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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). 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) and the Staff Activities and Research report (SAC-12-01).

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). Furthermore, environmental processes that operate on a variety of time 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 this report is significantly different from its predecessors, in content, structure, and purpose. Its primary purpose is to complement the annual report on the fishery (SAC-12-03) 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.

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 data

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

[2] Vessels with a carrying capacity <363 t

reported by CPCs to the IATTC. Purse-seine data were available through 2020, with data from the last 2 years considered preliminary as of March 2021. Longline data were available through 2019 as the deadline for data reporting for the previous year occurs after the annual SAC meeting. Each data source is described in detail below.

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. 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 purse seine, 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 required to carry observers. 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. 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, a current IATTC pilot project trialing the efficacy of electronic monitoring methodologies (SAC-11-11), and a voluntary observer program for smaller Ecuadorian vessels that began in 2018. The minimum observer-derived catch estimates for bycatch species by small vessel trips are included in this report (Table J-7) 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 2020, most trips (76%) made by smaller vessels were unobserved, 17% were from the voluntary Ecuador observer program, 5% from National Observer program and 2% from the IATTC 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. Under the AIDCP program, an observer is placed on a large purse-seine vessel prior to each trip. 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 2005–2020 are shown in Table A-7 of Document SAC-12-03.

Despite the observer requirement, 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.

[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

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). 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. This is the same data source used to compile annual longline estimates for principal tuna and tuna-like species SAC-12-03. Because there is uncertainty in whether the IATTC is receiving all bycatch data from the longline fishery of each CPC, these data are considered incomplete, or 'sample data', and are therefore regarded as minimum annual reported catch estimates for 1993–2019. A staff-wide collaboration is underway to revise 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).

During this process, the staff were able to determine that the longline catches of sharks, reported by CPCs 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 has been improving since Resolution C-19-08 entered into force. The staff has received detailed set-by-set operational level observer data for several CPCs, although the level of observer coverage has often been less than the current mandated coverage of 5% of the total number of hooks or "effective days fishing". Furthermore, for most CPCs, the coverage is significantly lower than the 20% coverage recommended by the staff, the Working Group on Bycatch, and the Scientific Advisory Committee. The effectiveness of the mandated 5% observer coverage for assessing whether the observer coverage is representative of the activities of the total fleet is presented in BYC-10 INF-D. Although CPCs 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 bycatch species. IATTC staff will seek to provide estimates of longline catches in the EPO based on observer data in the future, but the results of the aforementioned analysis highlights a clear need for data reporting of bycatch species to improve (see SAC-12-09).

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 Xiiphidae families, are reported in Document SAC-12-03. The staff has developed stock assessments and/or stock status indicators (SSIs) for tunas (SAC-12-05), a workplan for bigeye and yellowfin stock assessments (SAC-12-01) and skipjack assessment methods (SAC-12-06). The staff has also collaborated in the assessments of Pacific bluefin and

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.

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 will collaborate on the ISC assessment for northern EPO swordfish to be carried out in 2021. A workplan for completing a southern EPO swordfish assessment and a progress report on the assessment is provided in SAC-12-07.

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 (Figure J-1).

Estimates of incidental mortality of dolphins in the purse-seine fishery of large vessels during 1993–2020 are shown in Table J-1. In 2020, the stock of dolphins with the highest incidental mortality was the eastern spinner (*n*=251), followed by the western-southern spotted (*n*=154), whitebelly spinner (*n*=138), and northeastern spotted dolphins (*n*=105). Common dolphins were least impacted by the fishery, with mortalities of 1 northern, 17 central, and 3 southern common dolphins.

The staff plans to analyze available reported and observed marine mammal interaction data for the purse-seine and longline fisheries. These data will be reported in the near future.

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 under fish-aggregating devices (FADs) and drown or be injured or killed by fishing gear.

Figure J-2 shows the number of estimated sea turtle mortalities and interactions recorded by observers on large purse-seine vessels, by set type, during 1993–2020. 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. The olive ridley turtle (*Lepidochelys olivacea*) is, by far, the species of sea turtle most frequently caught, with a total of 21,429 interactions and 949 mortalities (~4%) during 1993-2020, but only 297 interactions (zero mortalities) in 2020 (Table J-2). In 2020, there were 42 interactions recorded with eastern Pacific (23 green turtle, 23 loggerhead, 6 hawksbill, 3 leatherback, and 155 unidentified turtles) and only 2 mortalities, each of an unidentified turtle species.

One olive ridley turtle was reported by an observer onboard the smaller purse-seine vessels in 2020, but because 24% of small vessels carried an observer, this estimate must be considered as a minimum estimate only.

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 highest in "shallow" sets (<150 m) targeting albacore and 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.

Data on sea turtle interactions and mortalities in the longline fishery have not been available (SAC-08-07b), although they are expected to improve with the submission of operational-level observer data for longline vessels >20 m beginning in 2019 pursuant to Resolution C-19-08. Recalling the observer coverage for most longline vessels is 5% or less, compared to 100% of observed trips in the large-vessel purse-seine fishery, the observer data provided by CPCs for 2019 include 71 turtle interactions, of which eight (11%) resulted in mortalities. The reported interactions/mortalities by species were loggerhead (31/1), green (18/0), olive ridley (11/5), leatherback (8/3), and Kemp's ridley (1/1), plus unidentified sea turtles (1/1). 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 likely 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 long-line gears.

A preliminary vulnerability assessment was conducted 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 status of the stock was determined to be "most vulnerable" in 2018, while scenario modelling showed that if the implementation of improved handling and release practices by the longline fleet could reduce post-release mortality by around 20% or more the population might recover to a "least vulnerable", assuming fishing effort levels of all EPO fisheries do not increase. The staff has continued to collaborate with the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) in 2020–2021 to improve the assessment using updated fisheries data from coastal CPCs and is planned to be completed by late 2021.

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)).

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 from 2019 some minimum estimates are available for reporting. The observer data submitted by CPCs for 2019 contained 3,165 interactions with seabirds—all recorded as dead (or presumed dead due to incomplete disposition data)—with the exception of 18 black-footed albatross (*Phoebastria nigripes*) that were released alive with injuries. The reported interactions/mortalities by species were unidentified boobies and gannets (1,720/1,720), unidentified seabirds (546/546), black-footed albatross (370/352), wedge-tailed shearwater (306/306), Leach's storm-petrel (88/88), Wandering albatross

(71/71), and Laysan albatross (64/64). The staff hopes to report the first total longline fleet catch estimate for seabird species in the near future using the operational observer data.

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 four shark species in the EPO: silky (*Carcharhinus falciformis*) (Lennert-Cody *et al*. 2018; BYC-10 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.

Catches (t) of sharks in the large-vessel purse-seine fishery (1993–2020) and minimum reported catch estimates[4] by longline fisheries (1993–2019) are provided in Table J-3, while catches of the most frequently caught species, discussed below, are shown in Figure J-3. Total longline catch estimates for 2020 were not available at the time of this report and reporting of many shark species by longline gear began in 2006. The silky shark (family Carcharhinidae) is the species of shark most commonly caught in the purse-seine fishery with annual catches averaging 552 t—primarily from sets on floating objects (Figure J-3)—and being 357 t in 2020. In contrast, minimum reported annual catch in the longline sample data for 2006–2019 averaged 11,155 t and was 2,600 t in 2019. Annual catch for the oceanic whitetip shark (Carcharhinidae) in the purse-seine fishery averaged 59 t (also primarily from sets on floating objects) and was 4 t in 2020. The minimum reported annual catch in the longline fishery from 2006–2019 averaged 153 t and none were reported in 2019. Catches of oceanic whitetip have declined in the purse-seine fishery since the early 2000s, while catches have been variable in the longline fishery (Figure J-3). Minimum annual reported catch of blue shark in the longline fishery from 1993–2019 averaged 5,803 t and was 11,012t in 2019. By contrast, the annual catch in the purse-seine fishery averaged only 2 t, with 1 t caught in 2020.

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-3, Figure J-3). Catch estimates for the smooth hammerhead shark in the purse-seine fishery averaged 26 t (primarily caught in floating-object sets) and was 7 t in 2020, while in the longline fishery minimum annual reported catch averaged 959 t (2006–2019) and was 33 t in 2019. In contrast, the pelagic thresher was caught primarily in unassociated tuna school sets in the purse-seine fishery with the estimated annual catch averaging 5 t and was 2 t in 2020. Minimum annual reported catch of the pelagic thresher in the longline fishery averaged 2,199 t (2007–2019) and was 444 in 2019. Catch estimates for the mako sharks in the purse-seine fishery were lower than the aforementioned shark species averaging 3 t and was 3 t in 2020. However, in the longline fishery the minimum annual reported catch averaged 1,335 t (1993–2019) and was 1,927 t in 2019.

The limited observer data from small purse-seine vessels showed 17 t of silky shark and 3 t of scalloped

[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).

hammerhead were caught in floating-object sets in 2020, while those of other shark species or species groups were minimal (<1 t) (Table J-7).

The artisanal longline fisheries of the coastal CPCs 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)). An ongoing project is being undertaken to improve data collection on sharks, particularly for Central America, for the longline fleet through funding from 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 (SAC-07-06b(ii), SAC-07-06b(iii)). A one-year pilot study was conducted in 2019, collecting shark-fishery data and developing and testing sampling designs for a long-term sampling program for the shark fisheries throughout Central America (Phase 2 of the project). A progress report on the FAO-GEF ABNJ project was presented at SAC-11 (SAC-11-05). The pilot study will continue through 2020. Data obtained from this project may be included in future iterations of the *Ecosystem Considerations* report to provide improved catch estimates for sharks by the various longline fleets.

3.6. RAYS

Estimated annual catches of manta rays (Mobulidae) and stingrays (Dasyatidae) by the large-vessel purse-seine (1993–2020) and minimum reported annual catches by longline (1993–2019) fisheries are provided in Table J-4, while catches of key species are shown in Figure J-4. These rays are primarily caught by the purse-seine fishery, while limited catches were reported for the longline fishery only for the Munk's devil ray (2009: 6 t, 2010: 118 t) and Dasyatidae spp. (16 t over a 6-year period), with half the catches made in 2009 (Table J-4). The giant manta had the largest average catches in the purse-seine fishery (19 t), followed by the spinetail (14 t), and smoothtail (8 t) mobulid rays. Catches of these species in 2020 were 4, 13, and 1 t, respectively. Catches of the pelagic stingray were low, averaging only 2 t and being 2 t in 2020 (Table J-4). 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-4).

For the small purse-seine vessel fishery, the limited available observer data for 2020 was minimal (≤1 t) for all other ray species or species groups (Table J-7).

3.7. Other large fishes

Large pelagic fishes caught by the large-vessel purse-seine, primarily on floating-object sets, (1993–2020) and longline (1993–2019) fisheries are shown in Table J-5, 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 1,291 t (778 t in 2020) and the minimum reported annual catch for the longline fishery averaging 6,054 t (1,540 t in 2019). 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 was 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 377 t for the purse-seine fishery, although catches have declined from a peak of 1,025 t in 2001 to 127 t in 2020 (Figure J-5). Minimum reported annual catch of wahoo by the longline fishery have averaged 163 t and was 325 t in 2019. 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 48 t, with the peak catch in 2007 at 158 t and declining thereafter to 23 t in 2020 (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 349 t (1993–2019), 373 t (2006–2019), and 48 t (1993–2019), respectively. Catches of all these taxa have increased after the mid-2000s (Figure J-5). For the most recent year (2019), there were 681 t, 300 t, and 80 t of opah, snake mackerels, and pomfrets reported, respectively (Table J-5).

