	-	9	-	-	16	-	-	3	-	-
2018	41	-	-	1	-	-	18	-	-	6	-	-
2019	25	-	-	3	-	-	2	-	-	10	-	2
2020	1	-	-	18	-	-	3	-	-	19	-	-
2021	3	-	-	6	-	-	5	-	-	6	-	-
2022	23	-	-	2	-	-	20	-	-	5	-	-
Total	2,214	38	-	2,280	-	-	1,108	19	-	1,612	64	41

Table J-1b. Minimum number of marine mammal interactions and mortalities in 2021 reported by observers onboard longline vessels under the current mandate of at least 5% coverage (C-19-08) of each CPC fleet operating in the eastern Pacific Ocean. All reported marine mammal interactions were precautionarily presumed to be mortalities (i.e., disposition was either not reported or reported as "Injured"). These data are considered incomplete as some CPCs suspended their observer programs due to the COVID-19 pandemic and data are insufficient for expanding to fleet totals (BYC-10 INF-D) (see section 2.2 for uncertainty and data gaps associated with longline data reporting).

Tabla J-1b. Número mínimo de interacciones con mamíferos marinos y mortalidades en 2021 reportadas por observadores a bordo de buques palangreros bajo el mandato actual de al menos 5% de cobertura (C-19-08) de cada flota de los CPC que opera en el Océano Pacífico oriental. Se supuso precautoriamente que todas las interacciones con mamíferos marinos reportadas resultaron en mortalidades (es decir, no se reportó la disposición o se reportó como "Herido"). Estos datos se consideran incompletos ya que algunos CPC suspendieron sus programas de observadores debido a la pandemia de COVID-19 y los datos son insuficientes para expandirlos a totales de la flota (BYC-10 INF-D) (ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos asociadas a la notificación de datos de palangre)

Marine Mammal taxa	Interactions	Mortalities
Bottlenose dolphin, *Tursiops truncatus*	1	1
Unidentified spinner dolphin, *Stenella longirostris*	2	2
Dolphin, nei, Delphinidae	2	2
False killer whale, *Pseudorca crassidens*	4	4
Pygmy killer whale, *Feresa attenuata*	1	1
Unidentified cetacean, nei, Cetacea	1	1
Total numbers	11	11

Table J-2a. Estimated number of turtle interactions and mortalities by observers onboard purse-seine size-class 6 vessels with a carrying capacity >363 t (1993–2022). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Data for 2022 are considered preliminary.

Tabla J-2a. Número estimado de mortalidades e interacciones de tortugas por observadores a bordo de buques cerqueros de clase 6 con una capacidad de acarreo >363 t (1993–2022). Tipos de lances cerqueros: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Los datos de 2022 se consideran preliminares.

	Lepidochelys olivacea, olive Ridley (LKV)						*Chelonia agassizii, Chelonia mydas*, eastern Pacific green (TUG)						*Caretta caretta*, loggerhead (TTL)					
	Purse seine						Purse seine						Purse seine					
	interactions			mortality			interactions			mortality			interactions			mortality		
Year	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL
1993	285	376	102	24	41	13	54	220	18	2	13	-	3	51	2	-	4	-
1994	455	114	137	50	17	13	132	170	12	7	9	-	6	15	2	-	2	-
1995	537	89	117	66	11	14	181	196	8	10	2	1	9	52	3	-	2	-
1996	520	97	96	47	9	9	138	63	4	11	1	-	12	18	2	-	-	-
1997	544	439	112	54	33	7	164	59	16	8	3	2	7	38	3	1	3	1
1998	649	116	209	66	22	20	141	13	20	7	1	1	15	5	4	1	-	-
1999	1,005	140	160	82	18	9	130	16	21	5	2	4	9	9	2	1	3	-
2000	463	248	139	46	29	11	93	17	5	6	-	-	4	6	1	2	-	-
2001	802	162	136	51	11	4	164	24	8	6	2	-	10	1	2	1	-	-
2002	767	97	165	23	3	7	110	11	15	3	-	-	14	5	8	-	-	-
2003	762	147	168	16	4	3	107	25	15	-	-	-	14	4	6	-	-	-
2004	624	110	120	8	3	2	65	38	8	-	-	-	10	11	13	-	-	-
2005	606	872	249	7	6	4	101	122	21	1	1	-	5	15	14	-	-	-
2006	595	337	140	8	4	3	106	119	23	2	-	-	39	19	14	1	-	-
2007	450	494	210	6	1	3	83	56	31	-	1	-	56	38	12	1	-	-
2008	408	27	147	4	-	-	54	20	12	-	-	-	45	5	12	1	-	-
2009	464	30	110	10	-	2	56	12	19	1	-	-	30	5	20	-	-	-
2010	424	128	212	4	3	1	71	20	23	-	2	-	34	24	23	1	-	-
2011	502	96	115	6	-	1	70	89	25	1	1	-	29	46	16	-	1	-
2012	388	53	91	5	-	-	77	42	5	-	-	-	19	19	17	-	-	-
2013	454	20	66	7	1	-	61	10	7	1	-	-	24	9	8	-	-	-
2014	304	19	83	3	-	-	69	16	10	-	-	-	27	1	4	1	-	-
2015	195	49	78	2	-	1	54	12	21	-	-	-	28	6	13	-	-	-
2016	333	49	113	4	-	-	78	35	17	-	-	-	19	21	9	-	-	-
2017	285	24	72	2	-	1	39	21	34	-	-	-	31	20	7	-	-	-
2018	150	5	147	2	-	-	50	24	96	2	-	-	17	7	4	-	-	-
2019	170	28	129	1	-	-	72	13	10	-	-	-	14	46	9	-	-	-
2020	91	14	197	-	-	-	29	4	11	-	-	-	17	3	4	-	-	-
2021	191	2	54	1	-	1	32	17	3	-	-	-	13	5	11	-	-	-
2022	133	2	33	-	-	-	40	-	4	-	-	-	19	3	6	-	-	-
Total	13,557	4,385	3,908	606	215	130	2,619	1,485	522	73	38	8	579	507	251	11	14	1

Table J-2a continued

	Eretmochelys imbricata, hawksbill						*Dermochelys coriacea*, leatherback						Unidentified turtles					
	Purse seine						Purse seine						Purse seine					
	interactions			mortality			interactions			mortality			interactions			mortality		
Year	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**
1993	1	1	2	-	-	-	2	-	3	-	-	-	66	89	38	3	16	2
1994	5	5	4	-	2	-	3	2	-	1	-	-	151	27	83	34	2	9
1995	8	2	-	-	-	-	-	-	-	-	-	-	130	27	52	24	7	3
1996	8	-	6	-	-	1	5	-	-	-	-	-	151	58	37	30	6	2
1997	4	2	-	-	-	-	3	1	1	-	-	-	180	72	46	25	15	2
1998	7	-	3	3	-	-	1	2	1	-	-	-	121	24	97	26	8	7
1999	4	5	2	1	-	1	-	-	-	-	-	-	202	28	65	39	4	3
2000	4	1	3	1	-	-	1	1	1	-	-	-	92	68	74	17	9	2
2001	5	1	3	1	-	-	-	-	1	-	-	-	206	43	96	22	14	5
2002	8	1	2	-	-	-	1	1	-	-	-	-	175	33	82	6	5	2
2003	6	1	6	-	-	-	-	1	1	-	-	-	169	40	117	5	-	3
2004	12	4	3	-	-	-	1	4	4	-	-	-	151	53	48	4	2	-
2005	1	2	9	-	-	-	1	1	3	-	-	-	103	126	73	4	7	1
2006	12	11	4	-	-	-	1	3	2	-	-	-	184	64	77	1	-	-
2007	9	8	2	1	2	-	3	2	2	-	-	-	130	240	191	7	-	2
2008	7	-	12	-	-	-	2	3	2	-	-	-	182	18	107	1	-	-
2009	8	-	6	-	-	-	1	-	2	-	-	-	141	16	95	3	1	1
2010	11	-	4	1	-	-	3	-	-	-	-	-	122	24	187	3	1	1
2011	5	5	4	-	-	-	1	1	1	-	-	-	125	28	63	-	1	-
2012	4	-	2	-	-	-	1	1	-	-	-	-	99	19	40	3	-	-
2013	7	-	2	1	-	-	1	2	2	-	-	-	175	13	51	2	-	-
2014	7	1	2	-	-	1	7	1	2	-	-	-	132	18	53	1	-	-
2015	2	1	2	-	-	-	4	2	-	-	-	-	174	152	42	-	4	-
2016	14	3	5	-	-	-	2	1	-	-	-	-	307	59	120	2	-	-
2017	7	3	5	-	-	-	2	1	1	-	-	-	243	43	83	-	-	-
2018	7	2	1	-	-	-	3	-	1	-	-	-	160	22	169	-	-	-
2019	5	2	-	-	-	-	-	-	-	-	-	-	193	155	59	-	1	-
2020	5	1	-	-	-	-	2	1	-	-	-	-	108	8	45	1	-	1
2021	4	1	-	-	-	-	1	-	-	-	-	-	102	5	53	-	-	-
2022	10	1	-	-	-	-	2	1	1	-	-	-	92	1	23	-	-	-
Total	197	64	94	9	4	3	54	32	31	1	-	-	4,567	1,571	2,365	264	103	46

