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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.

[1] Postponed until a later date to be determined

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 practical tools required to implement EAFM in the tuna fisheries of the EPO. Current and planned ecosystem-related work by the staff is summarized in the SSP (IATTC-93-06a) and the Staff Activities and Research report (SAC-11-01).

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 bycatch species (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 distribution, abundance and availability of species to different degrees, which in turn affects their potential to be impacted by 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 non-target species. Similarly, given the complexity of marine ecosystems, there is no single indicator that can completely 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 for many years, 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-11-03) 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 advances in research related to assessing ecological impacts of fishing and the environment on the EPO ecosystem.

2. DATA SOURCES

In this report, catches of bycatch species were obtained from observer data for the large-vessel purse-seine fishery[2], while gross annual removals by the longline fishery were obtained from data reported to the IATTC. Purse-seine data were available through 2019, with data from the last 2 years considered preliminary as of March 2020. Longline data were available through 2018 as the deadline for data reporting

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

for the previous year occurs after the 2019 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 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 logbook and cannery datasets contain very limited data on bycatch species as captains and crew of the vessels who record the logbook data are primarily focused on reporting aspects of the 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. The cannery (or "unloading") data do not have an exact fishing position but rather a grouped position (*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.

Because the smaller (Class 1-5) purse-seine vessels are not required to carry observers, logbook records and the port sampling program are the primary data sources for these vessels. As such, the data are limited and contain little or no information on interactions with bycatch species. Some detailed operational data are available from a recent voluntary scheme in Ecuador in which several smaller vessels carried observers, from a small number of Class-5 vessels that have been required to carry observers for limited periods under the AIDCP, and a current IATTC pilot project trialing the efficacy of electronic monitoring methodologies (SAC-11-11). An analysis is planned to evaluate whether such voluntary data may be representative of the fleet as a whole and therefore included in future iterations of this report.

Therefore, in this report we focus on the comprehensive observer dataset from large purse-seine vessels to provide catch data 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 2004–2019 are shown in Table A-7 of Document SAC-11-03.

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.

2.2. Longline

The considerable variability in reporting formats of longline data has hindered the staff's ability to esti-

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

mate 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 (*i.e.* the total annual catch by species estimated by each CPC 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 in SAC-11-03. 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 1993–2018. 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.

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 staff's annual Fishery Status Reports since 2006 but were in fact taken by longline. 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 data reporting has been improving since the adoption of Resolution C-19-08. The staff is receiving detailed set-by-set operational level observer data for some CPCs, although the current mandated observer coverage of 5% of the total number of hooks or "effective days fishing" continues to be significantly lower than the 20% coverage recommended by the staff, the Working Group on Bycatch, and the Scientific Advisory Committee. As of August 2020, the staff had received longline observer data from eight CPCs (Chinese Taipei, Ecuador, Japan, Korea, Mexico, the United States, and the EU (Portugal) and EU (Spain)), and exploratory analyses of the data were initiated to identify how representative they are of the activities of the total fleet. The results of these analyses will be presented to the SAC in 2021. As longline data reporting continues to improve, IATTC staff will seek to provide estimates of longline catches in the EPO based on observer data.

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-11-03. The staff has developed stock assessments and/or stock status indicators (SSIs) for bigeye (SAC-11-06, SAC-11-05), yellowfin (SAC-11-07, SAC-11-05), and skipjack (SAC-11-05) tunas and has collaborated in the assessments of Pacific bluefin and albacore tunas led by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC).

3.2. Marine mammals

Marine mammals, especially spotted dolphins (*Stenella attenuata*), spinner dolphins (*S. longirostris*), and common dolphins (*Delphinus delphis*), are frequently found associated with yellowfin tuna in the EPO. Purse-seine fishers commonly set their nets around herds of dolphins and the associated schools of 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 since then (Figure J-1).

Incidental mortality of dolphins and other marine mammals in the purse-seine fishery during 1993-2019 is shown in Table J-1. In 2019, the stock of dolphins with the highest incidental mortality was the eastern spinner (*n*=270), followed by the western-southern spotted (*n*=220), whitebelly spinner (*n*=142), and northeastern spotted dolphins (*n*=104). Common dolphins were least impacted by the fishery, with mortalities of 25 northern, 3 central, and 2 southern common dolphins.

Marine mammals have not been reported in the longline data, although with new observer data, estimates may be able to be provided in 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 sea turtle mortalities and interactions recorded by observers on large purse-seine vessels, by set type, during 1993–2019. 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 19,104 interactions and 874 mortalities during 1993-2019, but only 368 interactions and 1 mortality in 2019 (Table J-2). In 2019, in 110 reported interactions with eastern Pacific green turtles, 70 with loggerheads, 9 with hawksbills, and none with leatherback turtles, only one mortality was recorded, of an unidentified turtle.

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 on incidental mortality of turtles due to longline and gillnet fishing are available, 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) for 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 longline vessels is only 5%, compared to 100% of observed trips in the large-vessel purse-seine fishery, the observer data provided in national reports for 2019 (SAC-11-INF-A(a-j)) include 115 turtle interactions, of which eight (7%) resulted in mortalities. The reported interactions/mortalities by species were loggerhead (39/1), green (31/0), olive ridley (29/4), leatherback (13/2), and Kemp's ridley (1/1), plus unidentified sea turtles (2/0). 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 2021.

Various IATTC resolutions, most recently C-19-04, have been intended to mitigate fishing impacts on sea turtles and establish safe handling and release procedures for sea turtles caught by purse-seine and longline gears.

A 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) and will be presented at the meeting of the Bycatch Working Group (BYC-10-01). In brief, the status of the stock was determined to be "most vulnerable" in 2018, while scenario modelling showed that the implementation of improved handling and release practices by the longline fleet would reduce post-release mortality to the extent that the population might be considered "least vulnerable".

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), although they are expected to improve with the submission of operational-level observer data for longline vessels >20 m beginning in 2019. The observer data available in national reports for 2019 (SAC-11 INF-A(a-j)) include seven interactions with unidentified seabirds, all recorded as dead, and one black-footed albatross (*Phoebastria nigripes*), released alive. The staff hopes to report the first total longline fleet catch estimate for seabird species in 2021 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 (1993–2019) and minimum reported catch estimates[4] by longline fisheries (1993–2018) 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 2019 were not available at the time of this report and reporting of many shark species 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 559 t—primarily from sets on floating objects (Figure J-3)—and being 430 t in 2019. In contrast, minimum reported annual catch in the longline sample data for 2006–2018 averaged 11,813 t and was 15,072 t in 2018. Annual catch for the oceanic whitetip shark (Carcharhinidae) in the purse-seine fishery averaged 61 t (also primarily from sets on floating objects) and was 5 t in 2019. The minimum reported annual catch in the longline fishery averaged 79 t and was 19 t in 2018. Catches of

[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 harmonizing shark data collection to improve the reliability of total catch estimates (e.g. SAC-11-13).

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 averaged 5,382 t and was 12,064 t in 2018. By contrast, the annual catch in the purse-seine fishery averaged only 1.9 t, with 1 t caught in 2019.

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). Catch estimates for the smooth hammerhead shark in the purse-seine fishery averaged 22 t (primarily caught in floating-object sets) and was 18 t in 2019, while in the longline fishery minimum annual reported catch averaged 496 t (2006–2018) and was 851 t in 2018 (Figure J-3). In contrast, the pelagic thresher was caught primarily in unassociated tuna school sets in the purse-seine fishery with estimated the annual catch averaging 4.8 t and was 2 t in 2019 (Figure J-3). Minimum annual reported catch of the pelagic thresher in the longline fishery averaged 1042 t and was 464 in 2018. Catch estimates for the mako sharks in the purse-seine fishery were lower than the aforementioned shark species averaging 2.6 t and was 1 t in 2019. However, in the longline fishery the minimum annual reported catch averaged 1,263 t and was 2,882 t in 2018.

The small-scale 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 completed 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 will be presented at this meeting (SAC-11-05). 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 (1993–2019) and minimum reported annual catches by longline (1993–2018) 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, with low catches reported 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 2007 by the longline fishery (Table J-4). The giant manta had the largest average catches in the purse-seine fishery (19.4 t), followed by the spinetail (13.9 t), and smoothtail (8.7 t) mobulid rays. Catches of these species in 2019 were 8, 19, and 5 t, respectively. Catches of the pelagic stingray were low, averaging only 2.5 t and being 2 t in 2019 (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).

3.7. Other large fishes

Large pelagic fishes caught by the large-vessel purse-seine, primarily on floating-object sets, (1993–2019) and longline (1993–2018) 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 1,309 t (1,237 t in 2019) and the minimum reported annual catch for the longline fishery averaging 5997 t (3499 t in 2018). 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 386 t, although catches have declined from a peak of 1025 t in 2001 to 202 t in 2019 (Figure J-5). Minimum reported annual catch of wahoo by the longline fishery have averaged 149 t and was 313 t in 2018. 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 have been 48 t, peaking in 2007 at 158 t and declining thereafter to 21 t in 2019 (Figure J-5).