The limited observer data available for 2020 for the small purse-seine fishery included 88 t of dorado and 16 t of wahoo caught in floating-object sets, while the remaining species or species groups of large fishes had ≤1 t reported (Table J-7).

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-6 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 1,053 t from 1993–2020. However, their catches have declined from 1,922 in 2005 to 481 t in 2020 (Figure J-6). Triggerfishes (Balistidae) and filefishes (Monacanthidae) are the second most commonly reported forage group with annual estimated catches averaging 260 t and totaling 47 t in 2020. Catches for this group peaked in 2004 at 914 t but have otherwise been variable. Annual catches of sea chubs (Kyphosidae) have averaged 15 t, which began to increase after 2002 but have steadily decreased to 3 t in 2020. Lastly, annual catches of the various species in the category 'epipelagic forage fishes' averaged 4 t with 4 t estimated to be caught in 2020. A total of 66 t of bullet and frigate tunas and 12 t of triggerfishes and filefishes were reported by observers on the limited number of trips on small purse-seine vessels that carried an observer in 2020. Catches of all other species or species groups of small fishes were minimal (≤1 t) (Table J-7).

4. PHYSICAL ENVIRONMENT

Environmental conditions affect marine ecosystems, the dynamics and catchability of target and bycatch species, and the activities of fishers, and physical factors can have important effects on the distribution and abundance of marine species[5]. The following summary of the physical environment covers: 1) short- and long-term environmental indicators, and 2) environmental conditions and their effect on the fishery

[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.

during the previous year, in this case, 2020.

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 makes tunas less vulnerable to capture, and thus reduces 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.

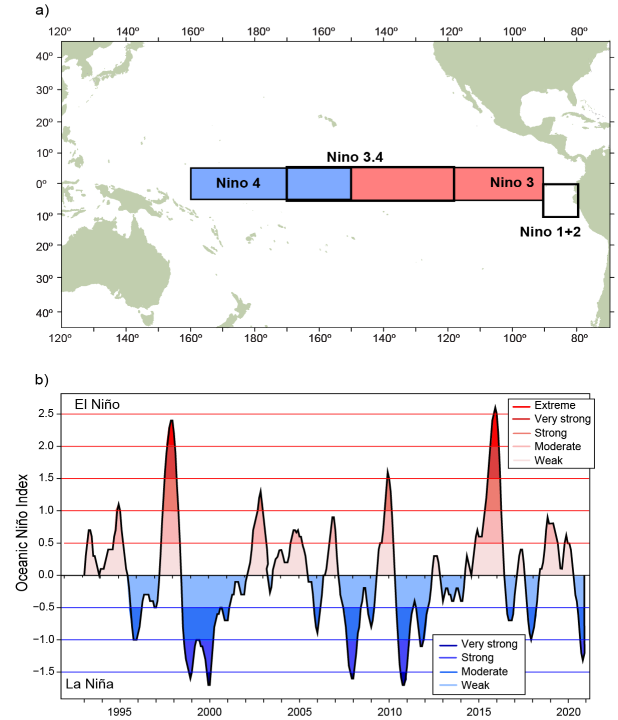

FIGURE J-7. El Niño regions used as indicators of El Niño Southern Oscillation (ENSO) events in the Pacific Ocean (top panel), and the Oceanic Niño Index (ONI) used to monitor ENSO conditions in Niño region 3.4 from 5°N to 5°S and 120°W to 170°W (bottom panel). Time series shows the running 3-month mean ONI values from the start of the IATTC observer program through December 2020. 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 2020. Datos del ONI obtenidos de: http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

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 2020 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 indicative of ENSO-neutral conditions during January–July and La Niña conditions during August–December.

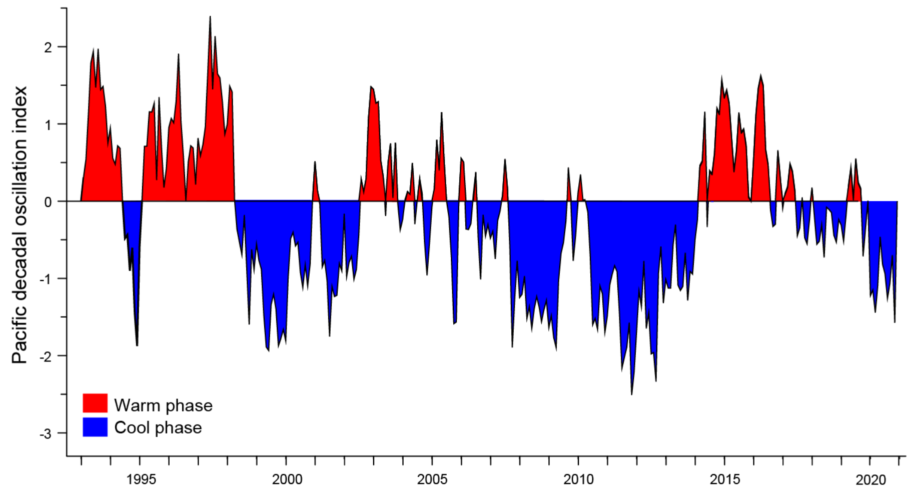

FIGURE J-8. Monthly values of the Pacific Decadal Oscillation (PDO) Index, January 1993–December 2020. PDO data obtained from: https://psl.noaa.gov/data/gridded/data.noaa.ersst.v5.html

FIGURA J-8. Valores mensuales del índice de Oscilación Decadal del Pacífico (PDO), enero de 1993–diciembre de 2020. Datos de la PDO obtenidos de: https://psl.noaa.gov/data/gridded/data.noaa.ersst.v5.html

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-7), 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-7). 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 El Niño event. ENSO-neutral conditions occurred during much of 2020, with moderate-strong La Niña conditions from August through December.

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. During 2020, cool PDO conditions persisted.

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 1993–2020, while that for CHL-a concentrations covers data for 2003–2020 due to data availability. The SST plot (Figure J-9) 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), although the pattern is less clear than the SST plot, shows an increase in CHL-a concentrations following the strong La Niña events in 2007–2008 and 2010–2011, likely due to increases in nutrient availability.

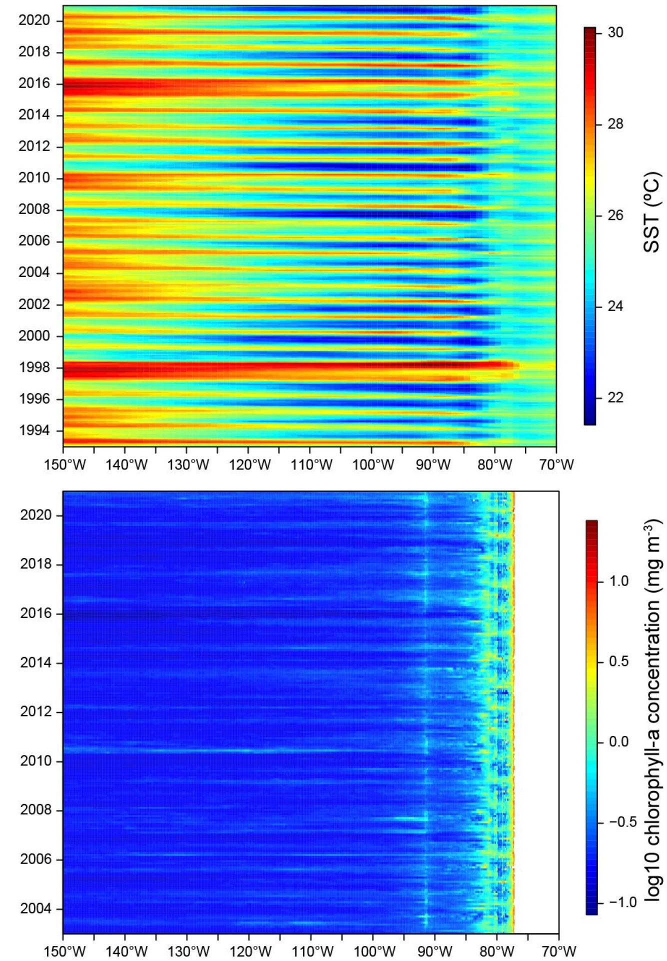

FIGURE J-9. Time-longitude Hovmöller diagram with data averaged across the tropical eastern Pacific Ocean from 5°N to 5°S for mean monthly SST for January 1993–December 2020 (top panel) (https://www.esrl.noaa.gov/psd/) and mean monthly chlorophyll-a concentration for January 2003–December 2020 (bottom panel) (https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday/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 2020 (panel superior) (https://www.esrl.noaa.gov/psd/) y concentración promedio mensual de clorofila-a de enero de 2003 a diciembre de 2020 (panel inferior) (https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday/index.html.

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, 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 2020. In future, the staff plans to incorporate the catch distribution of key bycatch species and develop species distribution models to better describe potential relationships between environment and species.

Cooler waters occurred off northern Mexico and the southwestern United States around 30°N and extended westwards during quarters 1 (January–March) and 2 (April–June), and off South America, south of the equator and east of 100°W, in quarters 3 (July–September) and 4 (October–December). Warmer waters developed off Central America and extended westwards during quarters 2 and 3. A secondary warm pool was observed in the southwestern EPO (10–20°S, 140°–150°W) during quarters 1 and 2.

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

During quarters 1 and 2, skipjack predominated in the catches in the cooler waters (~25°C) off the coast of South America, where CHL-a concentration was high. Yellowfin tuna was the predominant tuna species in the catch primarily north of the equator and east of 120°W during these same quarters where warmer waters occurred. 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 ~5°S with larger catches taken west of ~120°W where warmer waters persisted during quarters 1–3. A secondary concentration of catches occurred west of 130°W, close to the western boundary of the EPO, primarily during quarters 1–3.

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)—

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

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 per-recruit models to assess the vulnerability of each species using conventional biological reference points (*e.g.* F_{MSY}, $F_{0.1}$).

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). Therefore, 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.

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 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"). A full description of the structural update of the model, attaining mass-balance, and calibration to time series data is provided in SAC-12-13.

6.1. Ecological indicators

Since 2017, ETP8 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. Additionally, simulations using the version of ETP8 updated and rebalanced in 2021 ("ETP-21") were conducted to assess potential impacts of the FAD fishery on the structure of the ecosystem (SAC-10-15).

A significant update of the ETP8 model was undertaken in 2021 ("ETP-21") 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. 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 recalibrate to time series data 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 4.64 and 4.65 in 2018, respectively, as the purse-seine fishing effort on FADs 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 28 years, or 0.04 trophic levels per decade. The expansion of the FAD fishery 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 $TL_{MC4.0}$ community was at one of its highest values (4.493) in 1986 but has continued to decline to 4.470 in 2018 (Figure J-13). As a result of changes in predation pressure on lower trophic levels, between 1993 and 2018 the biomass of the $TL_{MC3.25}$ community increased from 3.801 to 3.829, while interestingly, the biomass of the $TL_{MC2.0}$ community also increased from 3.092 to 3.107.

Together, these indicators show that the ecosystem structure has likely changed over the 40-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.

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 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 IATTC's 5-year 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, beginning in 2022. The priority of groups to be assessed will likely be elasmobranchs, teleosts, turtles and cetaceans.

- A shortcoming of the ETP-21 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 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 2018–2020 to establish an ecological monitoring program to collect stomach content data to update the ecosystem model.

- A second limitation of the ETP-21 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, the staff concluded 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%.