Table J-2b. Minimum number of sea turtle interactions and mortalities in 2021 reported by observers onboard longline vessels under the current mandate of at least 5% coverage (C-19-08) of each CPC fleet operating in the eastern Pacific Ocean. Dispositions considered to indicate a survival event are those reported by observers as “Alive and Healthy”, “Light injuries” and “Released with a hook”, while those considered to indicate a mortality event are dispositions reported as “Dead”, “Discarded”, “Grave Injuries”, “Injured”, “Alive and injured”, or precautionarily where disposition was not reported. For 2021, all sea turtle interactions were precautionarily presumed to result in mortalities as dispositions were reported as “Injured”, “Dead” or not reported. These data are considered incomplete as some CPCs suspended their observer programs due to the COVID-19 pandemic and data are insufficient for expanding to fleet totals (BYC-10 INF-D) (see section 2.2 for uncertainty and data gaps associated with longline data reporting).

Tabla J-2b. Número mínimo de interacciones con tortugas marinas y mortalidades en 2021 reportadas por observadores a bordo de buques palangreros bajo el mandato actual de al menos 5% de cobertura (C-19-08) de cada flota de los CPC que opera en el Océano Pacífico oriental. Las disposiciones que se considera que indican un evento de supervivencia son las reportadas por los observadores como "Viva y sana", "Heridas leves" y "Liberada con un anzuelo", mientras que las que se considera que indican un evento de mortalidad son las disposiciones reportadas como "Muerta", "Descartada", "Heridas graves", "Herida", "Viva y herida" o, de manera precautoria, cuando la disposición no fue reportada. Para 2021, se supuso precautoriamente que todas las interacciones con tortugas marinas resultaron en mortalidades, ya que las disposiciones fueron reportadas como "Herida", "Muerta" o no se reportaron. Estos datos se consideran incompletos ya que algunos CPC suspendieron sus programas de observadores debido a la pandemia de COVID-19 y los datos son insuficientes para expandirlos a totales de la flota (BYC-10 INF-D) (ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos asociadas a la notificación de datos de palangre).

Sea turtle taxa	Interactions	Mortalities
Olive ridley turtle, *Lepidochelys olivacea*	5	5
Loggerhead turtle, *Caretta caretta*	3	3
Total numbers	8	8

Table J-3. Minimum number of seabird interactions in 2021 reported by observers onboard longline vessels under the current mandate of at least 5% coverage (C-19-08) of each CPC fleet operating in the eastern Pacific Ocean. All reported seabird interactions are precautionarily presumed to be mortalities (i.e., disposition was reported as "Discarded" or not reported). These data are considered incomplete as some CPCs suspended their observer programs due to the COVID-19 pandemic and data are insufficient for expanding to fleet totals (BYC-10 INF-D) (see section 2.2 for uncertainty and data gaps associated with longline data reporting).

Tabla J-3. Número mínimo de interacciones con aves marinas en 2021 reportadas por observadores a bordo de buques palangreros bajo el mandato actual de al menos 5% de cobertura (C-19-08) de cada flota de los CPC que opera en el Océano Pacífico oriental. Se supone precautoriamente que todas las interacciones con aves marinas reportadas son mortalidades (es decir, la disposición fue reportada como "Descartada" o no fue reportada). Estos datos se consideran incompletos ya que algunos CPC suspendieron sus programas de observadores debido a la pandemia de COVID-19 y los datos son insuficientes para expandirlos a totales de la flota (BYC-10 INF-D) (ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos asociadas a la notificación de datos de palangre).

Seabird taxa	Interactions	Mortalities
White-chinned petrel, *Procellaria aequinoctialis*	63	63
Wandering albatross, *Diomedea exulans*	58	58
Black-browed albatross, *Thalassarche melanophrys*	53	53
Laysan albatross, *Phoebastria immutabilis*	45	45
Black-footed albatross, *Phoebastria nigripes*	44	44
Cape petrel, *Daption capense*	27	27
Albatross nei, *Diomedea* spp.	25	25
Boobies and gannets nei, Sulidae	16	16
White-capped albatross, *Thalassarche steadi*	3	3
Terns nei, *Sterna* spp.	3	3
Great shearwater, *Puffinus gravis*	2	2
Petrels or shearwaters nei, Procellariidae	1	1
Total numbers	340	340

Table J-4a. Estimated purse-seine catches by set type in metric tons (t) of sharks by observers onboard size-class 6 vessels with a carrying capacity >363 t (1993–2022) and minimum reported longline (LL) catches of sharks (gross-annual removals in t) (1993–2021, *data not available; see section 2.2. for uncertainty and data gaps in reporting of bycatch caught by longline). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2021 (longline) and 2022 (purse-seine) are considered preliminary.

Tabla J-4a. Capturas cerqueras estimadas de tiburones, por tipo de lance, en toneladas (t), por observadores a bordo de buques de clase 6 con una capacidad de acarreo >363 t (1993–2022) y capturas palangreras (LL) mínimas reportadas de tiburones (extracciones anuales brutas en t) (1993–2021, *datos no disponibles; ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos en la notificación de especies capturadas incidentalmente con palangre). Tipos de lances cerqueros: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las especies en negritas se discuten en el texto principal. Los datos de 2021 (palangre) y 2022 (cerco) se consideran preliminares.

	Carcharhinidae															
	***Carcharhinus falciformis*, silky shark**				***Carcharhinus longimanus*, oceanic whitetip**				***Prionace glauca*, blue shark**				Other Carcharhinidae, requiem sharks			
	Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	447	360	51	-	44	18	9	-	<1	2	<1	360	2	5	3	-
1994	439	244	38	-	119	9	4	-	<1	1	<1	209	24	14	5	-
1995	471	120	162	-	200	36	18	-	<1	5	<1	280	4	2	11	-
1996	442	107	47	-	209	5	12	-	2	<1	<1	606	12	<1	7	-
1997	843	188	42	-	236	11	6	-	2	<1	<1	425	18	3	5	-
1998	710	59	171	-	211	7	5	-	1	<1	<1	1,164	4	<1	<1	-
1999	460	100	74	-	163	7	2	-	<1	<1	<1	2,185	9	<1	<1	-
2000	308	97	30	-	98	9	2	-	<1	<1	<1	2,112	5	<1	<1	-
2001	399	76	53	-	96	<1	<1	-	4	<1	<1	2,304	9	<1	-	-
2002	291	142	35	-	31	6	<1	<1	1	<1	<1	2,356	4	17	<1	-
2003	320	102	59	-	19	<1	<1	-	<1	<1	<1	2,054	7	6	<1	-
2004	247	68	76	-	9	<1	<1	<1	<1	<1	-	2,325	5	3	<1	-
2005	322	41	51	-	2	-	<1	-	<1	<1	-	2,825	4	2	3	-
2006	361	46	27	13,053	5	<1	<1	46	<1	1	<1	1,341	13	3	8	280
2007	316	156	41	12,771	2	-	<1	136	<1	1	-	3,169	8	24	11	419
2008	577	27	25	11,205	2	-	<1	55	<1	1	<1	6,838	11	<1	1	741
2009	339	31	33	14,042	4	<1	<1	294	<1	<1	<1	6,678	29	4	20	431
2010	347	66	70	12,510	2	-	<1	94	<1	1	1	10,130	17	10	21	4,259
2011	266	26	55	12,866	2	-	<1	63	<1	<1	1	13,863	20	6	4	4,730
2012	200	33	52	10,585	<1	<1	-	1	<1	2	<1	12,565	8	<1	1	4,082
2013	212	55	38	14,762	<1	<1	-	5	<1	<1	1	12,237	12	2	3	753
2014	422	68	45	5,511	2	-	-	25	1	<1	<1	10,728	13	<1	5	1,515
2015	540	133	48	5,690	3	<1	<1	647	<1	<1	<1	13,194	31	7	2	1,901
2016	488	36	63	9,610	5	<1	<1	755	<1	2	1	12,381	35	<1	3	2,755
2017	665	12	21	15,893	4	<1	<1	3	<1	<1	-	11,086	54	<1	2	2,562
2018	397	12	16	15,072	3	-	<1	19	<1	<1	<1	12,499	28	3	1	1,360
2019	392	13	25	2,599	5	<1	<1	-	<1	<1	<1	11,070	26	4	6	10
2020	345	11	33	14,752	4	-	<1	-	<1	<1	-	15,080	87	5	4	2,896
2021	542	10	21	12	12	<1	<1	-	<1	<1	<1	8,323	30	<1	<1	-
2022	615	23	7	*	11	<1	<1	*	1	<1	-	*	30	2	2	*
Total	12,726	2,463	1,508	17,0932	1,505	111	64	2,143	21	24	9	18,0390	558	130	131	28,695