Pelagic fishes commonly reported by the longline fishery include opah (Lamrpidae), snake mackerels (Gempylidae) and pomfrets (Bramidae). Minimum reported annual catches for these species averaged 324 t, 182 t, and 49 t, respectively. Catches of all these species have increased after the mid-2000s (Figure J-5). For the most recent year (2018), there were 1,024 t, 227 t, and 125 t of opah, snake mackerels, and pomfrets reported, respectively (Table J-5).

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 1,075 t from 1993–2019. However, their catches have declined from 1,922 in 2005 to 276 t in 2019 (Figure J-6). Triggerfishes (Balistidae) and filefishes (Monacanthidae) are the second most commonly reported forage group with annual estimated catches averaging 268 t and totaling 58 t in 2019. 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 <1 t in 2019. Lastly, annual catches of the various species in the category 'epipelagic forage fishes' averaged 4.2 t with 13 t estimated to be caught in 2019.

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 during the previous year, in this case, 2019.

[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.

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.

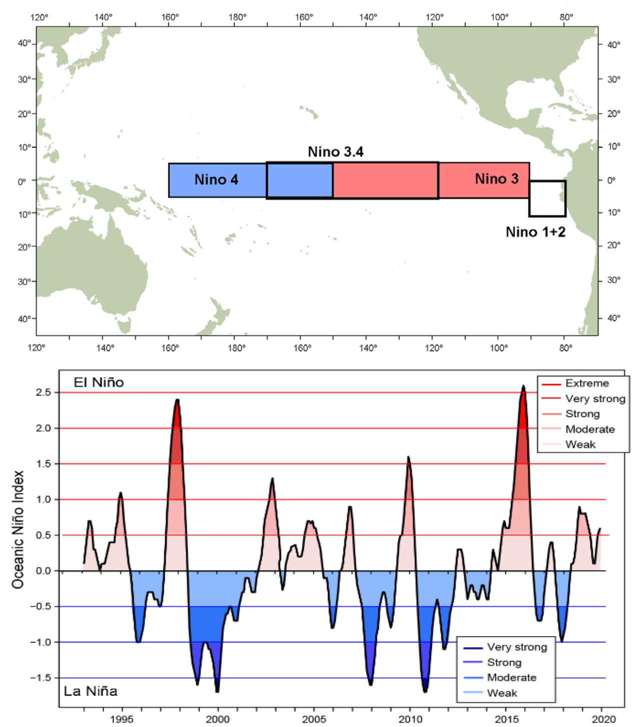

FIGURE J-7. El Niño regions used as indicators of El Niño Southern Oscillation (ENSO) events in the Pacific Ocean (top panel), and the Oceanic Niño Index (ONI) used to monitor ENSO conditions in Niño region 3.4 from 5°N to 5°S and 120°W to 170°W (bottom panel). Time series shows the running 3-month mean ONI values from the start of the IATTC observer program through December 2019. ONI data obtained from: http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

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 2019. Datos del ONI obtenidos de: http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

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).

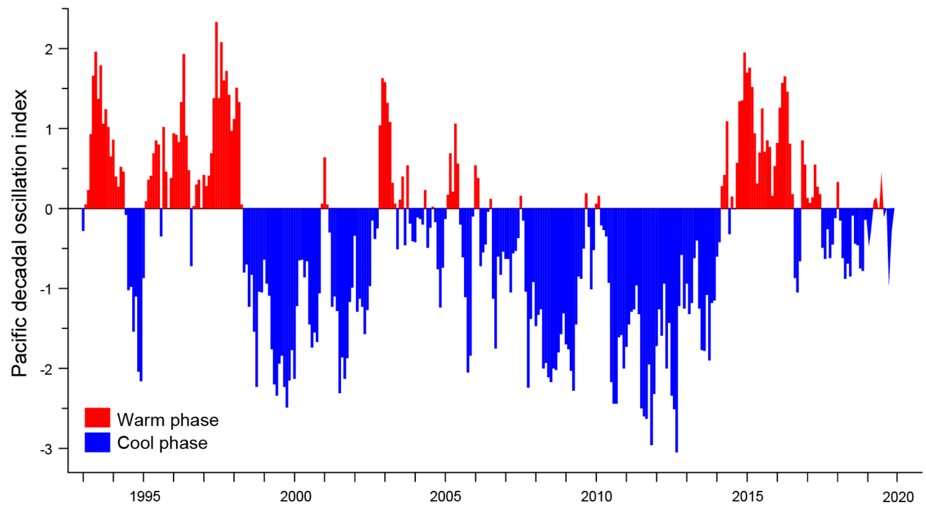

FIGURE J-8. Monthly values of the Pacific Decadal Oscillation (PDO) Index, January 1993-December 2019. PDO data obtained from: https://www.ncdc.noaa.gov/teleconnections/pdo/data.csv

FIGURA J-8. Valores mensuales del índice de Oscilación Decadal del Pacífico (PDO), enero de 1993–diciembre de 2019. Datos de la PDO obtenidos de: https://www.ncdc.noaa.gov/teleconnections/pdo/data.csv

The Climate Diagnostics Bulletin of the US National Weather Service reported that in 2019 anomalies—defined in the Bulletin as a departure from the monthly mean—in oceanic and atmospheric characteristics (surface and sub-surface temperatures, thermocline depth, wind, convection, *etc*.) were indicative of El Niño conditions during January-June and ENSO-neutral conditions during July-December.

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, while moderate-weak El Niño conditions persisted in 2019.

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 2019, PDO conditions were primarily cool.

4.2. Satio-temporal exploration of environmental conditions

A time series of SST and CHL-a (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 1993–2019, while that for CHL-a concentrations covers data for 2003–2019 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. Because large interannual variability was not observed with the CHL-a time series, SST may be a more important driver of any observed changes in catches.

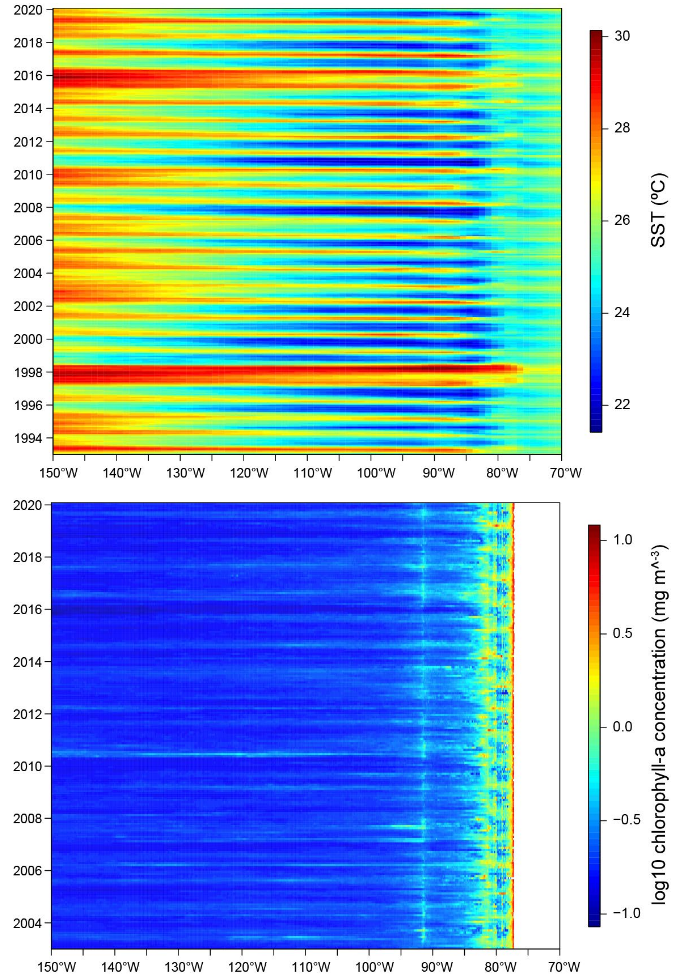

FIGURE J-9. Time-longitude Hovmöller diagram with data averaged across the tropical eastern Pacific Ocean from 5°N to 5°S for mean monthly SST for January 1993–January 2020 (top panel) (https://www.esrl.noaa.gov/psd/) and mean monthly chlorophyll-a concentration for January 2003–January 2020 (bottom 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 enero de 2020 (panel superior) (https://www.esrl.noaa.gov/psd/) y concentración promedio mensual de clorofila-a de enero de 2003 a enero 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 chlorophyll-a (CHL-a) levels (an indicator of primary productivity biomass) 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 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 2019. In future, staff plan to incorporate the catch distribution of bycatch species and apply sophisticated models to better describe relationships between environment and catches.