ACKNOWLEDGMENTS

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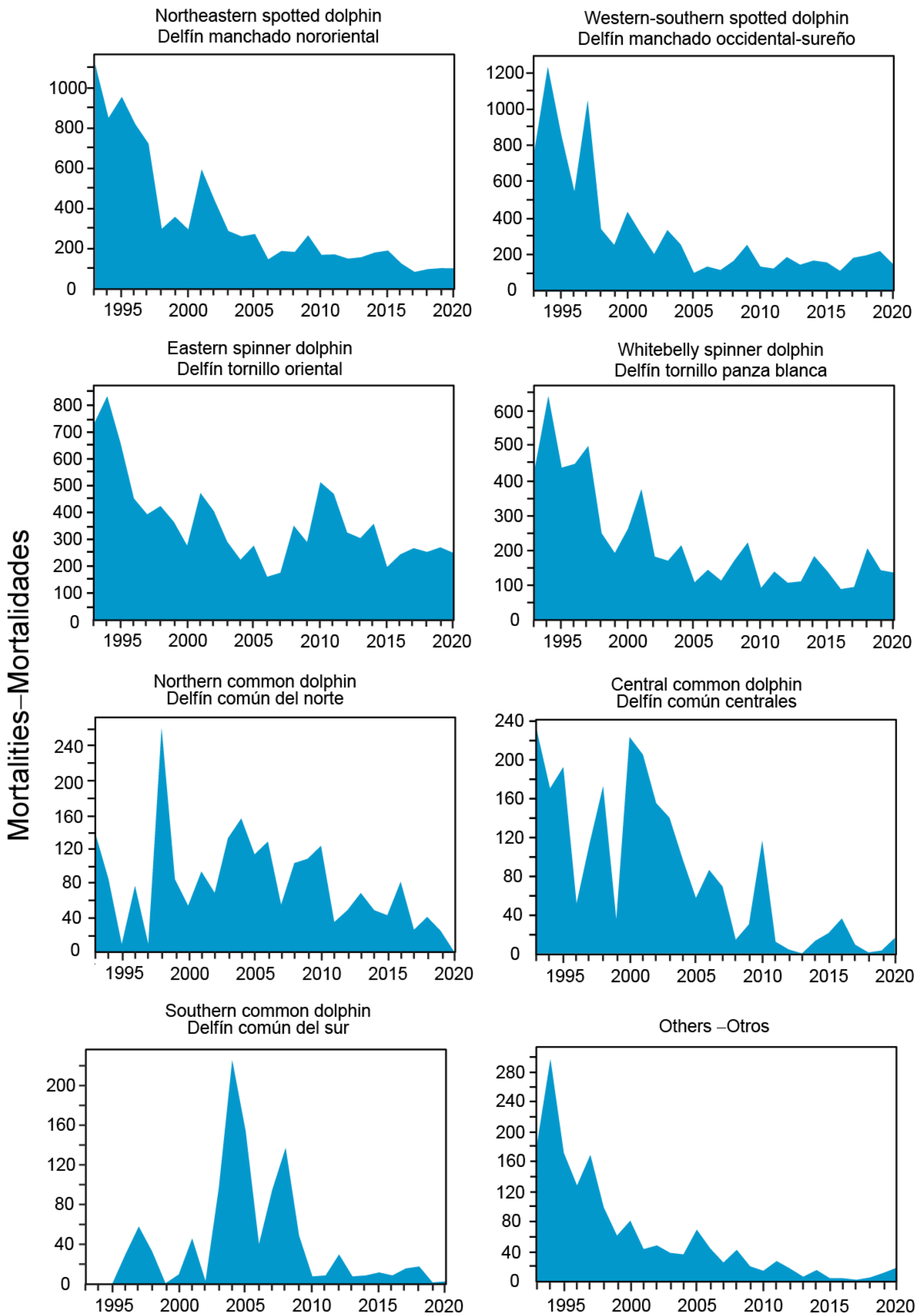

FIGURE J-1. Estimated number of incidental dolphin mortalities by observers onboard large purse-seine vessels, 1993–2020.

FIGURA J-1. Número estimado de mortalidades incidentales de delfines por observadores a bordo de buques cerqueros grandes, 1993–2020.

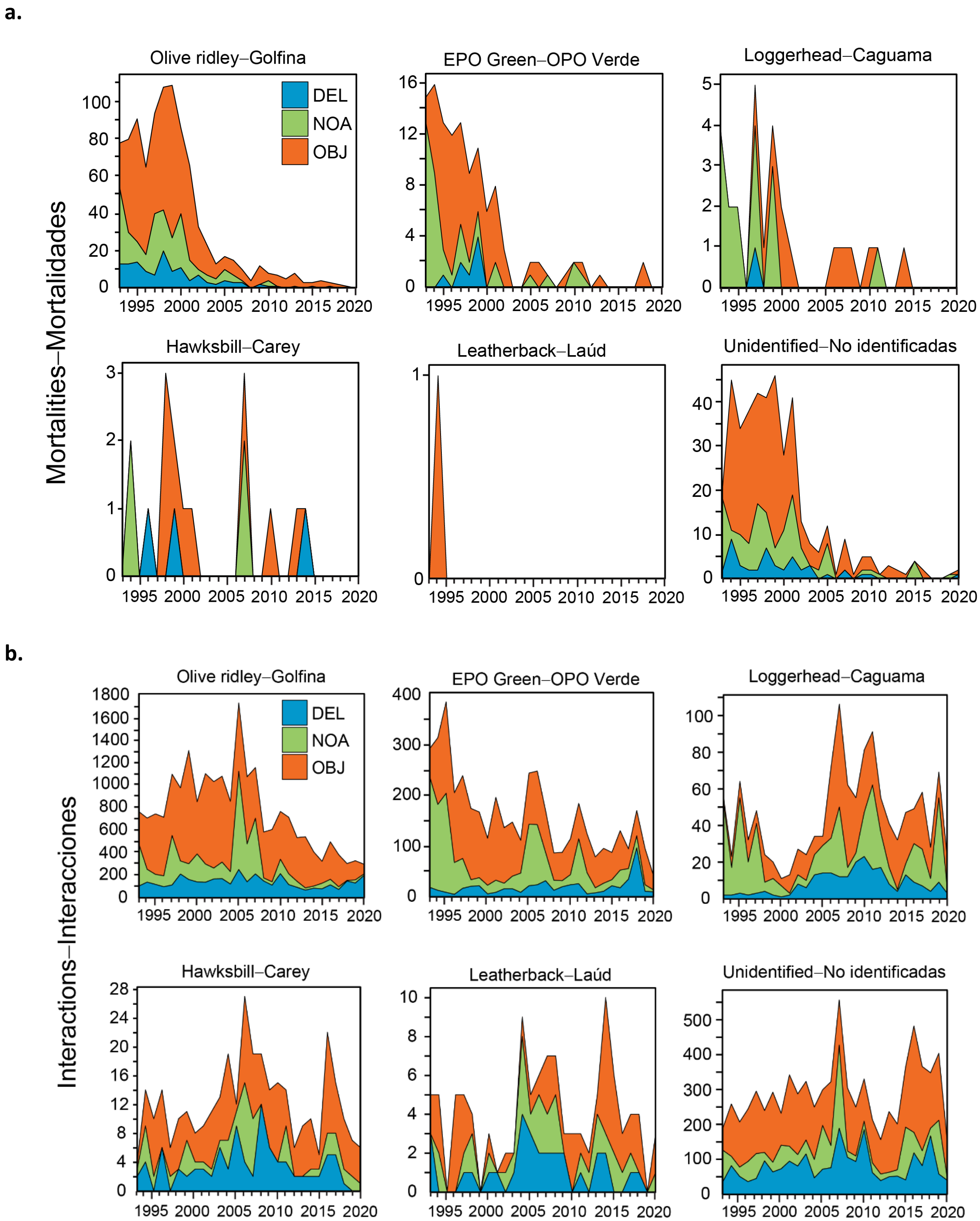

FIGURE J-2. Estimated number of sea turtle a) mortalities and b) interactions by observers onboard large purse-seine vessels, 1993–2020, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)).
FIGURA J-2. Número estimado de a) mortalidades y b) interacciones de tortugas marinas por observadores a bordo de buques cerqueros grandes, 1993-2020, por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)).

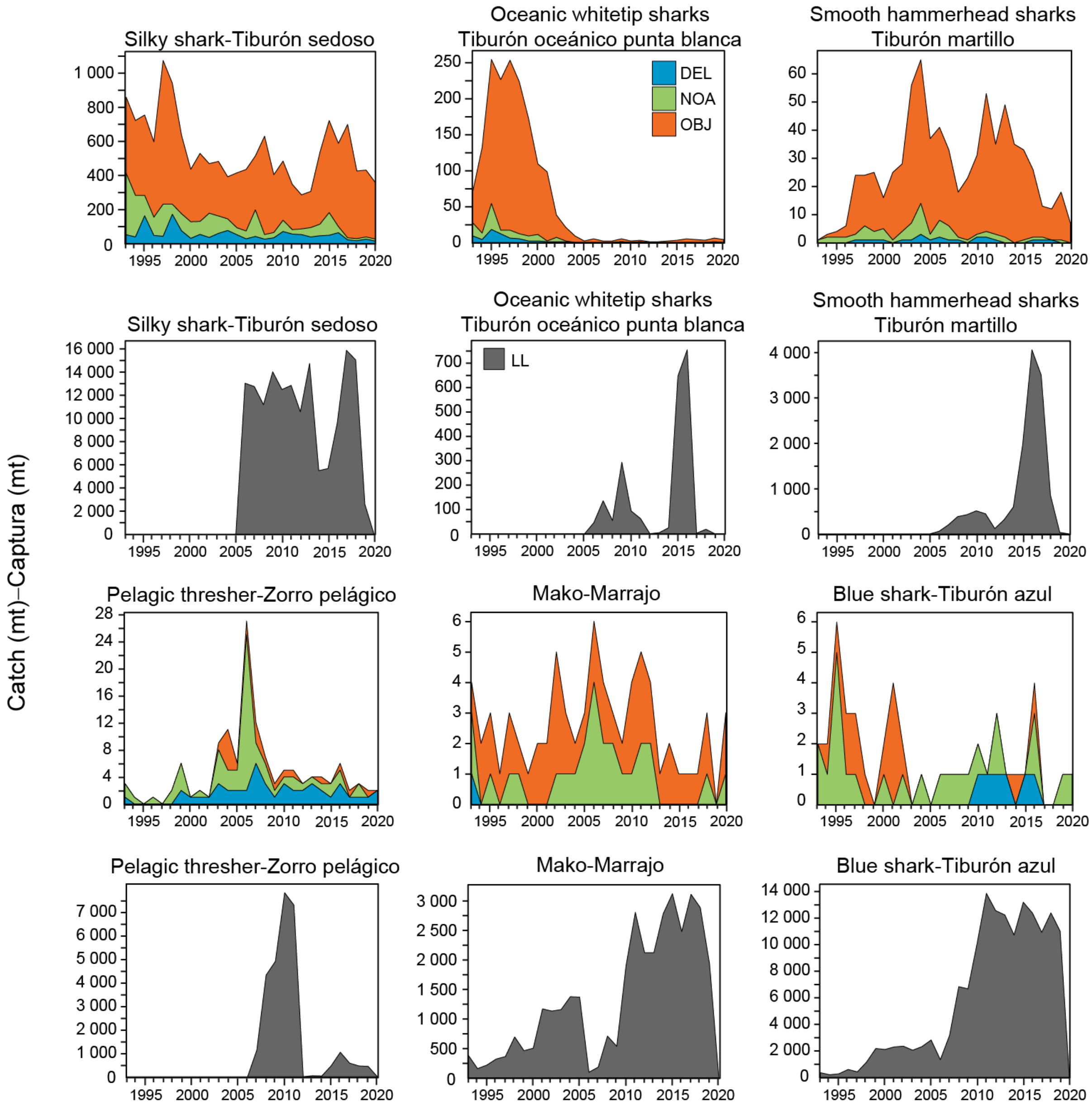

FIGURE J-3. Estimated catches in metric tons (t) of key shark species in the eastern Pacific Ocean recorded by observers onboard large purse-seine vessels and minimum longline (LL) estimates of gross annual removals reported by CPCs. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2020) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Longline catches (1993–2019) 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-3. 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. Se presentan las capturas cerqueras para buques de clase 6 con una capacidad de acarreo >363 t (1993-2020) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las capturas palangreras (1993–2019) 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).