Table J-4a Continued

	Sphyrnidae															
	***Sphyrna zygaena*, smooth hammerhead**				*Sphyrna lewini*, scalloped hammerhead				*Sphyrna* mokarran, great hammerhead				*Sphyrna* spp., hammerheads, nei			
	Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	-	<1	-	-	<1	1	-	-	<1	-	-	-	41	17	8	-
1994	1	2	<1	-	<1	4	<1	-	-	-	-	-	102	24	2	-
1995	2	2	-	-	<1	<1	<1	-	<1	-	-	-	71	15	4	-
1996	4	2	-	-	1	<1	-	-	<1	-	-	-	87	39	5	-
1997	21	2	<1	-	10	3	<1	-	1	<1	<1	-	63	10	3	-
1998	18	5	1	-	8	9	<1	-	3	<1	3	-	37	12	5	-
1999	21	3	<1	-	16	3	1	-	1	<1	<1	-	18	5	3	-
2000	11	4	<1	-	7	15	1	-	7	<1	<1	-	7	2	7	-
2001	24	1	<1	-	12	1	<1	-	5	-	<1	-	23	<1	1	-
2002	24	3	1	-	47	<1	1	-	7	-	<1	-	46	4	2	-
2003	49	6	1	-	38	3	3	-	13	<1	<1	-	52	3	2	-
2004	51	11	3	-	25	3	2	-	3	<1	<1	-	60	2	<1	-
2005	34	2	<1	-	25	10	3	-	2	-	<1	-	19	<1	<1	<1
2006	33	6	2	58	19	3	1	-	1	<1	<1	-	3	<1	<1	5
2007	27	5	<1	200	12	3	1	<1	-	<1	<1	-	1	1	<1	43
2008	16	<1	<1	381	16	11	<1	64	<1	-	<1	-	6	<1	1	42
2009	22	<1	<1	423	13	2	1	50	<1	-	-	-	5	1	<1	22
2010	28	1	2	508	13	1	1	143	<1	-	<1	-	3	<1	<1	118
2011	49	2	2	443	13	6	2	191	3	<1	<1	-	12	<1	1	131
2012	32	2	<1	118	9	4	<1	89	<1	<1	<1	-	5	2	1	130
2013	47	2	<1	311	22	2	<1	87	<1	<1	<1	-	9	1	<1	296
2014	35	<1	<1	593	23	2	<1	5	1	<1	<1	-	14	<1	<1	208
2015	32	1	<1	1,961	9	<1	<1	11	<1	<1	-	-	9	<1	<1	392
2016	24	1	<1	4,052	12	1	<1	6	5	<1	-	-	11	1	<1	338
2017	11	<1	<1	3,495	8	3	<1	83	<1	<1	<1	-	6	<1	<1	197
2018	11	<1	<1	851	7	<1	<1	<1	<1	-	-	-	6	<1	<1	173
2019	17	<1	<1	33	11	2	<1	43	1	-	<1	-	5	<1	<1	5
2020	7	<1	<1	941	13	<1	<1	39	<1	-	<1	-	5	<1	<1	1,021
2021	13	<1	<1	37	31	<1	<1	<1	2	-	<1	-	7	-	<1	-
2022	11	-	<1	*	47	<1	<1	*	<1	-	-	*	9	<1	<1	*
Total	676	69	22	14,406	470	97	26	814	62	4	5	-	741	146	52	3,122

Table J-4a Continued

	Alopiidae															
	***Alopias pelagicus*, pelagic thresher**				*Alopias superciliosus*, bigeye thresher				*Alopias vulpinus*, thresher shark				*Alopias* spp., thresher shark, nei			
	Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	-	2	<1	-	<1	2	3	-	-	<1	-	-	2	7	1	14
1994	-	<1	<1	-	-	6	<1	-	-	3	<1	-	<1	11	3	87
1995	<1	<1	<1	-	<1	2	<1	-	<1	1	1	-	1	6	3	200
1996	-	1	-	-	<1	1	<1	-	<1	<1	<1	-	<1	2	4	28
1997	<1	<1	-	-	<1	1	<1	-	<1	<1	<1	-	<1	4	<1	5
1998	<1	2	<1	-	<1	4	1	-	<1	2	<1	-	<1	5	3	5
1999	<1	4	2	-	<1	1	6	-	<1	<1	<1	-	<1	3	2	5
2000	<1	<1	<1	-	<1	8	1	-	<1	<1	<1	-	<1	<1	6	64
2001	<1	<1	<1	-	<1	4	2	-	<1	<1	<1	-	<1	4	1	172
2002	<1	<1	<1	-	2	8	1	-	<1	2	<1	-	<1	6	4	88
2003	1	5	3	-	<1	8	6	-	<1	<1	<1	-	<1	4	3	134
2004	6	3	2	-	<1	16	1	-	<1	2	<1	-	<1	4	2	43
2005	1	3	2	-	<1	6	3	-	<1	1	2	-	<1	<1	<1	12
2006	2	23	2	-	<1	22	3	187	<1	7	<1	60	<1	3	<1	8
2007	3	3	6	1,133	2	3	3	115	<1	<1	<1	35	<1	1	1	15
2008	1	3	3	4,323	<1	3	3	240	<1	2	<1	38	<1	1	2	17
2009	<1	<1	1	4,909	<1	<1	2	343	<1	<1	<1	76	<1	<1	1	4
2010	<1	<1	3	7,828	<1	<1	2	373	1	<1	<1	34	<1	<1	1	389
2011	<1	2	2	7,302	<1	2	2	458	<1	<1	<1	61	<1	1	<1	430
2012	<1	1	2	7	<1	1	2	326	<1	<1	<1	86	<1	1	<1	526
2013	<1	<1	3	46	<1	<1	2	543	<1	<1	<1	49	<1	<1	1	109
2014	<1	1	2	36	<1	3	2	636	<1	<1	<1	2	<1	<1	<1	850
2015	<1	2	1	463	<1	1	<1	859	<1	-	<1	13	<1	<1	<1	283
2016	<1	2	3	1,045	<1	<1	4	944	<1	1	<1	549	<1	<1	1	96
2017	<1	<1	<1	582	<1	<1	<1	1,148	-	<1	<1	1,682	<1	<1	<1	153
2018	<1	2	<1	464	<1	<1	<1	32	<1	<1	<1	1,684	<1	<1	<1	39
2019	1	<1	<1	444	<1	<1	<1	17	-	-	<1	1	<1	<1	<1	31
2020	<1	<1	2	342	<1	<1	1	1,273	-	-	<1	746	<1	<1	<1	6
2021	<1	<1	<1	1	<1	<1	<1	3	<1	<1	<1	<1	<1	<1	<1	1
2022	<1	<1	<1	*	<1	<1	<1	*	<1	<1	<1	*	<1	<1	<1	*
Total	23	66	45	28,925	17	108	55	7,496	5	28	13	5,116	15	70	47	3,814