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, predominantly around 5°S to 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 (0–20°S, 130°–150°W) all year long, but waters were warmer and larger in area in this region during quarters 1 and 2 compared to 3 and 4.

CHL-a concentrations were higher along the equator and the coast of the Americas year-round. The oligotrophic[6] South Pacific Gyre—located between around 20°–40°S—present in quarter 1 retracted in quarters 2 and 3 but 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. During quarter 3, a large portion of the tuna catches consisted of skipjack along a warm-water front (25–~28°C) slightly north of the equator from the coast of South America to about 120°W, also a region of high CHL-a concentration, and these persisted through quarter 4, although with greater catches east of 100°W. A secondary concentration of catches occurred west of 130°W, close to the western boundary of the EPO.

During quarter 1 most of the catch along the equator from about 110°W to 140°W consisted of yellowfin, while skipjack and bigeye constituted an increased proportion of catches during quarters 2–4.

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 (Class-6) purse-seine vessels (Duffy *et al*. 2019) and by the longline fishery (SAC-08-07d).

Because PSA is unable to quantitatively estimate the cumulative effects of multiple fisheries on data-poor bycatch species, a new approach—Ecological Assessment of Sustainable Impacts of Fisheries (EASI-Fish)—was developed by the IATTC staff in 2018 (SAC-09-12) to overcome this issue. This flexible, spatially-explicit method uses a smaller set of parameters than PSA to first produce a proxy for the fishing mortality rate (F) of each species, based on the 'volumetric overlap' of each fishery on the geographic distribution of these species. The estimate of F is then used in length-structured 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,

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

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-10-01). 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, beginning from the experimental determination of consumption estimates of yellowfin tuna at the IATTC's Achotines laboratory in the 1980s, to more recent analyses of stomach content and chemical indicators 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).

6.1. Ecological indicators

Since 2017, ETP8 has been used in the *Ecosystem Considerations* report to provide annual values for six 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' 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 ETP8 were conducted to assess potential impacts of the FAD fishery on the structure of the ecosystem (SAC-10-15).

An update assessment of the ETP8 model was not undertaken in 2020 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. Although catch estimates are now finalized for 2019 the staff is now tasked to assign species-specific catch to the relevant functional groups in the ETP8 model, and then rebalance and recalibrate the model to provide an updated ecosystem status for 2019 at SAC-11 in 2021.

The most recent report on ecological indicators undertaken in 2019 (SAC-10-14) showed that values for TL_c and MTI increased from 4.65 and 4.67 in 1970 to 4.69 and 4.70 in 1991, respectively, as the purse-seine fishing effort on FADs increased significantly (Figure J-13). TL_c continued to decrease to a low of 4.65 in 1997, due to the rapid expansion of the fishery from 1993 where there was increasing catches in the intervening period of high trophic level bycatch species that tend to aggregate around floating objects (*e.g.* sharks, billfish, wahoo and dorado). This expansion is seen in the FIB index that exceeds zero during the same period, and also a change in the evenness of biomass of the community indicated by Shannon's index. By the early 2000s, TL_c, MTI, and Shannon's index all show a gradual decline, while the FIB gradually increased further from zero to its peak in 2017 at 0.66 (Figure J-13). Both TL_c and MTI reached their lowest historic levels of 4.64 and 4.65 in 2017, respectively. Since its peak in 1991, TL_c declined by 0.05 of a trophic level in the subsequent 27 years, or 0.02 trophic levels per decade.

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 (4.449) in 1993 but has continued to decline to 4.443 in 2017 (Figure J-13). As a result of changes in predation pressure on lower trophic levels, between 1993 and 2017 the biomass of the $TL_{MC3.25}$ community increased from 3.800 to 3.803, while interestingly, the biomass of the $TL_{MC2.0}$ community also increased from 3.306 to 3.308.

Together, these indicators show that the ecosystem structure has likely changed over the 50-year analysis period. However, these changes, even if they are a direct result of fishing, do not appear to be currently ecologically detrimental, but the patterns of changes, particularly in the mean trophic level of the communities, certainly warrant the continuation, and possible 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 2021. The priority of groups to be assessed will likely be elasmobranchs, teleosts, turtles and cetaceans.

- A shortcoming of the ETP8 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, 2019 and 2020 to establish an ecological monitoring program to collect stomach content data to update the ecosystem model.

- A second limitation of the ETP8 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, future work is required to assess the representativeness of these data for future environmental analyses.

ACKNOWLEDGMENTS

We would like to thank Nick Vogel, Joydelee Marrow, and Joanne Boster for their assistance with data preparation, Alexandre Aires-da-Silva, Nick Webb and Paulina Llano for their reviews of this document, and Christine Patnode for improving the figures. We gratefully acknowledge the early ecosystem research by Robert Olson that contributed to this report. His initiation of the *Ecosystem Considerations* report was first presented at the 8th Meeting of the Working Group to Review Stock Assessments in 2007 (SAR-8-17 J) and has been updated annually.

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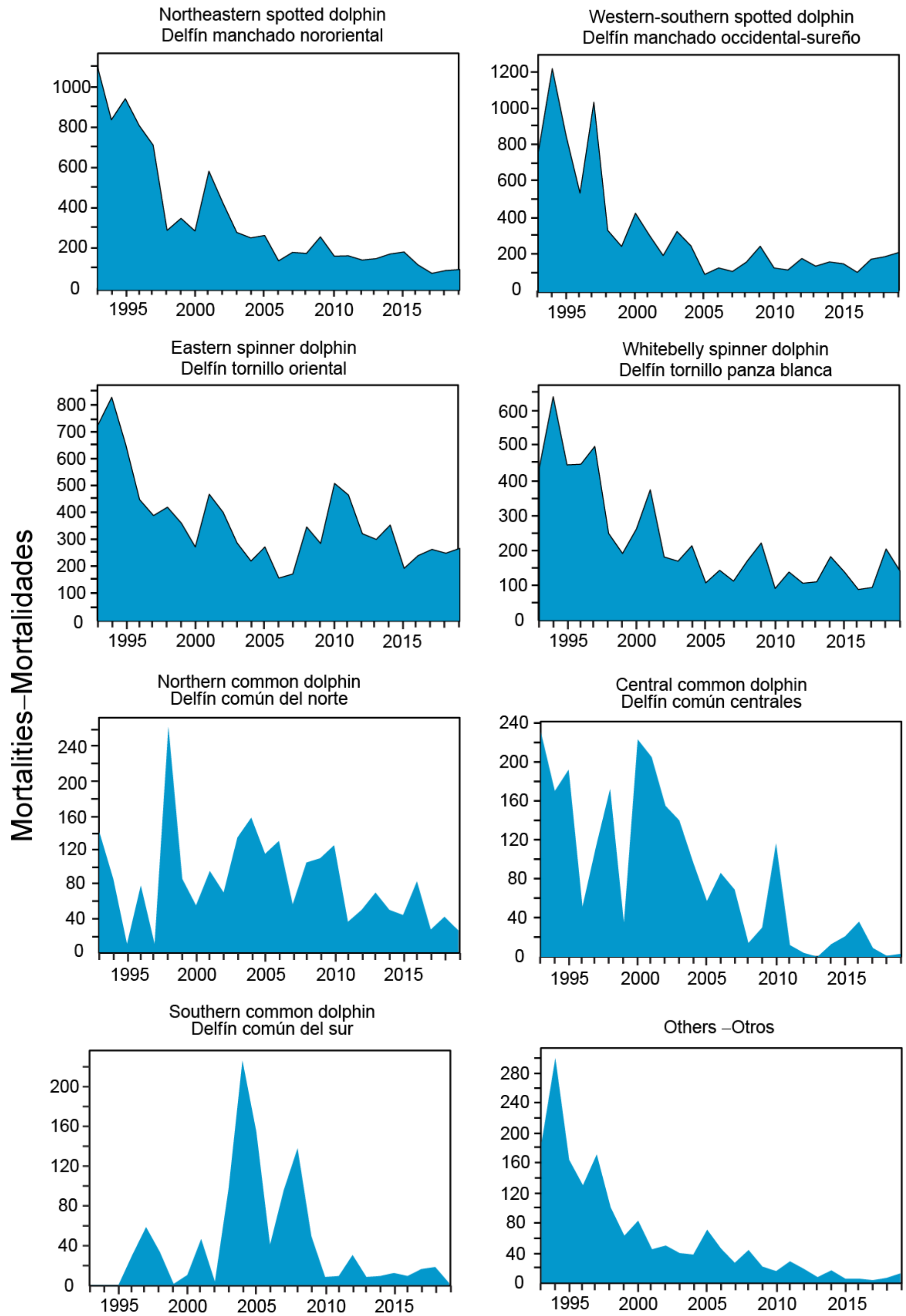
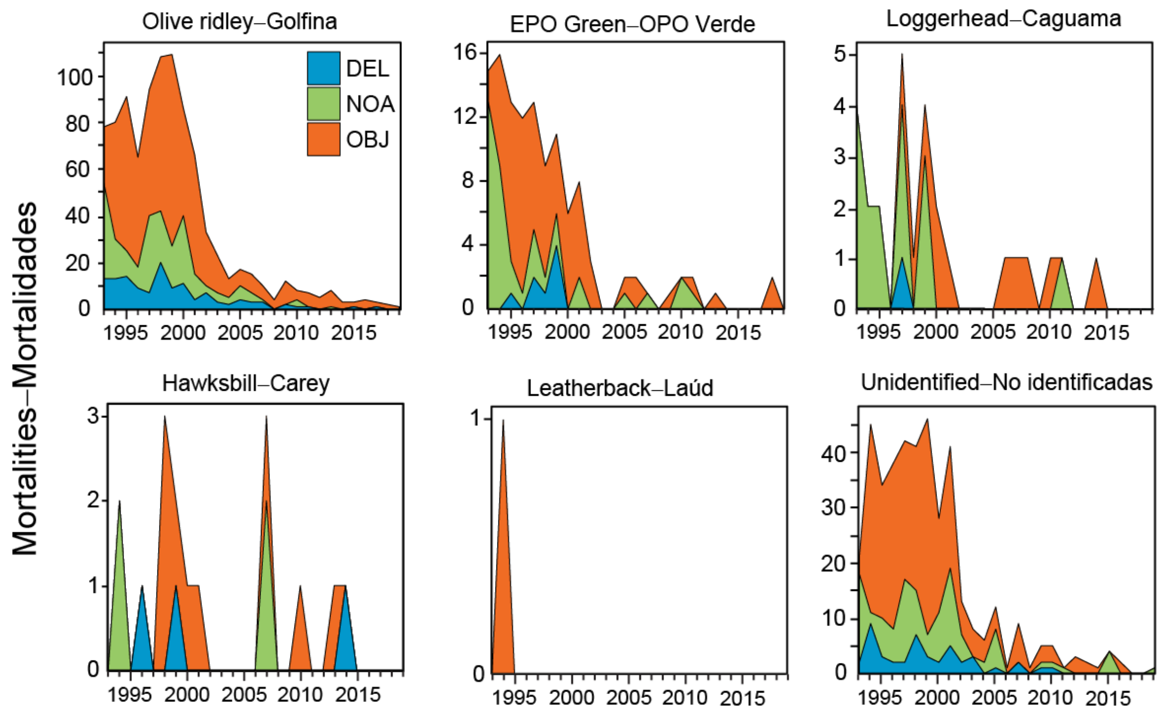