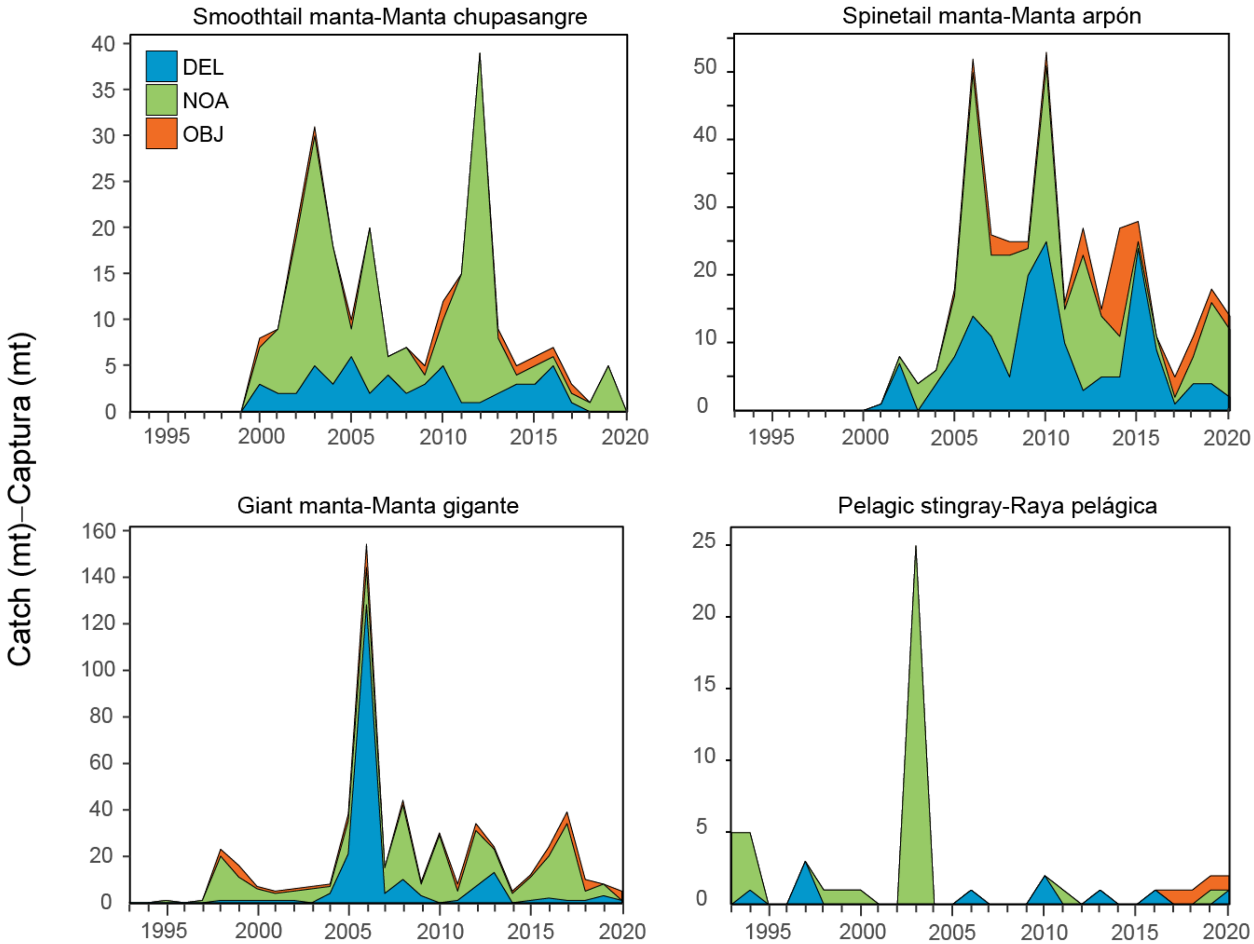

FIGURE J-4. Estimated purse-seine catches in metric tons (t) of key species of rays in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2020) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL).

FIGURA J-4. Capturas cerqueras estimadas en toneladas (t) 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 (1993-2020) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL).

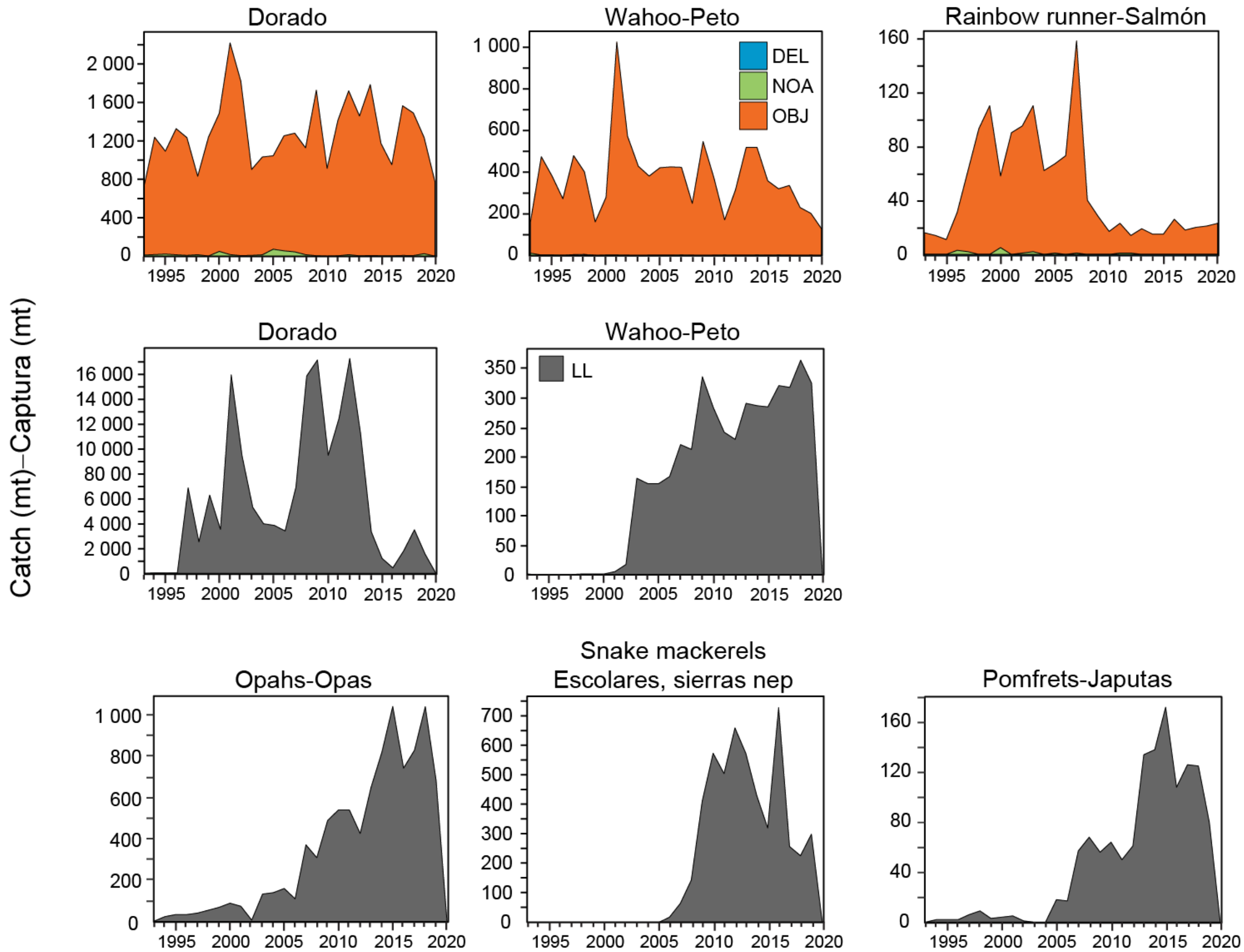

FIGURE J-5. Estimated purse-seine and longline catches in metric tons (t) of key species of large fishes in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2020) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Longline (LL) catches (1993–2019) are minimum reported gross-annual removals.

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 (1993-2020) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las capturas palangreras (LL) (1993–2019) son extracciones anuales brutas mínimas reportadas.

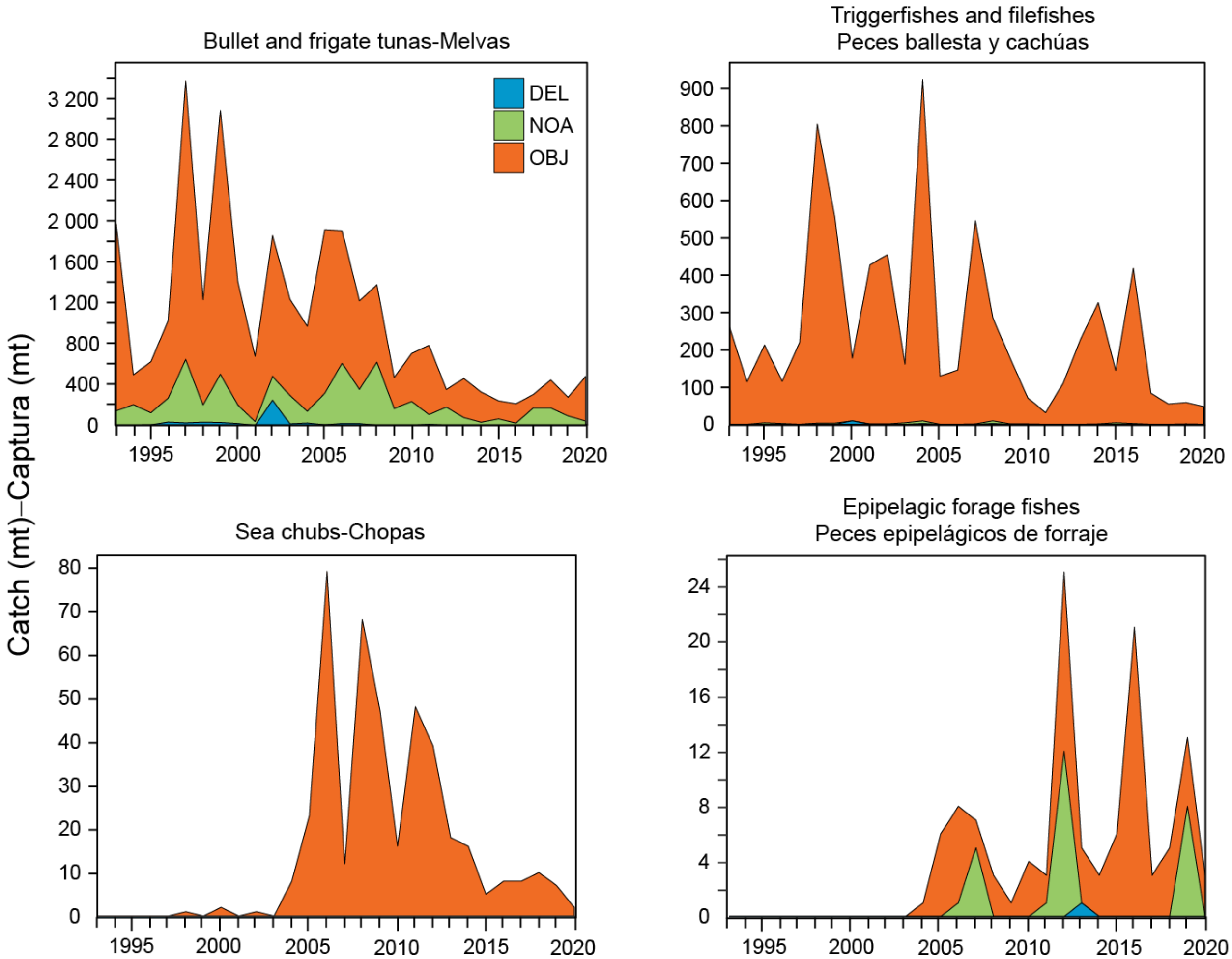

FIGURE J-6. Estimated purse-seine catches in metric tons (t) of key species of small fishes in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2020) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (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 (1993-2020) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL).