Table J-4a Continued

	Lamnidae								Triakidae											
	***Isurus* spp., mako sharks**				Lamnidae spp., mackerel sharks, porbeagles nei				Triakidae spp., houndsharks, nei				Other sharks				All sharks			
	Purse seine				Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	<1	2	<1	383	-	<1	-	-	-	-	-	-	84	19	14	271	623	438	90	1,028
1994	2	<1	<1	156	-	-	-	-	-	-	-	-	69	47	7	782	759	367	62	1,234
1995	2	<1	<1	216	-	-	-	-	-	-	-	-	103	29	13	226	856	220	213	922
1996	1	<1	<1	318	-	-	-	-	-	-	-	-	69	41	34	168	830	202	110	1,120
1997	2	1	-	361	-	-	-	-	-	-	-	-	88	4	2	166	1,287	230	62	956
1998	1	<1	<1	693	-	-	-	-	-	-	-	-	90	10	6	237	1,085	116	198	2,099
1999	<1	<1	<1	460	-	-	-	-	-	-	-	-	50	12	4	3,347	739	140	97	5,997
2000	2	<1	-	502	-	-	-	-	-	-	-	-	21	67	178	5,740	466	207	227	8,418
2001	2	<1	<1	1,168	-	-	-	-	-	-	-	-	29	4	2	8,896	605	94	62	12,540
2002	4	<1	<1	1,131	-	-	-	-	-	-	-	1,484	40	11	3	7,339	497	201	51	12,398
2003	2	<1	<1	1,156	-	-	-	-	-	-	-	1,287	12	37	4	9,866	516	177	83	14,498
2004	1	<1	<1	1,374	-	-	-	-	-	-	-	846	36	10	5	6,684	446	125	95	11,273
2005	1	2	<1	1,367	-	-	-	-	-	-	-	838	5	1	1	7,075	417	71	67	12,117
2006	2	4	<1	95	-	-	-	2	-	-	-	674	8	<1	<1	4,770	449	118	46	20,579
2007	2	2	-	181	-	-	-	1	-	-	-	996	5	3	1	5,786	380	203	67	25,000
2008	<1	2	<1	707	-	-	-	1	-	-	-	1,398	12	<1	2	4,091	644	52	40	30,141
2009	1	<1	<1	534	-	-	-	7	-	-	-	695	19	3	1	2,478	434	46	63	30,988
2010	3	<1	<1	1,901	-	-	-	<1	-	-	-	<1	17	4	2	2,246	433	87	104	40,533
2011	3	2	<1	2,802	-	-	-	26	-	-	-	7	30	<1	<1	2,074	401	51	72	45,449
2012	2	2	<1	2,120	-	-	-	12	-	-	-	-	10	<1	<1	1,242	272	50	62	31,889
2013	1	<1	<1	2,121	-	-	-	44	-	-	-	211	45	2	<1	1,517	351	67	49	33,090
2014	2	<1	<1	2,778	-	-	-	51	-	-	-	4,067	24	<1	<1	2,075	540	78	56	29,082
2015	<1	<1	<1	3,118	-	-	-	79	-	-	-	621	18	3	3	10,593	645	151	58	39,823
2016	1	<1	<1	2,476	-	-	-	91	-	-	-	538	19	3	<1	2,245	602	50	78	37,880
2017	<1	<1	-	3,256	-	-	-	112	-	-	-	987	16	1	<1	1,267	766	21	27	42,506
2018	2	<1	<1	3,161	-	-	-	111	-	-	-	730	5	<1	<1	1,161	460	21	20	37,357
2019	<1	<1	<1	2,021	-	-	-	8	-	-	-	<1	6	<1	<1	18	465	23	34	16,302
2020	2	<1	-	3,694	-	-	-	95	-	-	-	1,032	3	2	<1	2,261	467	21	42	44,178
2021	2	<1	-	1,399	-	-	-	7	-	-	-	2	6	<1	<1	32	646	12	24	9,820
2022	1	<1	-	*	-	-	-	*	-	-	-	*	2	<1	<1	*	731	27	11	*
Total	49	28	4	41,649	-	<1	-	649	-	-	-	16,414	942	319	287	94,652	17,810	3,663	2,270	59,9216

Table J-4b. Minimum number of shark interactions and mortalities in 2021 reported by observers onboard longline vessels under the current mandate of at least 5% coverage (C-19-08) of each CPC fleet operating in the eastern Pacific Ocean. Data are considered incomplete as some CPCs suspended their observer programs due to the COVID-19 pandemic and data are insufficient for expanding to fleet totals (BYC-10 INF-D) (see section 2.2 for uncertainty and data gaps associated with longline data reporting). Dispositions considered to indicate a survival event are those reported by observers as “Alive and Healthy”, “Alive with light injuries” and “Alive”, while those considered to indicate a mortality event are dispositions reported as “Dead”, “Alive mortal”, “Alive injured”, “Discarded”, “Unknown”, or precautionarily where disposition was not reported.

Tabla J-4b. Número mínimo de interacciones con tiburones y mortalidades en 2021 reportadas por observadores a bordo de buques palangreros bajo el mandato actual de al menos 5% de cobertura (C-19-08) de cada flota de los CPC que opera en el Océano Pacífico oriental. Los datos se consideran incompletos ya que algunos CPC suspendieron sus programas de observadores debido a la pandemia de COVID-19 y los datos son insuficientes para expandirlos a totales de la flota (BYC-10 INF-D) (ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos asociadas a la notificación de datos de palangre). Las disposiciones que se considera que indican un evento de supervivencia son las reportadas por los observadores como "Vivo y sano", "Vivo con heridas leves" y "Vivo", mientras que las que se considera que indican un evento de mortalidad son las disposiciones reportadas como "Muerto", "Vivo, mortalidad probable", “Vivo herido", “Descartado", "Desconocida" o precautoriamente cuando la disposición no fue reportada.

Shark taxa	Interactions	Mortalities
Blue shark, *Prionace glauca*	11,262	11,221
Short fin mako shark, *Isurus oxyrinchus*	975	975
Silky shark, *Carcharhinus falciformis*	486	477
Pelagic thresher shark, *Alopias pelagicus*	342	342
Bigeye thresher shark, *Alopias superciliosus*	207	195
Oceanic whitetip shark, *Carcharhinus longimanus*	181	172
Scalloped hammerhead shark, *Sphyrna lewini*	120	120
Crocodile shark, *Pseudocarcharias kamoharai*	62	44
Longfin mako shark, *Isurus paucus*	35	35
Sharks, rays, skates, etc. nei, Elasmobranchii	31	31
Velvet dogfish, *Scymnodon squamulosus*	30	28
Thresher shark, nei, *Alopias* spp.	19	11
Smooth hammerhead shark, *Sphyrna zygaena*	14	14
Thresher shark, *Alopias vulpinus*	13	13
Other sharks*	7	6
Total numbers	13,784	13,684
*"Other sharks" include those with ≤2 interactions from 5 taxa in 2021		

Table J-5a. Estimated purse-seine catches by set type in numbers of rays by observers onboard size-class 6 vessels with a carrying capacity >363 t (1993–2022). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2022 are considered preliminary.

Tabla J-5a. Capturas cerqueras estimadas de rayas, por tipo de lance, en número de rayas, por observadores a bordo de buques de clase 6 con una capacidad de acarreo >363 t (1993–2022). Tipos de lances cerqueros: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las especies en negritas se discuten en el texto principal. Los datos de 2022 se consideran preliminares.