FIGURE J-1. Incidental dolphin mortalities, in numbers of animals, by purse-seine vessels, 1993–2019.
FIGURA J-1. Mortalidades incidentales de delfines, en número de animales, por buques cerqueros, 1993–2019.

a.



b.

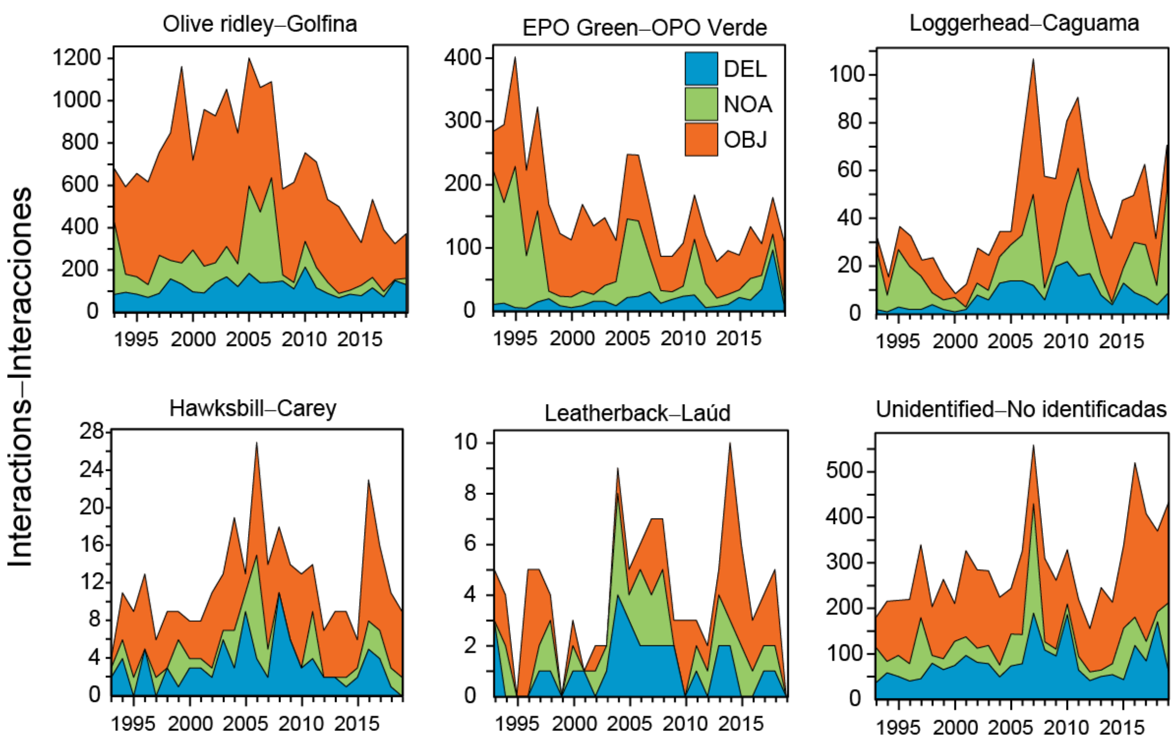


FIGURE J-2. Sea turtle a) mortalities and b) interactions, in numbers of animals, for large purse-seine vessels, 1993–2019, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)).

FIGURA J-2. a) Mortalidades y b) interacciones de tortugas marinas, en número de animales, por buques cerqueros grandes, 1993-2019, por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)).