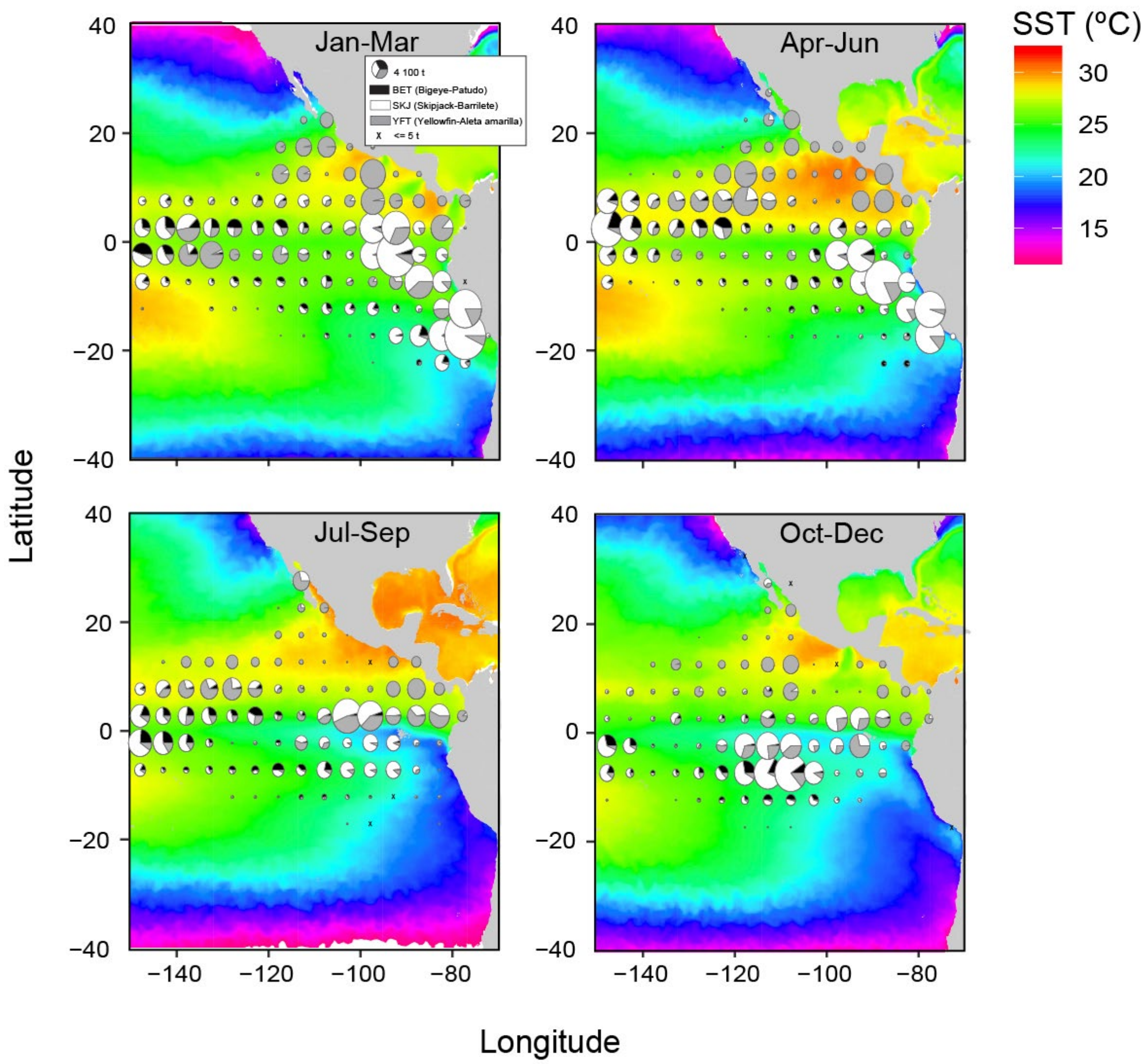

FIGURE J-10. Mean sea surface temperature (SST) for each quarter during 2020 with catches of tropical tunas overlaid. SST data obtained from NOAA NMFS SWFSC ERD on January 15, 2021, "Multi-scale Ultra-high Resolution (MUR) SST Analysis fv04.1, Global, 0.01°, 2002–present, Monthly", https://coastwatch.pfeg.noaa.gov/erddap/info/jplMURSST41mday/index.html.

FIGURA J-10 Temperatura superficial del mar (TSM) promedio para cada trimestre de 2020 con las capturas de atunes tropicales superpuestas. Datos de TSM obtenidos de NOAA NMFS SWFSC ERD el 15 de enero de 2021, "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.

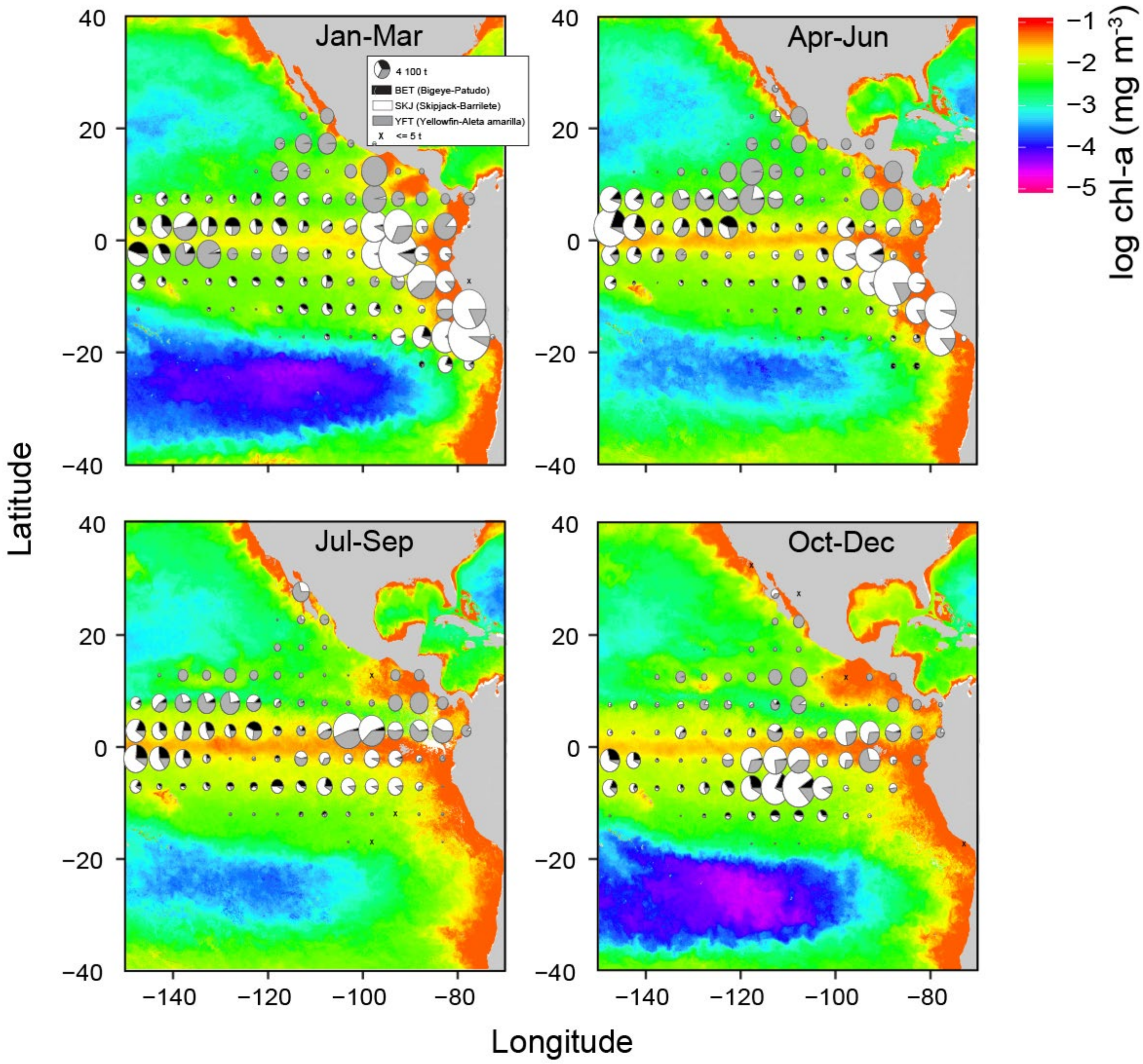

FIGURE J-11. Mean log chlorophyll-a concentration (in mg m^3) for each quarter during 2020 with catches of tropical tunas overlaid. Chlorophyll data obtained from NOAA CoastWatch on January 25, 2021, “Chlorophyll, NOAA, VIIRS, Science Quality, Global, Level 3, 2012-present, Monthly”, NOAA NMFS SWFSC ERD, https://coastwatch.pfeg.noaa.gov/erddap/info/nesdisVHNSQchlaMonthly/index.html.

FIGURA J-11. Concentración promedio de clorofila-a (en mg m^3) para cada trimestre de 2020 con las capturas de atunes tropicales superpuestas. Datos de clorofila obtenidos de NOAA CoastWatch el 25 de enero de 2021, “Chlorophyll, NOAA, VIIRS, Science Quality, Global, Level 3, 2012-present, Monthly”, NOAA NMFS SWFSC ERD, https://coastwatch.pfeg.noaa.gov/erddap/info/nesdisVHNSQchlaMonthly/index.html.