	Mobulidae														
	***Mobula thurstoni*, smoothtail manta**			***Mobula mobular*, spinetail manta**			*Mobula munkiana*, munk's devil ray			*Mobula tarapacana*, chilean devil ray			***Mobula birostris*, giant manta**		
	Purse seine			Purse seine			Purse seine			Purse seine			Purse seine		
Year	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	3	-	-	-	-	-	-	-	-	-	-	1	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
1998	-	8	-	-	-	-	-	-	-	-	-	-	4	94	1
1999	-	2	1	-	-	-	-	-	-	-	-	-	10	63	1
2000	34	121	101	-	-	-	-	-	-	-	-	-	1	12	2
2001	7	185	98	2	8	16	-	-	3	4	-	-	2	6	6
2002	18	2,048	72	7	8	96	1	3	10	7	15	7	2	6	5
2003	37	707	141	6	79	11	7	35	26	-	-	8	3	10	1
2004	8	429	86	2	30	57	-	15	17	1	28	4	2	47	15
2005	14	72	205	16	111	126	-	21	14	3	42	79	10	23	36
2006	14	572	43	19	473	187	-	65	31	5	52	45	30	37	219
2007	14	64	105	32	202	148	2	29	24	24	37	55	5	17	8
2008	14	126	50	30	247	87	8	127	36	10	276	30	3	61	18
2009	22	31	93	17	56	243	9	45	6	2	21	190	1	11	6
2010	39	123	132	22	334	303	1	48	33	7	12	148	2	1,163	4
2011	6	397	27	18	104	152	11	58	29	9	28	78	5	9	1
2012	15	1,435	67	48	243	34	3	63	6	7	94	21	6	949	13
2013	25	180	40	18	112	62	6	55	6	7	29	26	1	24	21
2014	22	29	75	179	87	57	6	4	15	5	10	18	7	9	-
2015	14	41	101	61	21	338	6	11	74	12	25	93	1	67	38
2016	18	31	166	5	26	115	2	236	86	13	17	26	7	68	3
2017	11	52	43	45	26	15	8	15	10	10	-	11	8	53	11
2018	6	29	5	37	48	56	22	4	12	8	2	2	11	7	1
2019	7	214	11	35	167	61	9	-	8	24	8	18	2	11	3
2020	9	4	12	19	113	37	1	-	47	5	2	7	7	-	1
2021	8	-	-	34	46	16	10	5	-	11	3	13	1	26	-
2022	4	-	98	42	8	25	12	-	4	22	-	12	3	-	8
Total	367	6,904	1,771	693	2,549	2,243	125	839	497	197	702	892	135	2,777	422

Table J-5a Continued

	Mobulidae			Dasyatidae											
	Mobulidae spp., mobulid rays, nei			***Pteroplatytrygon violacea*, pelagic stingray**			**Dasyatidae spp., stingrays, nei**			Other rays			All rays		
	Purse seine			Purse seine			Purse seine			Purse seine			Purse seine		
Year	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL	OBJ	NOA	DEL
1993	297	5,736	503	80	1,983	134	-	-	-	-	-	-	377	7,719	637
1994	52	1,266	375	140	1,632	337	-	-	-	-	-	-	193	2,901	712
1995	69	2,248	500	159	151	144	-	-	-	-	-	-	228	2,400	643
1996	124	1,341	385	101	165	176	-	-	-	-	-	-	225	1,506	561
1997	126	707	396	106	106	993	-	-	-	-	-	-	232	816	1,390
1998	73	2,906	337	95	258	170	-	1,136	-	2	1	-	174	4,403	508
1999	140	1,498	474	164	403	151	-	-	-	-	-	-	314	1,966	627
2000	36	1,805	1,276	104	221	159	-	-	-	-	-	-	175	2,159	1,537
2001	50	289	447	150	64	174	-	-	-	-	-	-	215	553	744
2002	40	1,994	723	113	60	153	2	-	-	-	-	-	190	4,133	1,066
2003	130	1,005	904	94	9,188	135	-	-	-	-	-	-	277	11,025	1,226
2004	63	656	351	138	39	86	4	282	5	-	-	-	218	1,526	620
2005	36	259	177	91	52	173	9	13	20	-	1,724	-	179	2,317	831
2006	43	340	295	153	91	202	29	764	30	-	-	160	293	2,394	1,213
2007	40	205	237	98	54	132	9	931	21	-	19	-	225	1,557	730
2008	41	145	91	97	19	87	14	20	28	-	-	-	217	1,022	427
2009	37	107	270	116	17	105	5	4	68	-	-	-	209	292	981
2010	97	629	256	101	21	901	5	-	60	-	1,596	-	274	3,926	1,837
2011	27	227	81	92	193	90	13	114	18	-	24	-	181	1,154	476
2012	18	186	41	121	30	100	13	17	3	1	12	7	232	3,029	292
2013	15	121	323	90	59	255	27	2	6	-	-	403	189	582	1,142
2014	24	72	24	173	43	108	19	22	18	-	-	-	436	277	315
2015	20	54	141	82	65	163	11	5	32	-	-	-	207	289	980
2016	41	248	162	60	37	352	12	-	70	-	-	-	159	663	980
2017	141	290	100	258	76	130	31	68	144	-	-	137	512	580	601
2018	102	117	155	247	61	123	62	17	14	-	-	-	495	286	368
2019	87	484	165	255	185	143	40	38	27	-	8	1	460	1,114	437
2020	62	67	163	260	145	160	17	14	41	-	-	-	380	345	468
2021	85	73	154	388	178	117	46	3	14	-	25	-	584	360	314
2022	128	23	95	421	76	187	34	9	7	-	-	-	667	116	437
Total	2,244	25,099	9,601	4,548	15,672	6,339	403	3,459	626	3	3,409	709	8,716	61,410	23,100

Table J-5b. Minimum number of ray interactions and mortalities in 2021 reported by observers onboard longline vessels under the current mandate of at least 5% coverage (C-19-08) of each CPC fleet operating in the eastern Pacific Ocean. Data are considered incomplete as some CPCs suspended their observer programs due to the COVID-19 pandemic and data are insufficient for expanding to fleet totals (BYC-10 INF-D) (see section 2.2 for uncertainty and data gaps associated with longline data reporting). Dispositions considered to indicate a survival event are those reported by observers as "Alive and Healthy", "Alive with light injuries" and "Alive", while those considered to indicate a mortality event are dispositions reported as "Dead", "Alive mortal", Alive injured", Discarded", "Unknown", or precautionarily where disposition was not reported.

Tabla J-5b. Número mínimo de interacciones con rayas y mortalidades en 2021 reportadas por observadores a bordo de buques palangreros bajo el mandato actual de al menos 5% de cobertura (C-19-08) de cada flota de los CPC que opera en el Océano Pacífico oriental. Los datos se consideran incompletos ya que algunos CPC suspendieron sus programas de observadores debido a la pandemia de COVID-19 y los datos son insuficientes para expandirlos a totales de la flota (BYC-10 INF-D) (ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos asociadas a la notificación de datos de palangre). Las disposiciones que se considera que indican un evento de supervivencia son las reportadas por los observadores como "Viva y sana", "Viva con heridas leves" y "Viva", mientras que las que se considera que indican un evento de mortalidad son las disposiciones reportadas como "Muerta", "Viva, mortalidad probable", "Viva herida", "Descartada", "Desconocida" o precautoriamente cuando la disposición no fue reportada.

Ray taxa	Total interactions	Mortalities
Pelagic stingray, *Pteroplatytrygon violacea*	3,909	3,703
Stingray, nei, Dasyatidae	45	
Manta rays, Mobulidae	4	4
Total numbers	3,960	3,708
*"Other rays" include those with ≤2 interactions from 2 taxa in 2021.		

Table J-6a. Estimated purse-seine catches by set type in metric tons (t) of large fishes by observers onboard size-class 6 vessels with a carrying capacity >363 t (1993–2022) and minimum reported longline (LL) catches of large fishes (gross-annual removals in t) (1993–2021, *data not available , see section 2.2. for uncertainty and data gaps in reporting of bycatch caught by longline). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2021 (longline) and 2022 (purse-seine) are considered preliminary.

Tabla J-6a. Capturas cerqueras estimadas de peces grandes, por tipo de lance, en toneladas (t), por observadores a bordo de buques de clase 6 con una capacidad de acarreo >363 t (1993–22) y capturas palangreras (LL) mínimas reportadas de peces grandes (extracciones anuales brutas en t) (1993–2021, *datos no disponibles; ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos en la notificación de especies capturadas incidentalmente con palangre). Tipos de lances cerqueros: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las especies en negritas se discuten en el texto principal. Los datos de 2021 (palangre) y 2022 (cerco) se consideran preliminares.