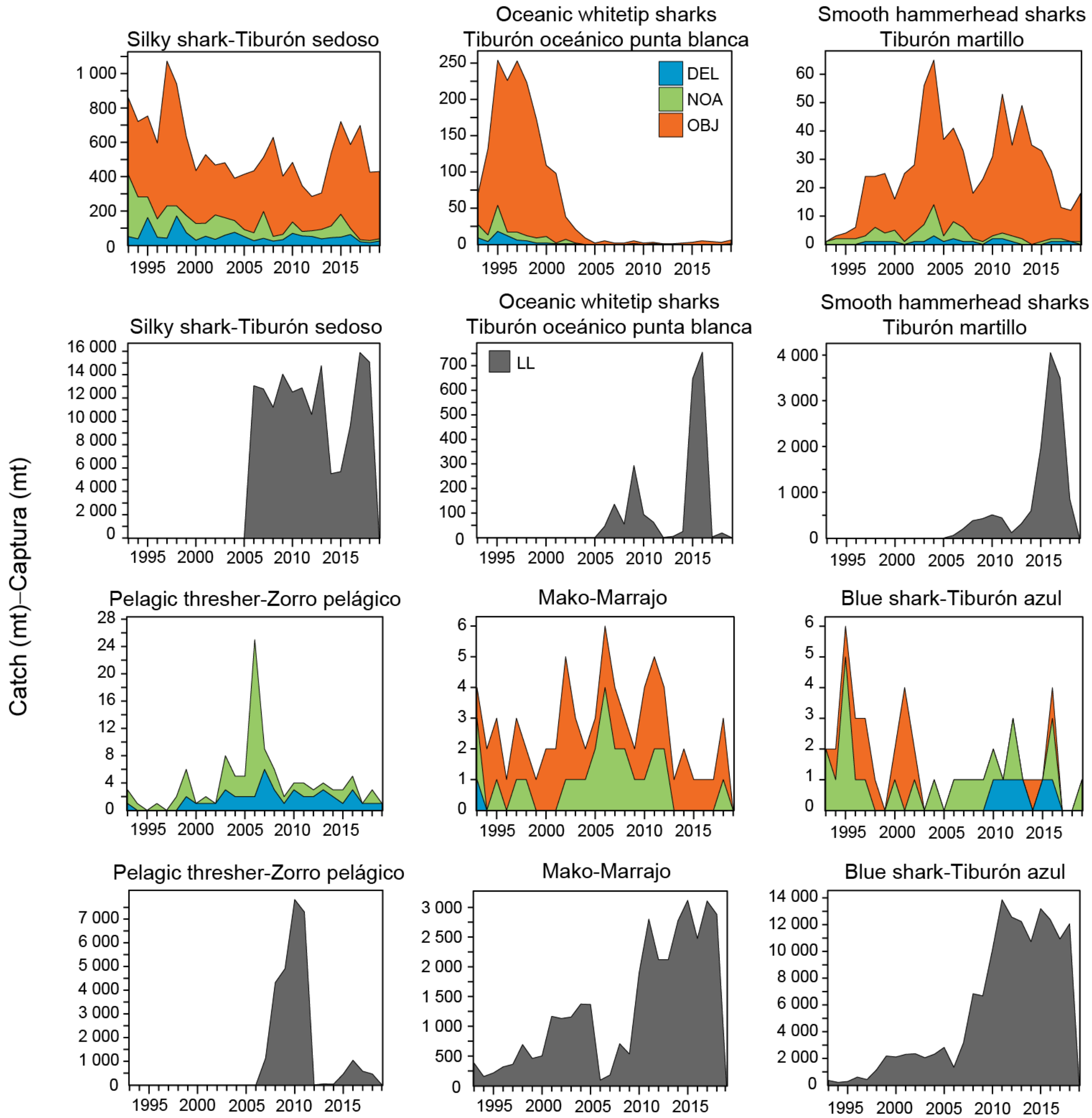


FIGURE J-3. Estimated purse-seine (top panel) and longline (bottom panel) catches in metric tons (t) of key species of sharks in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2019) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Longline catches 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 cerqueras (panel superior) y palangreras (panel inferior) estimadas en toneladas (t) de especies clave de tiburones en el Océano Pacífico oriental. Se presentan las capturas cerqueras para buques de clase 6 con una capacidad de acarreo >363 t (1993-2019) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las capturas palangreras 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).

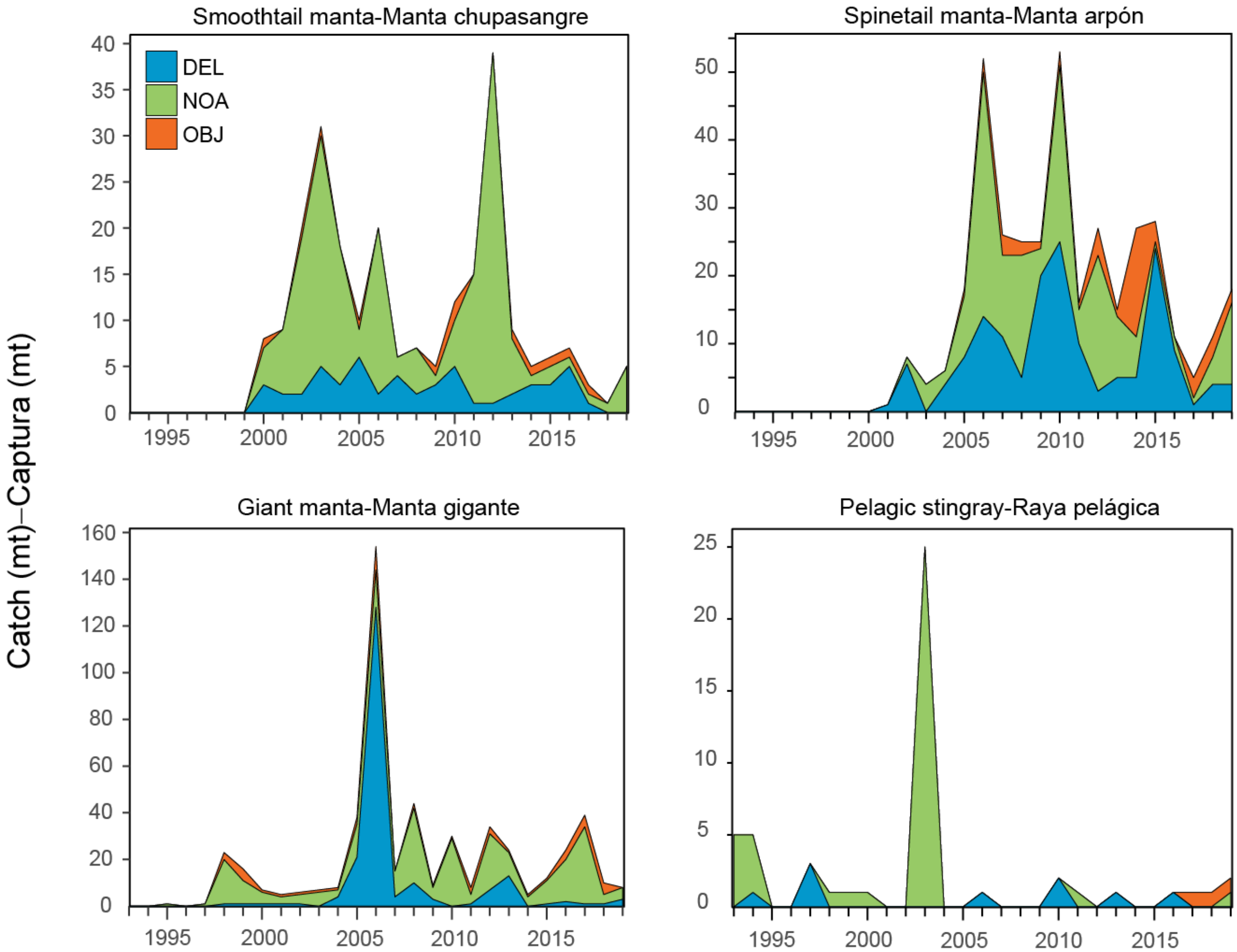


FIGURE J-4. Estimated purse-seine catches in metric tons (t) of key species of rays in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2019) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL).

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 (1993-2019) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL).

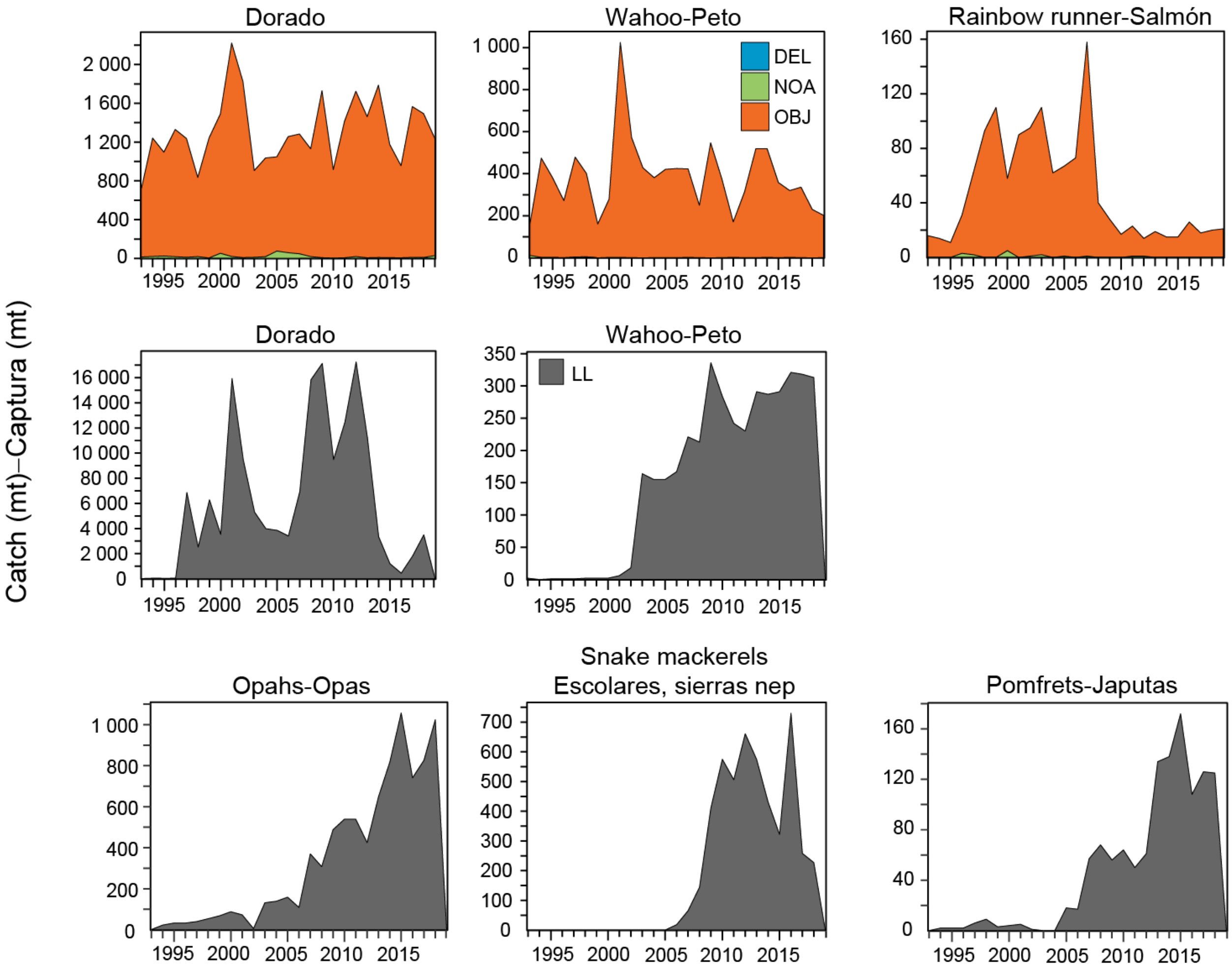


FIGURE J-5. Estimated purse-seine and longline catches in metric tons (t) of key species of large fishes in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2019) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Longline catches 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 (1993-2019) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Las capturas palangreras son extracciones anuales brutas mínimas reportadas.