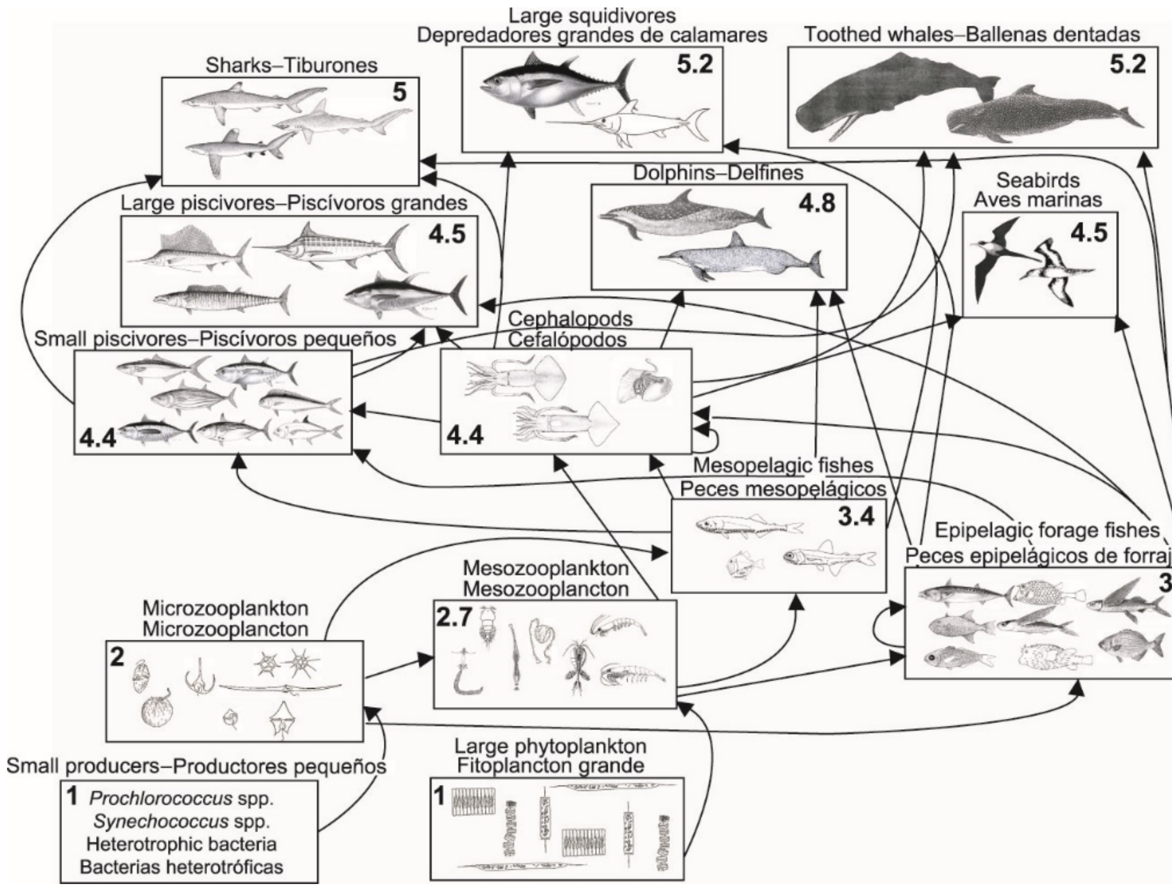

FIGURE J-12. Simplified food-web diagram of the pelagic ecosystem in the tropical EPO. The numbers inside the boxes indicate the approximate trophic level of each group.

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.

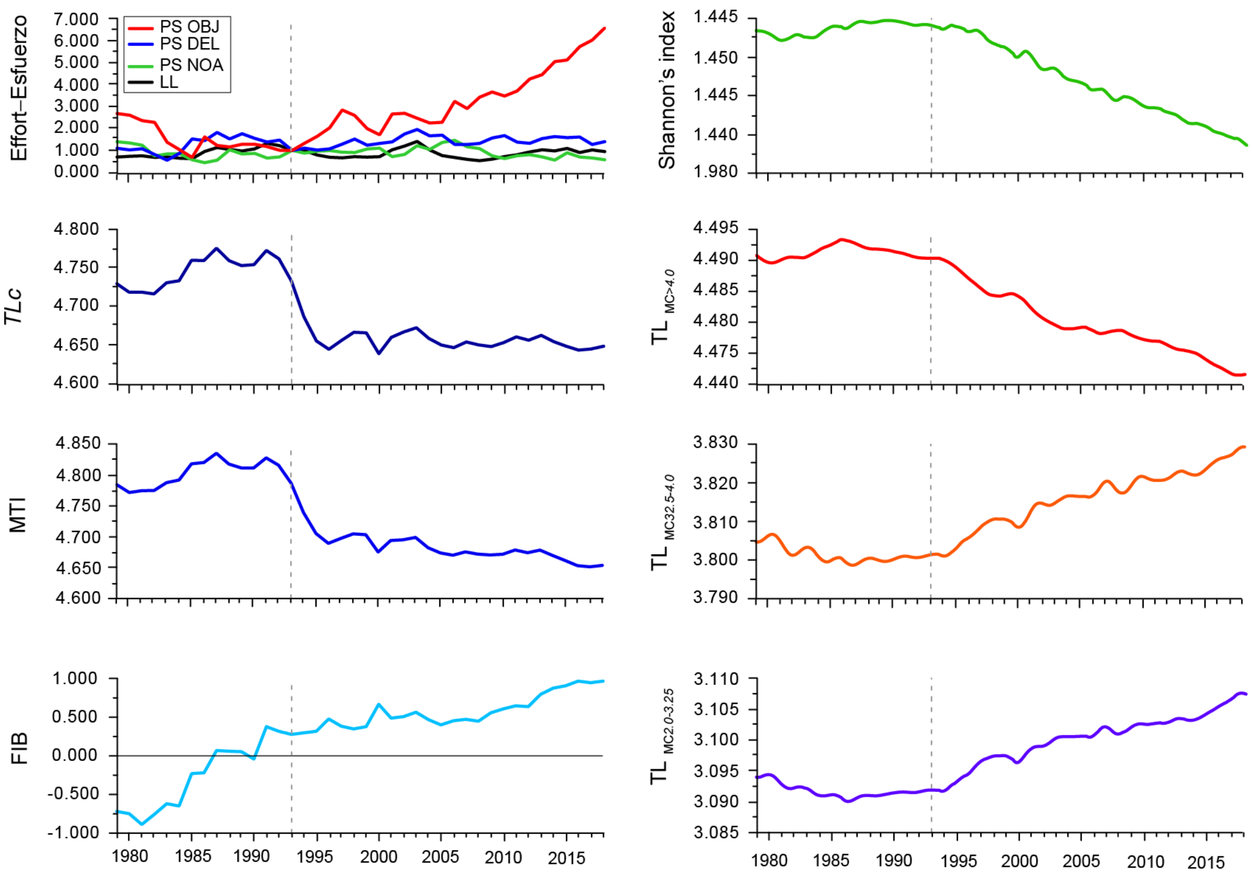

FIGURE J-13. Annual values for seven ecological indicators of changes in different components of the tropical EPO ecosystem, 1979–2018 (see Section 6 of text for details), and an index of longline (LL) and purse-seine (PS) fishing effort, by set type (dolphin (DEL), unassociated (NOA), floating object (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, 1979–2018 (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-1. Incidental dolphin mortalities in numbers of individuals (Num) and average weights in metric tons (t) by stock in the eastern Pacific Ocean caused by the large vessel purse-seine fishery with a carrying capacity >363 t from 1993–2020. Data for 2020 are considered preliminary.
Tabla J-1. Mortalidades incidentales de delfines, en número de individuos (Núm.) y peso promedio en toneladas (t), por población, en el océano Pacífico oriental ocasionadas por la pesquería cerquera de buques grandes con una capacidad de acarreo >363 t de 1993-2020. Los datos de 2020 se consideran preliminares.

	Stenella attenuata				*Stenella longirostris*				*Delphinus delphis*							
	Offshore[1]				Spinner				Common							
	Northeastern		Western-southern		Eastern		Whitebelly		Northern		Central		Southern		Other dolphins	
Year	Num	Wt	Num	Wt	Num	Wt	Num	Wt	Num	Wt	Num	Wt	Num	Wt	Num	Wt
1993	1,112	56.3	773	44.4	725	34.4	437	22.5	139	9.1	230	15.1	0	0.0	185	8.0
1994	847	42.9	1,228	70.6	828	39.3	640	32.9	85	5.6	170	11.1	0	0.0	298	12.0
1995	952	48.2	859	49.4	654	31.0	436	22.4	9	<1	192	12.6	0	0.0	173	13.0
1996	818	41.4	545	31.3	450	21.3	447	23.0	77	5.0	51	3.3	30	2.0	129	5.0
1997	721	36.5	1,044	60.0	391	18.5	498	25.6	9	<1	114	7.5	58	3.8	170	14.0
1998	298	15.1	341	19.6	422	20.0	249	12.8	261	17.1	172	11.3	33	2.2	100	8.0
1999	358	18.1	253	14.5	363	17.2	192	9.9	85	5.6	34	2.2	1	<1	62	4.0
2000	295	14.9	435	25.0	275	13.0	262	13.5	54	3.5	223	14.6	10	<1	82	5.0
2001	592	30.0	315	18.1	470	22.3	374	19.2	94	6.2	205	13.4	46	3.0	44	<1
2002	435	22.0	203	11.7	403	19.1	182	9.4	69	4.5	155	10.2	3	<1	49	3.0
2003	288	14.6	335	19.3	290	13.8	170	8.7	133	8.7	140	9.2	97	6.4	39	3.0
2004	261	13.2	256	14.7	223	10.6	214	11.0	156	10.2	97	6.4	225	14.7	37	<1
2005	273	13.8	100	5.8	275	13.0	108	5.6	114	7.5	57	3.7	154	10.1	70	3.0
2006	147	7.4	135	7.8	160	7.6	144	7.4	129	8.4	86	5.6	40	2.6	45	2.0
2007	189	9.6	116	6.7	175	8.3	113	5.8	55	3.6	69	4.5	95	6.2	26	<1
2008	184	9.3	167	9.6	349	16.6	171	8.8	104	6.8	14	<1	137	9.0	43	3.0
2009	266	13.5	254	14.6	288	13.7	222	11.4	109	7.1	30	2.0	49	3.2	21	<1
2010	170	8.6	135	7.8	510	24.2	92	4.7	124	8.1	116	7.6	8	<1	15	<1
2011	172	8.7	124	7.1	467	22.1	139	7.1	35	2.3	12	<1	9	<1	28	2.0
2012	151	7.6	187	10.8	324	15.4	107	5.5	49	3.2	4	<1	30	2.0	18	0.0
2013	158	8.0	145	8.3	303	14.4	111	5.7	69	4.5	0	0.0	8	<1	7	<1
2014	181	9.2	168	9.7	356	16.9	183	9.4	49	3.2	13	<1	9	<1	16	<1
2015	191	9.7	158	9.1	196	9.3	139	7.1	43	2.8	21	1.4	12	<1	5	<1
2016	127	6.4	111	6.4	243	11.5	89	4.6	82	5.4	36	2.4	9	<1	5	<1
2017	85	4.3	183	10.5	266	12.6	95	4.9	26	1.7	9	<1	16	1.0	3	<1
2018	99	5.0	197	11.3	252	12.0	205	10.5	41	2.7	1	<1	18	1.2	6	<1
2019	104	5.3	220	12.7	269	12.8	143	7.4	25	1.6	3	<1	2	<1	12	<1
2020	105	5.3	154	8.9	251	11.9	138	7.1	1	<1	17	1.1	3	<1	20	1.1
Total	9,579	485.2	9,141	525.6	10,178	482.7	6,300	323.9	2,226	145.8	2,271	148.8	1,102	72.2	1,708	94.8

[1]Estimates for offshore spotted dolphins include mortalities of coastal spotted dolphins

Table J-2. Estimated number of turtle interactions and mortalities by observers onboard purse-seine size-class 6 vessels with a carrying capacity >363 t (1993–2020). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Data for 2020 are considered preliminary.

Tabla J-2. 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 (1993–2020). Tipos de lances cerqueros: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Los datos de 2020 se consideran preliminares.