	Coryphaenidae				Scombridae				Carangidae											
	Coryphaenidae spp., dorado				***Acanthocybium solandri, wahoo***				***Elagatis bipinnulata, rainbow runner***				*Seriola spp., amberjacks, nei*				*Caranx* spp., jacks, crevalles, nei			
	Purse seine				Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	702	14	<1	17	152	11	<1	2	16	<1	<1	-	-	-	-	-	-	-	-	-
1994	1,221	20	<1	46	472	1	1	<1	14	<1	<1	-	<1	-	-	-	-	-	-	-
1995	1,071	22	3	39	379	<1	<1	1	11	<1	<1	-	<1	<1	-	-	-	-	-	-
1996	1,312	18	<1	43	271	<1	<1	1	28	3	<1	-	4	-	-	-	-	-	-	-
1997	1,225	12	<1	6,866	475	3	1	<1	60	2	<1	-	1	-	-	-	<1	-	-	-
1998	816	18	<1	2,528	396	<1	4	2	93	<1	<1	-	4	-	-	-	<1	-	-	-
1999	1,238	4	<1	6,283	161	<1	<1	2	110	<1	<1	-	<1	-	-	-	<1	-	-	-
2000	1,437	51	2	3,537	277	2	<1	2	53	5	<1	-	<1	-	-	-	<1	-	-	-
2001	2,202	17	3	15,942	1,023	2	<1	6	90	<1	<1	-	1	-	-	-	<1	-	-	-
2002	1,815	8	<1	9,464	571	<1	<1	18	94	1	<1	-	<1	<1	-	-	<1	-	-	-
2003	894	11	1	5,301	428	<1	<1	164	108	2	-	-	1	<1	-	-	<1	-	-	-
2004	1,018	17	1	3,986	380	<1	<1	155	62	<1	-	-	56	9	<1	1	2	<1	-	-
2005	972	75	1	3,854	420	<1	<1	155	66	<1	<1	-	26	2	<1	-	2	1	-	-
2006	1,197	58	<1	3,408	424	1	<1	167	73	<1	<1	-	53	8	<1	-	10	220	<1	-
2007	1,235	47	1	6,907	421	2	<1	221	157	<1	-	-	18	80	<1	-	1	11	-	-
2008	1,112	17	2	15,845	249	1	<1	213	40	<1	<1	-	27	<1	-	-	17	18	-	-
2009	1,722	7	<1	17,136	547	<1	<1	336	28	<1	<1	-	13	<1	-	-	11	8	-	-
2010	912	3	<1	9,484	373	1	<1	284	17	<1	<1	-	3	23	-	-	1	48	-	-
2011	1,410	7	<1	12,438	169	2	<1	242	22	<1	-	-	7	33	-	<1	4	14	-	1
2012	1,705	18	<1	17,255	313	<1	<1	230	13	1	-	-	10	7	-	-	2	15	<1	-
2013	1,455	7	<1	11,249	518	1	<1	291	19	<1	-	-	6	<1	<1	-	4	2	<1	-
2014	1,779	9	<1	3,342	517	2	<1	287	15	<1	<1	-	6	2	-	-	3	<1	<1	-
2015	1,167	8	<1	1,206	357	1	<1	285	15	<1	-	-	6	<1	-	-	9	8	<1	-
2016	949	7	<1	446	318	2	<1	321	26	<1	<1	-	12	<1	<1	-	4	<1	8	-
2017	1,557	11	<1	2,118	335	<1	<1	319	18	<1	<1	-	12	5	<1	-	4	12	-	-
2018	1,483	5	5	3,927	230	<1	<1	366	20	<1	-	-	62	<1	-	-	9	<1	-	-
2019	1,208	29	<1	1,964	201	<1	<1	331	21	<1	<1	-	12	4	<1	-	5	<1	-	-
2020	783	4	<1	2,506	130	<1	<1	310	23	-	<1	-	9	1	-	<1	3	<1	<1	-
2021	2,183	13	<1	1,413	132	<1	<1	211	28	<1	<1	-	81	3	-	-	3	<1	-	-
2022	2,320	12	2	*	164	<1	<1	*	35	<1	0	*	25	4	-	*	6	<1	-	*
Total	40,102	550	33	168,551	10,806	42	10	4,924	1,375	20	<1	-	459	183	<1	2	101	360	9	1

Table J-6a Continued

	Carangidae				Molidae				Lobotidae				Sphyraenidae				Lampridae			
	Seriola, Caranx spp., amberjacks, jacks, crevalles, nei				*Molidae spp., molas, nei*				*Lobotes surinamensis, tripletail*				*Sphyraenidae spp., barracudas*				***Lampris spp., opahs***			
	Purse seine				Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	13	35	<1	-	-	20	<1	-	<1	<1	-	-	-	-	-	-	-	-	-	1
1994	19	6	<1	-	1	3	2	-	<1	-	-	-	<1	34	-	-	-	-	-	23
1995	17	19	-	-	2	4	<1	-	<1	<1	-	-	<1	3	-	-	-	-	-	33
1996	29	153	-	-	5	6	<1	-	<1	-	-	-	<1	<1	-	-	-	-	-	33
1997	68	16	3	-	5	4	3	-	1	<1	<1	-	<1	<1	-	-	-	-	-	40
1998	72	7	<1	-	2	2	1	-	16	<1	-	-	<1	<1	-	-	-	-	-	54
1999	52	46	-	-	2	5	1	-	8	<1	-	-	-	-	-	-	-	-	-	68
2000	29	19	<1	4	2	4	1	-	4	<1	-	-	<1	-	<1	-	-	-	-	88
2001	70	<1	<1	18	6	2	1	-	<1	-	-	-	<1	<1	-	-	-	-	-	73
2002	26	9	<1	15	6	2	1	-	3	-	-	-	<1	-	-	-	-	-	-	6
2003	43	<1	<1	54	<1	4	<1	-	3	<1	-	-	<1	-	-	-	-	-	-	132
2004	8	7	<1	-	6	<1	1	-	1	<1	-	-	<1	-	-	-	-	-	-	139
2005	1	<1	-	-	2	9	2	-	7	<1	<1	-	<1	-	<1	-	-	-	-	159
2006	29	-	-	-	26	14	2	-	9	<1	<1	-	<1	-	-	-	-	-	-	109
2007	2	2	-	6	9	8	2	-	3	<1	<1	-	<1	1	-	-	-	-	-	370
2008	4	-	-	5	9	6	4	-	2	<1	-	-	<1	-	<1	-	-	-	-	308
2009	3	<1	<1	10	6	5	1	-	7	<1	<1	-	1	<1	-	-	-	-	-	488
2010	<1	4	-	8	9	44	1	-	<1	-	-	-	<1	-	<1	-	-	<1	-	539
2011	<1	4	-	7	4	113	<1	-	3	<1	-	-	<1	2	<1	8	-	-	-	539
2012	7	1	-	1	9	12	<1	-	3	<1	-	-	<1	<1	-	-	-	<1	-	425
2013	2	<1	-	<1	9	28	2	-	2	-	<1	-	<1	-	<1	-	-	<1	-	648
2014	2	2	-	11	3	9	1	-	2	-	<1	-	<1	<1	-	-	-	<1	-	818
2015	2	-	<1	11	6	12	1	87	2	<1	-	-	<1	-	-	-	-	-	-	1039
2016	7	5	<1	11	10	7	<1	275	2	-	-	-	<1	<1	-	-	-	-	-	741
2017	4	4	-	-	8	4	<1	<1	5	-	<1	-	<1	-	-	-	-	-	-	846
2018	2	-	-	-	5	2	<1	-	3	<1	-	-	<1	<1	-	-	-	-	-	1102
2019	3	<1	-	-	2	6	<1	-	2	-	<1	-	<1	-	-	-	-	-	<1	740
2020	<1	1	-	-	1	<1	<1	-	2	<1	-	-	<1	-	-		-	-	-	683
2021	2	<1	-	-	<1	2	<1	-	1	<1	-	-	1	<1	-	-	-	-	-	449
2022	4	<1	-	*	2	2	<1	*	4	<1	<1	*	<1	-	-	*	-	-	-	*
Total	522	341	5	162	159	338	34	362	98	<1	<1	0	11	41	<1	8	0	<1	<1	10,692