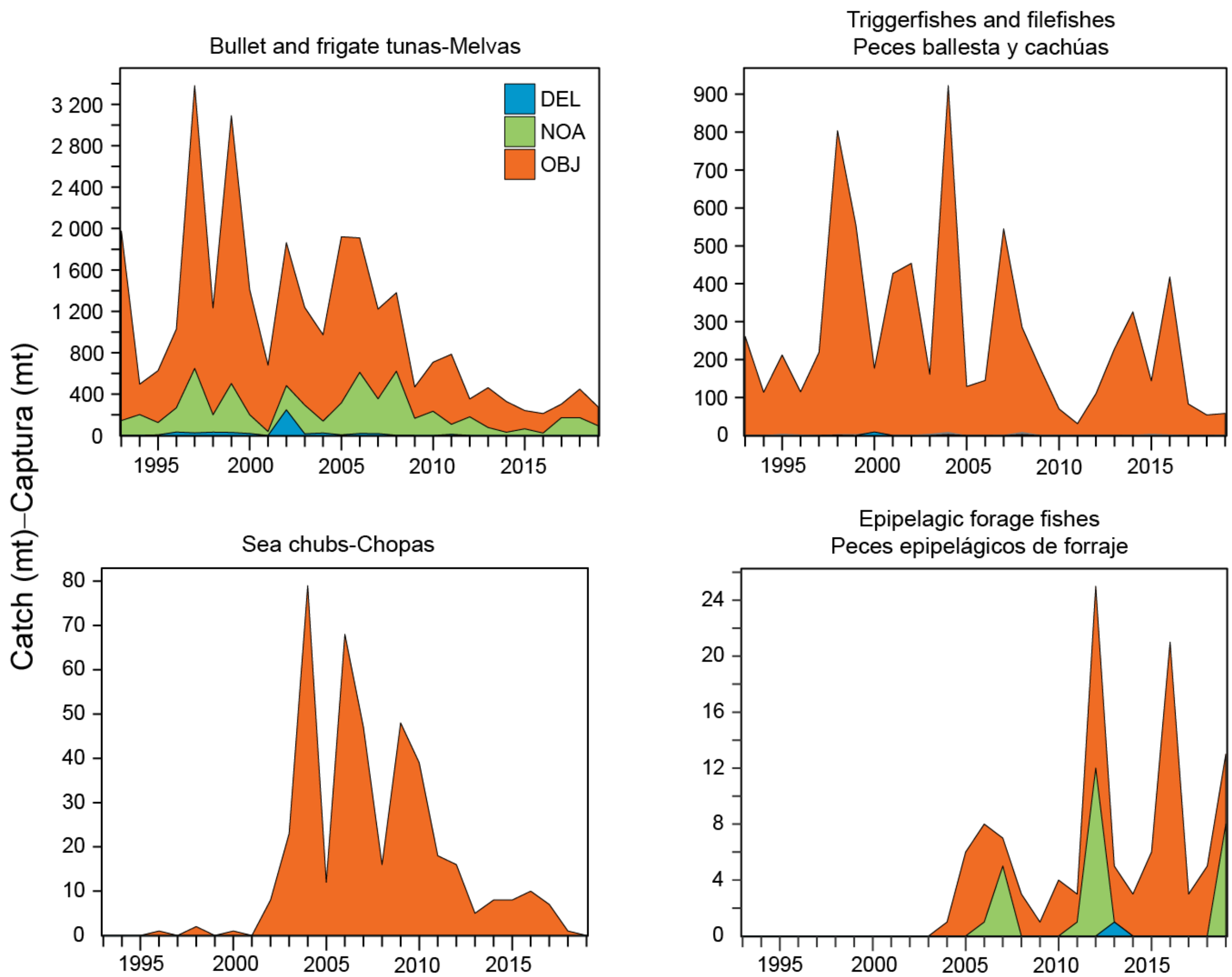


FIGURE J-6. Estimated purse-seine catches in metric tons (t) of key species of small fishes in the eastern Pacific Ocean. Purse seine catches are provided for size-class 6 vessels with a carrying capacity >363 t (1993–2019) by set type: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (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 (1993-2019) por tipo de lance: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL).

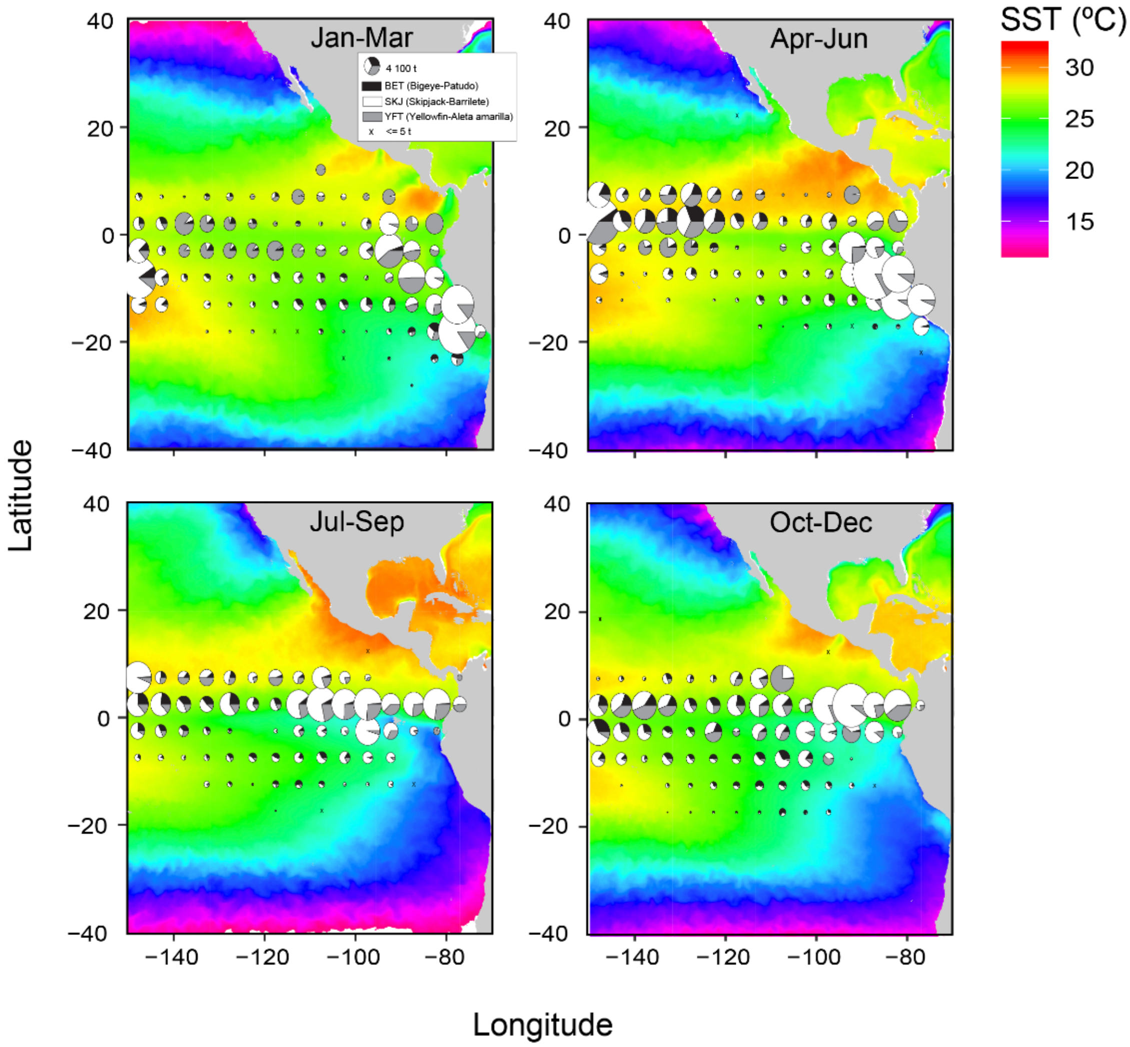


FIGURE J-10. Mean sea surface temperature (SST) for each quarter during 2019 with catches of tropical tunas overlaid. SST data obtained from NOAA NMFS SWFSC ERD on March 5, 2020, "Multi-scale Ultra-high Resolution (MUR) SST Analysis fv04.1, Global, 0.01°, 2002–present, Monthly", https://coastwatch.pfeg.noaa.gov/erddap/info/jplMURSST41mday/index.html.