	***Lepidochelys olivacea*, olive ridley**						***Chelonia agassizii, Chelonia mydas*, eastern Pacific green**						***Caretta caretta*, loggerhead**					
	Interactions			**Mortalities**			**Interactions**			**Mortalities**			**Interactions**			**Mortalities**		
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	0	3	51	2	0	4	0
1994	455	114	137	50	17	13	132	170	12	7	9	0	6	15	2	0	2	0
1995	537	89	117	66	11	14	181	196	8	10	2	1	9	52	3	0	2	0
1996	520	97	96	47	9	9	138	63	4	11	1	0	12	18	2	0	0	0
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	0	0
1999	1005	140	160	82	18	9	130	16	21	5	2	4	9	9	2	1	3	0
2000	463	248	139	46	29	11	93	17	5	6	0	0	4	6	1	2	0	0
2001	802	162	136	51	11	4	164	24	8	6	2	0	10	1	2	1	0	0
2002	767	97	165	23	3	7	110	11	15	3	0	0	14	5	8	0	0	0
2003	762	147	168	16	4	3	107	25	15	0	0	0	14	4	6	0	0	0
2004	624	110	120	8	3	2	65	38	8	0	0	0	10	11	13	0	0	0
2005	606	872	249	7	6	4	101	122	21	1	1	0	5	15	14	0	0	0
2006	595	337	140	8	4	3	106	119	23	2	0	0	39	19	14	1	0	0
2007	450	494	210	6	1	3	83	56	31	0	1	0	56	38	12	1	0	0
2008	408	27	147	4	0	0	54	20	12	0	0	0	45	5	12	1	0	0
2009	464	30	110	10	0	2	56	12	19	1	0	0	30	5	20	0	0	0
2010	424	128	212	4	3	1	71	20	23	0	2	0	34	24	23	1	0	0
2011	502	96	115	6	0	1	70	89	25	1	1	0	29	46	16	0	1	0
2012	388	53	91	5	0	0	77	42	5	0	0	0	19	19	17	0	0	0
2013	454	20	66	7	1	0	61	10	7	1	0	0	24	9	8	0	0	0
2014	304	19	83	3	0	0	69	16	10	0	0	0	27	1	4	1	0	0
2015	195	49	78	2	0	1	54	12	21	0	0	0	28	6	13	0	0	0
2016	333	49	113	4	0	0	78	35	17	0	0	0	19	21	9	0	0	0
2017	285	24	72	2	0	1	39	21	34	0	0	0	31	20	7	0	0	0
2018	150	5	147	2	0	0	50	24	96	2	0	0	17	7	4	0	0	0
2019	170	28	129	1	0	0	72	13	10	0	0	0	14	46	9	0	0	0
2020	89	14	194	0	0	0	29	4	9	0	0	0	17	3	3	0	0	0
Total	**13,231**	**4,381**	**3,818**	**605**	**215**	**129**	**2,547**	**1,468**	**513**	**73**	**38**	**8**	**547**	**499**	**233**	**11**	**14**	**1**

Table J-2 continued

	Eretmochelys imbricata, hawksbill						*Dermochelys coriacea*, leatherback						Unidentified turtles					
	Interactions			Mortalities			Interactions			Mortalities			Interactions			Mortalities		
Year	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**
1993	1	1	2	0	0	0	2	0	3	0	0	0	66	89	38	3	16	2
1994	5	5	4	0	2	0	3	2	0	1	0	0	151	27	83	34	2	9
1995	8	2	0	0	0	0	0	0	0	0	0	0	130	27	52	24	7	3
1996	8	0	6	0	0	1	5	0	0	0	0	0	151	58	37	30	6	2
1997	4	2	0	0	0	0	3	1	1	0	0	0	180	72	46	25	15	2
1998	7	0	3	3	0	0	1	2	1	0	0	0	121	24	97	26	8	7
1999	4	5	2	1	0	1	0	0	0	0	0	0	202	28	65	39	4	3
2000	4	1	3	1	0	0	1	1	1	0	0	0	92	68	74	17	9	2
2001	5	1	3	1	0	0	0	0	1	0	0	0	206	43	96	22	14	5
2002	8	1	2	0	0	0	1	1	0	0	0	0	175	33	82	6	5	2
2003	6	1	6	0	0	0	0	1	1	0	0	0	169	40	117	5	0	3
2004	12	4	3	0	0	0	1	4	4	0	0	0	151	53	48	4	2	0
2005	1	2	9	0	0	0	1	1	3	0	0	0	103	126	73	4	7	1
2006	12	11	4	0	0	0	1	3	2	0	0	0	184	64	77	1	0	0
2007	9	8	2	1	2	0	3	2	2	0	0	0	130	240	191	7	0	2
2008	7	0	12	0	0	0	2	3	2	0	0	0	182	18	107	1	0	0
2009	8	0	6	0	0	0	1	0	2	0	0	0	141	16	95	3	1	1
2010	11	0	4	1	0	0	3	0	0	0	0	0	122	24	187	3	1	1
2011	5	5	4	0	0	0	1	1	1	0	0	0	125	28	63	0	1	0
2012	4	0	2	0	0	0	1	1	0	0	0	0	99	19	40	3	0	0
2013	7	0	2	1	0	0	1	2	2	0	0	0	175	13	51	2	0	0
2014	7	1	2	0	0	1	7	1	2	0	0	0	132	18	53	1	0	0
2015	2	1	2	0	0	0	4	2	0	0	0	0	174	152	42	0	4	0
2016	14	3	5	0	0	0	2	1	0	0	0	0	307	59	120	2	0	0
2017	7	3	5	0	0	0	2	1	1	0	0	0	243	43	83	0	0	0
2018	7	2	1	0	0	0	3	0	1	0	0	0	160	22	169	0	0	0
2019	5	2	0	0	0	0	0	0	0	0	0	0	193	155	59	0	1	0
2020	5	1	0	0	0	0	2	1	0	0	0	0	107	8	41	1	0	1
Total	**183**	**62**	**94**	**9**	**4**	**3**	**51**	**31**	**30**	**1**	**0**	**0**	**4,371**	**1,565**	**2,285**	**264**	**103**	**47**

Table J-3. 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 (1993–2020) and minimum reported longline (LL) catches of sharks (gross-annual removals in t) (1993–2019, *data not available). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2019 (longline) and 2020 (purse-seine) are considered preliminary. “Other sharks” include whale shark (*Rhincodon typus*), basking shark (*Cetorhinus maximus*) and unidentified sharks (Euselachii).

Tabla J-3. 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 (1993–2020) y capturas palangreras (LL) mínimas reportadas de tiburones (extracciones anuales brutas en t) (1993–2019, *datos no disponibles). 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 2019 (palangre) y 2020 (cerco) se consideran preliminares. “Otros tiburones” incluyen el tiburón ballena (*Rhincodon typus*), el tiburón peregrino (*Cetorhinus maximus*) y tiburones (Euselachii) no identificados.

	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	-	10,931	54	<1	2	2,562
2018	397	12	16	15,072	3	-	<1	19	<1	<1	<1	12,394	28	3	1	1,360
2019	392	13	25	2,600	5	<1	<1	-	<1	<1	<1	11,012	26	4	6	10
2020	332	12	14	*	4	-	<1	*	<1	<1	-	*	87	5	4	*
Total	**11,556**	**2,431**	**1,462**	**156,170**	**1,482**	**111**	**64**	**2143**	**19**	**24**	**9**	**156,668**	**498**	**128**	**130**	**25,799**

Table J-3 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	42	1	-	<1	-	5	<1	<1	5
2020	7	<1	<1	*	13	<1	<1	*	<1	-	<1	*	5	<1	<1	*
Total	**652**	**68**	**22**	**13,427**	**392**	**96**	**26**	**773**	**59**	**4**	**5**	**-**	**724**	**146**	**52**	**2,101**

Table J- 3 Continued

	Alopiidae															
	***Alopias pelagicus*, pelagic thresher**				*Alopias superciliosus*, bigeye thresher				*Alopias vulpinus, thresher shark*				*Alopias* spp., thresher shark, nei			
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	*	<1	<1	<1	*	-	-	<1	*	<1	<1	<1	*
Total	**22**	**65**	**45**	**28,582**	**17**	**108**	**54**	**6,220**	**5**	**28**	**13**	**4,370**	**14**	**69**	**46**	**3,806**

Table J-3 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	-	3,108	-	-	-	95	-	-	-	986	16	1	<1	1,263	766	21	27	42,180
2018	2	<1	<1	2,883	-	-	-	86	-	-	-	729	5	<1	<1	1,156	460	21	20	36,944
2019	<1	<1	<1	1,927	-	-	-	<1	-	-	-	-	6	<1	<1	12	465	23	34	16,136
2020	2	<1	-	*	-	-	-	*	-	-	-	*	3	2	<1	*	454	21	23	*
Total	**46**	**27**	**4**	**36,036**	**-**	**<1**	**-**	**497**	**-**	**-**	**-**	**15,378**	**934**	**318**	**287**	**92,344**	**16,420**	**3,625**	**2,217**	**544,313**

Table J-4. Estimated purse-seine catches by set type in metric tons (t) of rays by observers onboard size-class 6 vessels with a carrying capacity >363 t (1993–2020) and minimum reported longline (LL) catches of rays (gross-annual removals in t) (1993–2019, *data not available). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2019 (longline) and 2020 (purse-seine) are considered preliminary. “Other rays” include Chilean torpedo (*Torpedo tremens*), Pacific cownose (*Rhinoptera steindachneri*), and unidentified eagle rays (Myliobatidae).

Tabla J-4. Capturas cerqueras estimadas de rayas, por tipo de lance, en toneladas (t), por observadores a bordo de buques de clase 6 con una capacidad de acarreo >363 t (1993–2020) y capturas palangreras (LL) mínimas reportadas de rayas (extracciones anuales brutas en t) (1993–2019, *datos no disponibles). 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 2019 (palangre) y 2020 (cerco) se consideran preliminares. “Otras rayas” incluyen la raya temblara (*Torpedo tremens*), raya gavilán dorado (*Rhinoptera steindachneri*), y águilas de mar (Myliobatidae) no identificadas.

	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**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	-	-
1998	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	19	<1	-
1999	-	<1	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	5	10	<1	-
2000	1	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	5	<1	-
2001	<1	7	2	-	<1	<1	1	-	-	-	<1	-	<1	-	-	-	1	3	<1	-
2002	<1	17	2	-	<1	<1	7	-	<1	<1	<1	-	<1	1	<1	-	1	4	1	-
2003	<1	25	5	-	<1	4	<1	-	<1	<1	<1	-	-	-	<1	-	<1	6	<1	-
2004	<1	15	3	-	<1	2	4	-	-	<1	<1	-	<1	2	<1	-	1	3	4	-
2005	<1	3	6	-	1	9	8	-	-	<1	<1	-	<1	4	7	-	3	14	21	-
2006	<1	18	2	-	2	36	14	-	-	2	<1	-	<1	6	3	-	10	16	128	-
2007	<1	2	4	-	3	12	11	-	<1	<1	<1	-	2	4	2	-	<1	11	4	-
2008	<1	5	2	-	2	18	5	-	<1	3	<1	-	<1	24	3	-	2	32	10	-
2009	<1	1	3	-	1	4	20	-	<1	1	<1	6	<1	<1	8	-	<1	5	3	-
2010	2	5	5	-	2	26	25	-	<1	1	<1	118	<1	1	8	-	1	29	<1	-
2011	<1	14	<1	-	1	5	10	-	<1	1	<1	-	<1	3	7	-	3	4	<1	-
2012	<1	38	1	-	4	20	3	-	<1	1	<1	-	<1	7	1	-	3	24	7	-
2013	<1	6	2	-	1	9	5	-	<1	1	<1	-	<1	3	1	-	<1	10	13	-
2014	<1	<1	3	-	16	6	5	-	<1	<1	<1	-	<1	<1	<1	-	<1	4	-	-
2015	<1	2	3	-	3	1	24	-	<1	<1	1	-	1	2	6	-	<1	10	<1	-
2016	<1	<1	5	-	<1	2	9	-	<1	2	2	-	1	2	2	-	4	18	2	-
2017	<1	<1	1	-	3	1	1	-	<1	<1	<1	-	<1	-	<1	-	5	33	<1	-
2018	<1	1	<1	-	3	4	4	-	<1	<1	<1	-	1	<1	<1	-	5	4	<1	-
2019	<1	5	<1	-	2	12	4	-	<1	-	<1	-	3	<1	1	-	<1	5	3	-
2020	<1	<1	<1	*	2	10	2	*	<1	-	<1	*	<1	<1	<1	*	4	-	<1	*
Total	**12**	**172**	**53**	-	**46**	**180**	**162**	-	**2**	**15**	**10**	-	**16**	**64**	**54**	-	**55**	**272**	**201**	-