Table J-6a Continued

	***Gempylidae* spp., snake mackerels, nei**				***Bramidae* spp., pomfrets, nei**				Other large fishes				Unidentified fishes				All fishes			
	Purse seine				Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	-	-	-	-	-	-	-	<1	3	<1	<1	-	<1	-	<1	183	887	79	1	203
1994	-	-	-	-	-	-	-	2	3	87	<1	-	<1	<1	12	250	1,731	152	16	321
1995	-	-	-	-	-	-	-	2	<1	3	<1	-	3	1	<1	209	1,485	53	4	285
1996	-	-	-	-	-	-	-	2	3	125	<1	-	3	<1	<1	456	1,655	306	1	535
1997	-	-	-	-	-	-	-	6	7	5	<1	-	7	2	-	847	1,850	44	7	7,760
1998	-	-	-	-	-	-	-	9	13	10	<1	-	7	<1	<1	1,338	1,420	38	7	3,931
1999	-	-	-	-	-	-	-	3	4	54	<1	-	22	4	<1	974	1,599	114	2	7,330
2000	-	-	-	-	-	-	-	4	1	1	-	-	1	<1	<1	1,485	1,804	82	4	5,119
2001	-	-	-	-	-	-	-	5	2	9	<1	-	3	<1	<1	1,720	3,398	30	4	17,763
2002	-	-	-	-	-	-	-	<1	2	<1	<1	-	2	6	<1	1,895	2,521	27	2	11,399
2003	-	-	-	-	-	-	-	-	4	<1	-	-	2	2	-	4,386	1,484	19	2	10,037
2004	-	-	-	-	-	-	-	-	4	<1	<1	-	10	<1	<1	377	1,548	35	3	4,658
2005	-	-	-	-	-	-	-	18	<1	<1	<1	-	3	<1	<1	303	1,501	89	3	4,489
2006	-	-	-	18	-	<1	-	17	<1	<1	<1	7	3	<1	<1	285	1,824	302	3	4,011
2007	-	-	-	65	-	-	-	57	1	<1	<1	5	1	5	<1	1,763	1,848	158	4	9,394
2008	-	-	-	144	-	-	-	68	1	<1	<1	-	<1	<1	<1	793	1,462	44	6	17,375
2009	-	-	-	412	-	-	-	56	1	<1	<1	67	2	-	<1	1,077	2,343	21	2	19,581
2010	-	-	-	575	-	-	-	64	<1	-	<1	-	<1	<1	-	879	1,318	122	2	11,833
2011	-	-	-	506	-	<1	-	50	<1	<1	-	15	<1	-	<1	612	1,621	175	<1	14,418
2012	-	-	-	661	-	-	-	61	<1	2	<1	11	1	<1	-	1,305	2,065	57	1	19,949
2013	-	-	-	574	-	-	-	134	<1	<1	<1	36	<1	<1	-	1,112	2,016	40	3	14,045
2014	-	-	-	431	-	-	-	138	<1	<1	-	77	<1	-	-	1,013	2,329	25	2	6,115
2015	-	-	-	321	<1	-	-	172	<1	<1	-	7	2	<1	-	1,367	1,568	30	2	4,495
2016	<1	-	-	730	-	-	-	108	<1	<1	<1	100	<1	1	-	506	1,328	23	9	3,238
2017	-	-	-	301	-	-	-	126	<1	<1	-	62	1	-	-	1,532	1,946	36	1	5,304
2018	-	-	-	260	-	-	-	125	<1	-	-	1	-	-	-	222	1,816	9	6	6,003
2019	-	-	-	338	-	-	-	81	<1	-	-	26	<1	<1	<1	272	1,455	41	1	3,753
2020	-	-	-	288	-	-	-	70	<1	-	-	213	<1	<1	<1	462	953	9	<1	4,533
2021	-	-	-	277	-	-	-	50	<1	<1	-	<1	<1	<1	-	1,153	2,432	19	1	3,553
2022	-	-	-	*	<1	-	-	*	<1	<1	-	*	<1	-	-	*	2,560	19	3	*
Total	<1	-	-	5,901	<1	<1	-	1,427	57	298	<1	628	75	24	13	28,776	53,765	2,198	105	221,433

Table J-6b. Minimum number of interactions and mortalities of large fishes in 2021 reported by observers onboard longline vessels under the current mandate of at least 5% coverage (C-19-08) of each CPC fleet operating in the eastern Pacific Ocean. Data are incomplete as some CPCs suspended their observer programs due to the COVID-19 pandemic and data are insufficient for expanding to fleet totals (BYC-10 INF-D) (see section 2.2 for uncertainty and data gaps associated with longline data reporting). Dispositions considered to indicate a survival event are those reported by observers as "Alive and Healthy", "Alive with light injuries" and "Alive", while those considered to indicate a mortality event are dispositions reported as "Dead", "Alive mortal", Alive injured", Discarded", "Unknown", or where disposition was not reported.
Tabla J-6b. Número mínimo de interacciones y mortalidades de peces grandes en 2021 reportadas por observadores a bordo de buques palangreros bajo el mandato actual de al menos 5% de cobertura (C-19-08) de cada flota de los CPC que opera en el Océano Pacífico oriental. Los datos se consideran incompletos ya que algunos CPC suspendieron sus programas de observadores debido a la pandemia de COVID-19 y los datos son insuficientes para expandirlos a totales de la flota (BYC-10 INF-D) (ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos asociadas a la notificación de datos de palangre). Las disposiciones que se considera que indican un evento de supervivencia son las reportadas por los observadores como "Vivo y sano", "Vivo con heridas leves" y "Vivo", mientras que las que se considera que indican un evento de mortalidad son las disposiciones reportadas como "Muerto", "Vivo, mortalidad probable", "Vivo herido", "Descartado", "Desconocida" o cuando la disposición no fue reportada.

Large fish taxa	Interactions	Mortalities
Long snouted lancetfish, *Alepisaurus ferox*	11,309	11,309
Escolar, *Lepidocybium flavobrunneum*	6,007	6,002
Snake mackerel, *Gempylus serpens*	3,050	3,031
Wahoo, *Acanthocybium solandri*	2,717	2,717
Opah, *Lampris guttatus*	2,394	2,393
Dorado, mahi mahi, dolphin fish, nei, Coryphaenidae	2,306	2,306
Sickle pomfret, *Taractichthys steindachneri*	1,272	1,272
Common dolphinfish, *Coryphaena hippurus*	602	601
Pomfrets, ocean breams nei, Bramidae	571	570
Oilfish, *Ruvettus pretiosus*	407	402
Mackerels nei, Scombridae	122	122
Pompano dolphinfish, *Coryphaena equiselis*	117	117
Ocean sunfish, Mola, *Mola mola*	44	43
Great barracuda, *Sphyraena barracuda*	40	40
Barracudas nei, *Sphyraena* spp.	23	23
Rough pomfret, *Taractes asper*	10	4
Other large fishes*	40	40
Total numbers	31,031	30,992
"Other large fishes" includes those with <10 interactions from 15 taxa in 2021.		

Table J-7. Estimated purse-seine catches by set type in metric tons (t) of small forage fishes by observers onboard size-class 6 vessels with a carrying capacity >363 t (1993–2022) and minimum reported longline (LL) catches of small forage fishes (gross-annual removals in t) (1993–2021, *data not available, see section 2.2. for uncertainty and data gaps in reporting of bycatch caught by longline). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2021 (longline) and 2022 (purse seine) are considered preliminary. "Epipelagic forage fishes" include various mackerels and scad (*Decapterus* spp., *Trachurus* spp., *Selar crumenophthalmus*), Pacific saury (*Cololabis saira*), and tropical two-wing flyingish (*Exocoetus volitans*).