FIGURA J-10 Temperatura superficial del mar (TSM) promedio para cada trimestre de 2019 con las capturas de atunes tropicales superpuestas. Datos de TSM obtenidos de NOAA NMFS SWFSC ERD el 5 de marzo de 2020, "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.

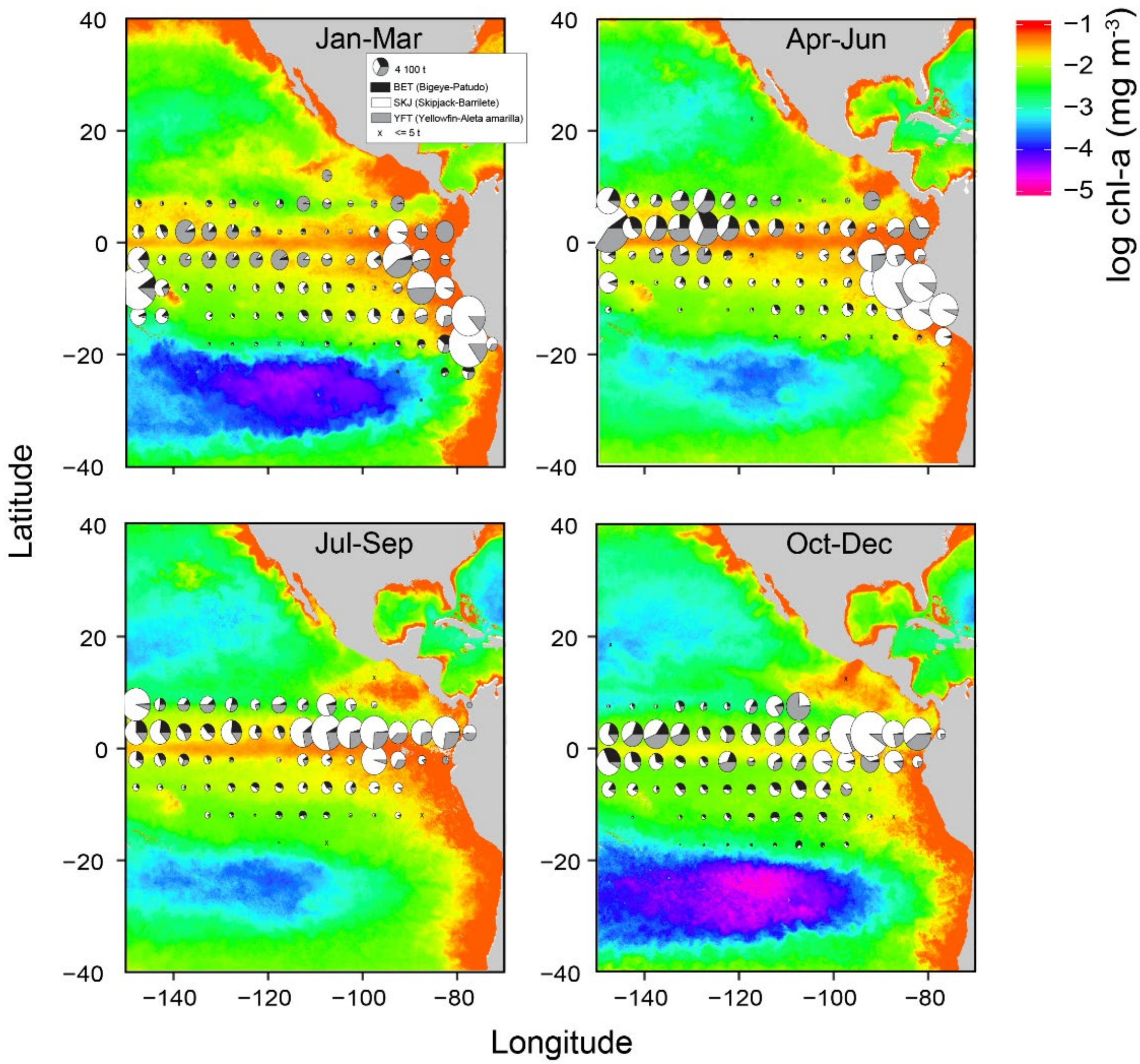


FIGURE J-11. Mean log chlorophyll-a concentration (in mg m^3) for each quarter during 2019 with catches of tropical tunas overlaid. Chlorophyll data obtained from NOAA CoastWatch on February 19, 2020, "Chlorophyll, NOAA, VIIRS, Science Quality, Global, Level 3, 2012-present, Monthly", NOAA NMFS SWFSC 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 2019 con las capturas de atunes tropicales superpuestas. Datos de clorofila obtenidos de NOAA CoastWatch el 19 de febrero de 2020, "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.

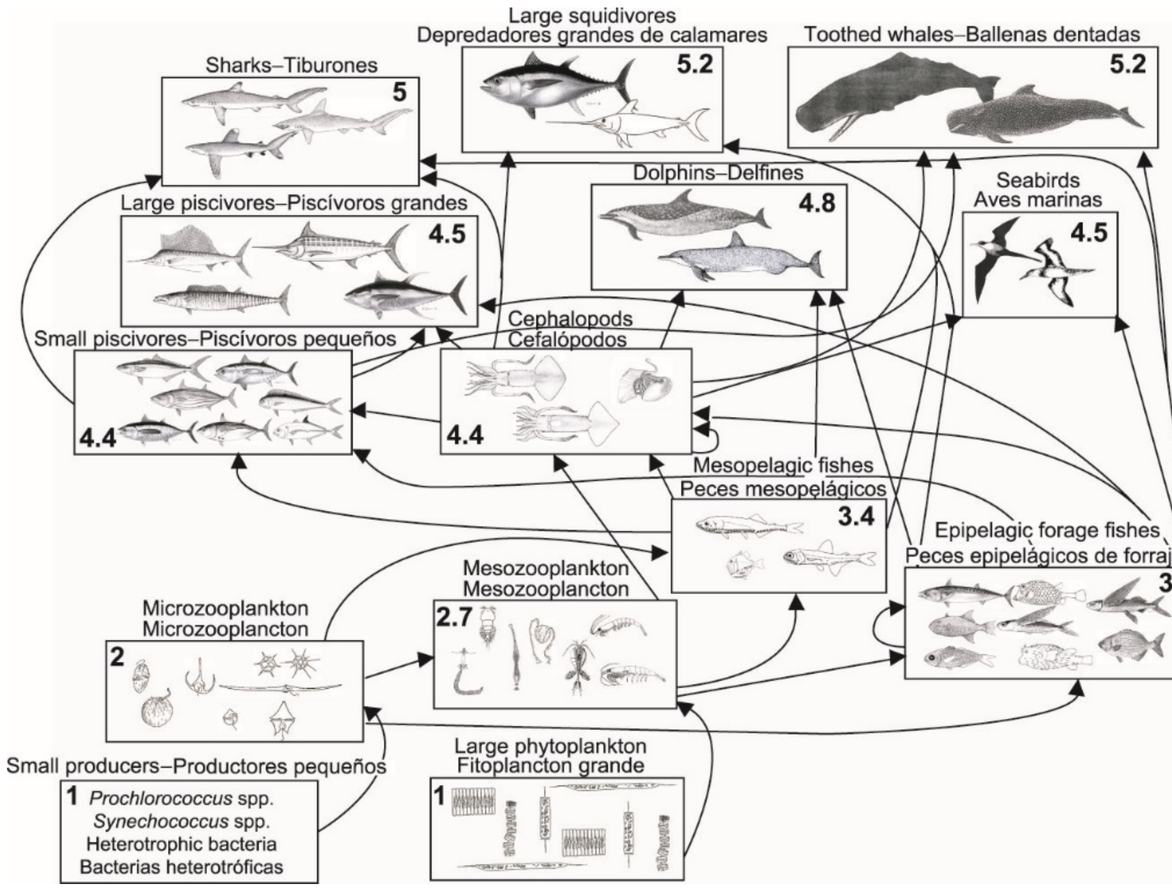


FIGURE J-12. Simplified food-web diagram of the pelagic ecosystem in the tropical EPO. The numbers inside the boxes indicate the approximate trophic level of each group.

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.