Table J-4 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**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**	**OBJ**	**NOA**	**DEL**	**LL**
1993	9	213	27	-	<1	5	<1	-	-	-	-	-	-	-	-	-	9	219	27	-
1994	3	73	19	-	<1	4	<1	-	-	-	-	-	-	-	-	-	3	77	20	-
1995	3	29	30	-	<1	<1	<1	-	-	-	-	-	-	-	-	-	3	30	30	-
1996	4	73	16	-	<1	<1	<1	-	-	-	-	-	-	-	-	-	4	74	16	-
1997	5	41	17	-	<1	<1	3	-	-	-	-	-	-	-	-	-	5	42	20	-
1998	5	228	18	-	<1	<1	<1	-	-	3	-	-	<1	<1	-	-	7	251	20	-
1999	8	84	16	-	<1	1	<1	-	-	-	-	-	-	-	-	-	13	96	17	-
2000	2	94	23	-	<1	<1	<1	-	-	-	-	-	-	-	-	-	4	104	27	-
2001	3	20	23	-	<1	<1	<1	-	-	-	-	-	-	-	-	-	5	30	27	-
2002	2	69	37	-	<1	<1	<1	-	<1	-	-	-	-	-	-	-	6	92	48	-
2003	9	61	37	-	<1	25	<1	-	-	-	-	-	-	-	-	-	11	121	44	-
2004	4	46	19	-	<1	<1	<1	-	<1	5	<1	-	-	-	-	-	6	75	31	-
2005	2	19	11	-	<1	<1	<1	-	<1	<1	<1	-	-	31	-	-	8	80	53	-
2006	3	23	14	-	<1	<1	<1	-	<1	12	<1	-	-	-	3	-	16	115	166	-
2007	2	12	12	-	<1	<1	<1	-	<1	3	<1	2	-	<1	-	-	8	44	35	2
2008	3	10	5	-	<1	<1	<1	-	<1	<1	<1	2	-	-	-	-	8	93	27	2
2009	2	7	15	-	<1	<1	<1	-	<1	<1	1	8	-	-	-	-	6	19	50	13
2010	7	20	17	-	<1	<1	2	-	<1	-	<1	3	-	20	-	-	13	103	58	121
2011	1	11	5	-	<1	<1	<1	-	<1	<1	<1	<1	-	<1	-	-	7	40	25	<1
2012	1	10	3	-	<1	<1	<1	-	<1	<1	<1	-	<1	<1	<1	-	9	100	16	-
2013	<1	6	6	-	<1	<1	<1	-	<1	<1	<1	-	-	-	1	-	5	36	28	-
2014	1	4	1	-	<1	<1	<1	-	<1	<1	<1	-	-	-	-	-	20	17	11	-
2015	1	4	9	-	<1	<1	<1	-	<1	<1	1	1	-	-	-	-	7	20	46	1
2016	3	12	11	-	<1	<1	<1	-	<1	-	<1	-	-	-	-	-	10	37	32	-
2017	7	20	6	-	<1	<1	<1	-	<1	<1	<1	-	-	-	<1	-	18	56	11	-
2018	6	5	6	-	<1	<1	<1	-	<1	<1	<1	-	-	-	-	-	17	15	12	-
2019	4	16	8	-	<1	<1	<1	-	<1	<1	<1	-	-	<1	<1	-	11	40	18	-
2020	4	5	9	*	<1	<1	<1	*	<1	<1	<1	*	-	-	-	*	11	15	14	*
Total	**104**	**1,214**	**420**	**-**	**10**	**42**	**16**	**-**	**4**	**27**	**7**	**16**	**<1**	**52**	**5**	**-**	**249**	**2,039**	**928**	**-**

Table J-5. 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 (1993–2020) and minimum reported longline (LL) catches of large fishes (gross-annual removals in t) (1993–2019, *data not available). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2019 (longline) and 2020 (purse-seine) are considered preliminary. "Other large fishes" include unidentified mackerels (Scombridae), luvar (*Luvarus imperialis*), and large fishes nei (not elsewhere identified).

Tabla J-5. 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 (1993–2020) y capturas palangreras (LL) mínimas reportadas de peces grandes (extracciones anuales brutas en t) (1993–2019, *datos no disponibles). 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 2019 (palangre) y 2020 (cerco) se consideran preliminares. "Otros peces grandes" incluyen caballas (Scombridae) no identificadas, pez emperador (*Luvarus imperialis*), y peces grandes nep (no identificados en otra parte).

	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	1,804	335	<1	<1	318	18	<1	<1	-	12	5	<1	-	4	12	-	-
2018	1,483	5	5	3,500	230	<1	<1	364	20	<1	-	-	62	<1	-	-	9	<1	-	-
2019	1,208	29	<1	1,540	201	<1	<1	325	21	<1	<1	-	12	4	<1	-	5	<1	-	-
2020	774	4	<1	*	127	<1	<1	*	23	-	<1	*	9	2	-	*	2	<1	<1	*
Total	**35,589**	**525**	**30**	**163,466**	**10,506**	**42**	**10**	**4,393**	**1,313**	**19**	**<1**	**-**	**353**	**176**	**<1**	**2**	**92**	**360**	**9**	**1**

Table J-5 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	-	-	-	-	-	-	1,039
2016	7	5	<1	11	10	7	<1	275	2	-	-	-	<1	<1	-	-	-	-	-	741
2017	4	4	-	-	8	4	<1	<1	5	-	<1	-	<1	-	-	-	-	-	-	827
2018	2	-	-	-	5	2	<1	-	3	<1	-	-	<1	<1	-	-	-	-	-	1,038
2019	3	<1	-	-	2	6	<1	-	2	-	<1	-	<1	-	-	-	-	-	<1	681
2020	<1	1	-	*	1	<1	<1	*	2	<1	-	*	<1	-	-	*	-	-	-	*
Total	**516**	**340**	**5**	**162**	**157**	**335**	**34**	**362**	**93**	**<1**	**<1**	**-**	**9**	**41**	**<1**	**8**	**-**	**<1**	**<1**	**9,419**

Table J-5 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	23	1	<1	-	1,293	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	-	-	-	258	-	-	-	126	<1	<1	-	62	1	-	-	1,532	1,946	36	1	4,928
2018	-	-	-	227	-	-	-	125	<1	-	-	<1	<1	<1	<1	222	1,816	9	6	5,478
2019	-	-	-	300	-	-	-	80	<1	-	-	25	<1	<1	<1	274	1,455	41	1	3,225
2020	-	-	-	*	-	-	-	*	<1	-	-	*	<1	<1	<1	*	940	9	<1	*
Total	**<1**	**-**	**-**	**5,223**	**<1**	**<1**	**-**	**1,306**	**56**	**298**	**<1**	**425**	**75**	**24**	**13**	**27,151**	**48,759**	**2,160**	**101**	**211,918**

Table J-6. 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 (1993–2020) and minimum reported longline (LL) catches of small forage fishes (gross-annual removals in t) (1993–2019, *data not available). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Species highlighted bold are discussed in main text. Data for 2019 (longline) and 2020 (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*). "Other small fishes" include various Tetraodontiformes, driftfishes (Nomeidae), Pacific chub mackerel (*Scomber japonicus*), Pacific tripletail (*Lobotes pacificus*), remoras (Echeneidae), longfin batfish (*Platax teira*), and small fishes not elsewhere identified (nei).

Tabla J-6. 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 (1993–2020) y capturas palangreras (LL) mínimas reportadas de peces forrajeros pequeños (extracciones anuales brutas en t) (1993-2019, *datos no disponibles). 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 2019 (palangre) y 2020 (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*). "Otros peces pequeños" incluyen varios Tetraodontiformes, derivantes (Nomeidae), estornino del Pacífico (*Scomber japonicus*), dormilona del Pacífico (*Lobotes pacificus*), remoras (Echeneidae), pez murciélago teira (*Platax teira*), y peces pequeños (nep) no identificados en otra parte.

	***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	437	43	<1	-	47	<1	<1	-	2	-	<1	-	3	<1	-	-	<1	<1	-	-	<1	<1	<1	-
Total	**22,990**	**6,010**	**495**	**-**	**7,212**	**46**	**15**	**-**	**418**	<1	<1	**-**	**88**	**28**	<1	**<1**	**21**	**6**	<1	**-**	**1,182**	**95**	**51**	**77**

Table J-7. Minimum nominal purse-seine catches by set type in metric tons (t) in 2020 for size-class 1–5 vessels with a carrying capacity <363 t as reported by observers in 24% of all trips that carried an observer. Purse-seine set types: floating object (OBJ) and unassociated tuna schools (NOA).

Tabla J-7. Capturas cerqueras nominales mínimas, por tipo de lance, en toneladas (t), en 2020 para buques de clases 1-5 con una capacidad de acarreo <363 t según lo reportado por los observadores en el 24% de todos los viajes que llevaban observador a bordo. Tipo de lances cerqueros: objeto flotante (OBJ) y atunes no asociados (NOA).

			Set type	
Taxa	**Common name**	**Scientific name**	**OBJ**	**NOA**
Sharks	Silky shark	*Carcharhinus falciformis*	17	<1
	Blue shark	*Prionace glauca*	-	<1
	Other Carcharhinidae	Carcharhinidae spp.	<1	-
	Smooth hammerhead	*Sphyrna zygaena*	<1	<1
	Scalloped hammerhead	*Sphyrna lewini*	3	-
	Hammerhead, nei	*Sphyrna* spp.	<1	-
	Pelagic thresher shark	*Alopias pelagicus*	<1	-
	Other shark		<1	-
Rays	Smoothtail manta	*Mobula thurstoni*	<1	<1
	Spinetail manta	*Mobula mobular*	<1	1
	Munk's devil ray	*Mobula munkiana*	-	<1
	Chilean devil ray	*Mobula tarapacana*	<1	<1
	Giant manta	*Mobula birostris*	-	<1
	Mobulidae ray, nei	Mobulidae spp.	<1	<1
	Pelagic stingray	*Pteroplatytrygon violacea*	<1	<1
	Stingray, nei	Dasyatidae spp.	<1	<1
Large fishes	Dorado	Coryphaenidae spp.	88	<1
	Wahoo	*Acanthocybium solandri*	16	<1
	Rainbow runner	*Elagatis bipinnulata*	1	-
	Amberjack, nei	*Seriola* spp.	1	-
	Jacks, crevalles, nei	*Caranx* spp.	<1	-
	Amberjack, jack, crevalles, nei	*Seriola, Caranx* spp.	<1	-
	Mola, nei	Molidae spp.	<1	-
	Tripletail	*Lobotes surinamensis*	<1	<1
	Other large fish		<1	-
Small fishes	Bullet and frigate tunas	*Auxis* spp.	60	6
	Triggerfishes, filefishes	Balistidae, Monacanthidae spp.	12	<1
	Sea chubs	Kyphosidae spp.	<1	-
	Small carangid, nei	Carangidae spp.	<1	<1
	Epipelagic forage fishes		<1	-