Tabla J-7. Capturas cerqueras estimadas de peces forrajeros pequeños, por tipo de lance, en toneladas (t), por observadores a bordo de buques de clase 6 con una capacidad de acarreo >363 t (1993–2022) y capturas palangreras (LL) mínimas reportadas de peces forrajeros pequeños (extracciones anuales brutas en t) (1993-2021, *datos no disponibles; ver Sección 2.2. para consultar información sobre la incertidumbre y las deficiencias de los datos en la notificación de especies capturadas incidentalmente con palangre). Tipos de lances cerqueros: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las especies en negritas se discuten en el texto principal. Los datos de 2021 (palangre) y 2022 (cerco) se consideran preliminares. "Peces epipelágicos de forraje" incluyen varias caballas y jureles (*Decapterus* spp., *Trachurus* spp., *Selar crumenophthalmus*), paparda del Pacífico (*Cololabis saira*), y volador tropical (*Exocoetus volitans*).

	***Auxis* spp., bullet and frigate tunas**				**Balistidae, Monacanthidae spp., triggerfishes and filefishes**				**Kyphosidae, sea chubs**				**Epipelagic forage fishes**				Small Carangidae spp., carangids, nei				Other small fishes			
	Purse seine				Purse seine				Purse seine				Purse seine				Purse seine				Purse seine			
Year	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL	OBJ	NOA	DEL	LL
1993	1,832	142	2	-	261	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	182	3	4	-
1994	294	200	2	-	114	<1	<1	-	<1	-	-	-	-	-	-	-	<1	-	-	-	53	15	2	-
1995	501	119	6	-	208	4	<1	-	<1	-	-	-	-	-	-	-	<1	-	-	-	319	4	4	-
1996	761	234	33	-	113	2	<1	-	-	-	-	-	-	-	-	-	-	<1	-	-	55	8	25	-
1997	2,734	623	25	-	219	<1	<1	-	-	-	-	-	-	-	-	-	<1	-	-	-	151	12	2	-
1998	1,033	168	32	-	801	2	1	-	<1	-	-	-	<1	-	-	-	<1	-	-	-	91	15	3	-
1999	2,589	473	29	-	551	3	<1	-	<1	<1	-	-	<1	-	-	-	<1	<1	-	-	85	3	2	-
2000	1,210	181	19	-	168	<1	9	-	2	-	-	-	-	-	-	-	<1	-	-	-	68	8	6	-
2001	641	38	-	-	426	1	-	-	<1	-	-	-	-	-	-	-	<1	-	-	-	27	2	<1	-
2002	1,382	234	248	-	453	<1	-	-	<1	-	-	-	-	-	-	-	<1	-	-	-	25	3	<1	-
2003	944	278	16	-	157	4	<1	-	<1	-	-	-	<1	-	-	-	<1	-	-	-	75	1	1	-
2004	834	115	24	-	914	7	2	-	8	<1	<1	-	<1	<1	-	-	<1	<1	-	-	22	1	<1	-
2005	1,606	309	6	-	129	<1	<1	-	23	<1	<1	-	6	<1	<1	-	2	<1	<1	-	<1	9	<1	-
2006	1,300	591	19	-	145	<1	<1	-	79	<1	<1	-	7	1	-	-	2	<1	<1	-	5	1	<1	-
2007	868	336	18	-	544	1	<1	-	12	<1	<1	-	2	5	-	-	<1	<1	<1	-	4	<1	<1	-
2008	759	619	2	-	276	7	2	-	68	<1	<1	-	3	<1	-	-	10	<1	-	-	2	<1	<1	-
2009	303	165	1	-	174	1	<1	-	47	<1	-	-	<1	<1	-	-	<1	<1	<1	-	1	<1	<1	-
2010	474	234	<1	-	69	<1	<1	-	16	-	<1	-	4	<1	<1	-	1	<1	-	-	<1	-	<1	-
2011	677	97	11	-	31	<1	-	-	48	<1	-	-	2	<1	<1	-	<1	<1	-	-	<1	<1	<1	-
2012	173	179	1	-	110	<1	-	-	39	-	-	-	13	12	-	-	<1	<1	-	-	4	2	-	-
2013	385	77	-	-	228	<1	<1	-	18	-	<1	-	4	-	<1	-	<1	4	<1	-	2	<1	<1	-
2014	297	30	<1	-	325	<1	<1	-	16	-	-	-	3	<1	<1	-	<1	<1	-	-	1	<1	<1	-
2015	177	64	-	-	140	4	<1	-	5	-	<1	-	6	-	-	-	<1	<1	-	-	1	<1	<1	-
2016	189	23	<1	-	416	2	<1	-	8	-	-	-	21	-	<1	<1	<1	<1	-	-	3	<1	<1	77
2017	131	172	-	-	83	<1	-	-	8	-	-	-	3	-	-	-	<1	<1	-	-	<1	<1	-	-
2018	276	172	-	-	54	<1	<1	-	10	-	-	-	5	<1	-	-	<1	-	-	-	<1	<1	<1	-
2019	182	94	<1	-	57	<1	<1	-	7	<1	<1	-	5	8	<1	-	<1	<1	-	-	<1	5	-	-
2020	435	44	<1	-	47	<1	<1	-	2	-	<1	-	4	<1	-	<1	<1	<1	-	<1	<1	<1	<1	<1
2021	423	18	-	-	50	<1	-	-	6	-	<1	-	15	-	-	-	<1	<1	-	-	<1	1	<1	<1
2022	682	17	<1	*	543	2	<1	*	21	1	-	*	15	-	<1	*	<1	<1	-	*	1	3	<1	*
Total	24,092	6,046	496	-	7,804	48	16	-	445	2	<1	-	118	28	<1	<1	23	6	<1	<1	1,184	100	51	78

Table J-8a. Minimum nominal purse-seine catches of a) sharks, large fishes and small fishes in metric tons (t) and b) rays in numbers of individuals in 2022 for size-class 1–5 vessels with a carrying capacity <363 t as reported by observers in 34% of all trips that carried an observer. Purse-seine set types: floating object (OBJ) and unassociated tuna schools (NOA).

Tabla J-8a. Capturas cerqueras nominales mínimas de a) tiburones, peces grandes y peces pequeños, en toneladas (t), y b) rayas en número de individuos en 2022 para buques de clases 1-5 con una capacidad de acarreo <363 t según lo reportado por los observadores en el 34% de todos los viajes que llevaban observador a bordo. Tipo de lances cerqueros: objeto flotante (OBJ) y atunes no asociados (NOA).

a.

			Set type	
Broad group	Common name	Scientific name	OBJ	NOA
Sharks	Silky shark	*Carcharhinus falciformis*	29	<1
	Oceanic whitetip shark	*Carcharhinus longimanus*	<1	-
	Blue shark	*Prionace glauca*	<1	-
	Other Carcharhinidae spp.	Carcharhinidae spp.	<1	-
	Scalloped hammerhead shark	*Sphyrna lewini*	4	-
	Smooth hammerhead shark	*Sphyrna zygaena*	2	-
	Great hammerhead shark	*Sphyrna mokarran*	<1	-
	Pelagic thresher shark	*Alopias pelagicus*	<1	-
	Bigeye thresher shark	*Alopias superciliosus*	<1	-
	Mako shark	*Isurus* spp.	<1	-
Large fishes	Dorado	Coryphaenidae spp.	289	<1
	Wahoo	*Acanthocybium solandri*	26	<1
	Rainbow runner	*Elagatis bipinnulata*	2	
	Amberjack, nei	Seriola spp.	2	
	Jacks, crevalles, nei	Caranx spp.	<1	
	Amberjack, jack, crevalles, nei	Seriola, Caranx spp.	<1	
	Tripletail	Lobotes surinamensis	2	
	Mola, nei	Molidae spp.	<1	
	Other large fish		<1	
Small fishes	Bullet and frigate tunas	*Auxis spp.*	128	-
	Triggerfishes, Filefishes	Balistidae, Monacanthidae spp.	84	<1
	Sea chubs	Kyphosidae spp.	3	
	Small carangid, nei	Carangidae spp.	<1	
	Epipelagic forage fishes		<1	

b.

			Set type	
Broad group	Common name	Scientific name	OBJ	NOA
Rays	Pelagic stingray	*Pteroplatytrygon violacea*	36	5
	Spinetail manta	*Mobula mobular*	18	8
	Smoothtail manta	*Mobula thurstoni*	11	
	Mobulidae ray, nei	Mobulidae spp.	10	
	Giant manta	*Mobula birostris*	8	
	Chilean devil ray	*Mobula tarapacana*	7	
	Stingray nei	Dasyatidae spp.	3	