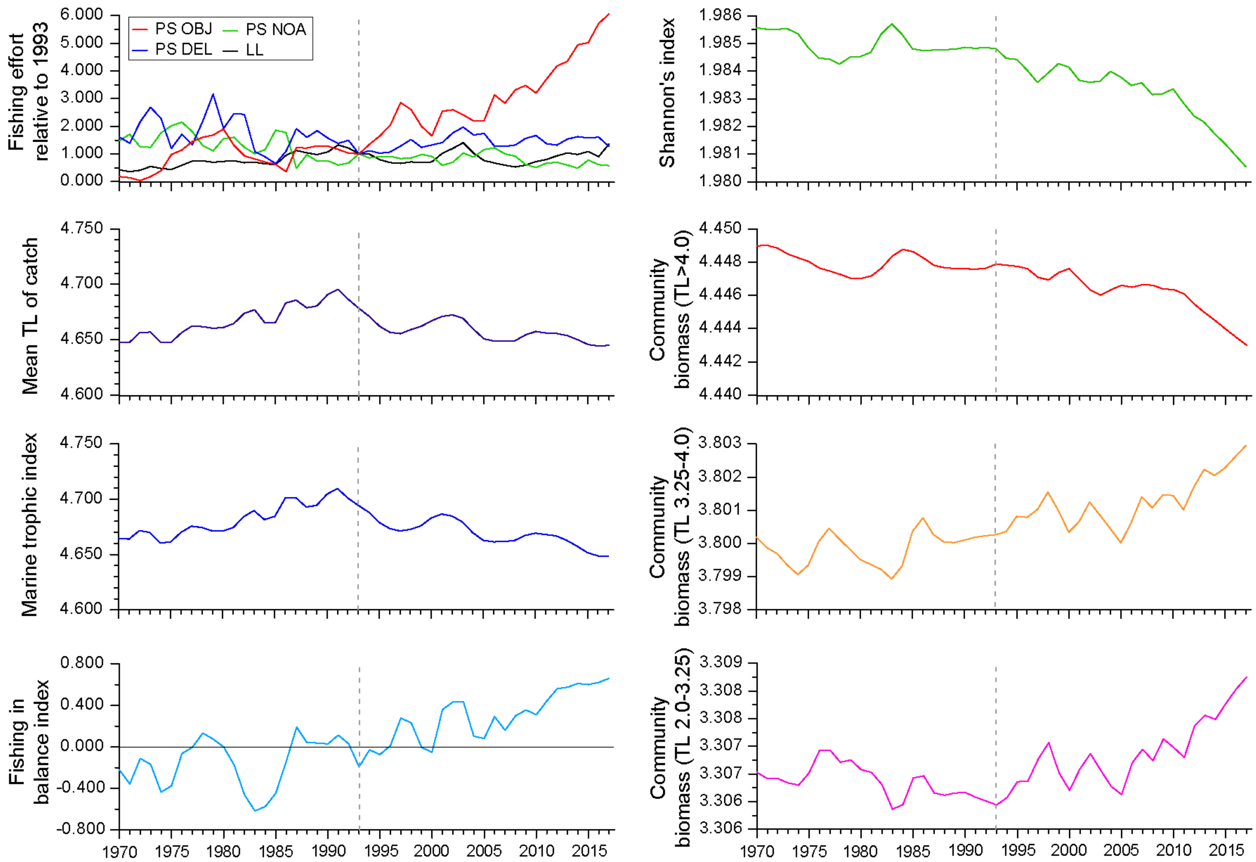


FIGURE J-13. Annual values for seven ecological indicators of changes in different components of the tropical EPO ecosystem, 1970–2017 (see Section 6 of text for details), and an index of longline (LL) and purse-seine (PS) fishing effort, by set type (dolphin (DEL), unassociated (NOA), floating object (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 tropical del OPO, 1970–2017 (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 purse-seine fishery from 1993–2019.
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 durante 1993-2019.

	Stenella attenuata				*Stenella longirostris*				*Delphinus delphis*							
	Offshore[1]				Spinner				Common							
	Northeastern		Western-southern		Eastern		Whitebelly		Northern		Central		Southern		Other mammals	
Year	**Num**	**t**	**Num**	**t**	**Num**	**t**	**Num**	**t**	**Num**	**t**	**Num**	**t**	**Num**	**t**	**Num**	**t**
1993	1,112	56	773	44	725	34	437	22	139	9	230	15	0	0	185	8
1994	847	43	1228	71	828	39	640	33	85	6	170	11	0	0	298	12
1995	952	48	859	49	654	31	445	23	9	1	192	13	0	0	163	13
1996	818	41	545	31	450	21	447	23	77	5	51	3	30	2	129	5
1997	721	37	1044	60	391	19	498	26	9	1	114	7	58	4	170	14
1998	298	15	341	20	422	20	249	13	261	17	172	11	33	2	100	8
1999	358	18	253	15	363	17	192	10	85	6	34	2	1	<1	62	4
2000	295	15	435	25	275	13	262	13	54	4	223	15	10	1	82	5
2001	592	30	315	18	470	22	374	19	94	6	205	13	46	3	44	1
2002	435	22	203	12	403	19	182	9	69	5	155	10	3	<1	49	3
2003	288	15	335	19	290	14	170	9	133	9	140	9	97	6	39	3
2004	261	13	256	15	223	11	214	11	156	10	97	6	225	15	37	1
2005	273	14	100	6	275	13	108	6	114	7	57	4	154	10	70	3
2006	147	7	135	8	160	8	144	7	129	8	86	6	40	3	45	2
2007	189	10	116	7	175	8	113	6	55	4	69	5	95	6	26	1
2008	184	9	167	10	349	17	171	9	104	7	14	1	137	9	43	3
2009	266	13	254	15	288	14	222	11	109	7	30	2	49	3	21	1
2010	170	9	135	8	510	24	92	5	124	8	116	8	8	1	15	1
2011	172	9	124	7	467	22	139	7	35	2	12	1	9	1	28	2
2012	151	8	187	11	324	15	107	6	49	3	4	<1	30	2	18	0
2013	158	8	145	8	303	14	111	6	69	5	0	0	8	1	7	1
2014	181	9	168	10	356	17	183	9	49	3	13	1	9	1	16	0
2015	191	10	158	9	196	9	139	7	43	3	21	1	12	1	5	0
2016	127	6	111	6	243	12	89	5	82	5	36	2	9	1	5	0
2017	85	4	183	11	266	13	95	5	26	2	9	1	16	1	3	0
2018	99	5	197	11	252	12	205	11	41	3	1	<1	18	1	6	0
2019	104	5	220	13	270	13	142	7	25	2	3	<1	2	<1	12	0
Total	**9,474**	**480**	**8,987**	**517**	**9,928**	**471**	**6,170**	**317**	**2,225**	**146**	**2,254**	**148**	**1,099**	**72**	**1,678**	**91**

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

Table J-2. Purse-seine a) mortalities b) interactions reported by onboard observers in numbers of turtles for size-class 6 vessels with a carrying capacity >363 t (1993–2019). Purse-seine set types: floating object (OBJ), unassociated tuna schools (NOA) and dolphins (DEL). Data for 2019 are considered preliminary.
Tabla J-2. a) Mortalidades e b) interacciones cerqueras reportadas por observadores a bordo, en número de tortugas, para buques de clase 6 con una capacidad de acarreo >363 t (1993–2019). Tipos de lances cerqueros: objeto flotante (OBJ), atunes no asociados (NOA) y delfines (DEL). Los datos de 2019 se consideran preliminares.

a)

	***Lepidochelys olivacea*, olive ridley**			***Chelonia agassizii*, *C. mydas*, eastern Pacific green**			***Caretta caretta*, loggerhead**			**Eretmochelys imbricata, hawksbill**			***Dermochelys coriacea*, leatherback**			**Unidentified turtles**		
	Purse seine			**Purse seine**			**Purse seine**			**Purse seine**			**Purse seine**			**Purse seine**		
Year	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**
1993	23	40	12	2	13	0	0	2	0	0	0	0	0	0	0	3	16	2
1994	50	15	10	7	9	0	0	1	0	0	1	0	1	0	0	34	2	7
1995	66	10	11	10	2	1	0	1	0	0	0	0	0	0	0	24	7	3
1996	47	6	7	11	1	0	0	0	0	0	0	1	0	0	0	30	4	2
1997	52	14	6	8	3	2	1	1	1	0	0	0	0	0	0	25	15	2
1998	66	19	16	7	1	1	1	0	0	3	0	0	0	0	0	26	8	6
1999	81	14	8	4	2	2	1	2	0	1	0	1	0	0	0	39	4	3
2000	45	25	8	6	0	0	1	0	0	1	0	0	0	0	0	17	8	2
2001	49	9	3	5	2	0	1	0	0	1	0	0	0	0	0	22	14	5
2002	21	3	6	3	0	0	0	0	0	0	0	0	0	0	0	6	5	2
2003	16	4	3	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2
2004	8	3	2	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0
2005	7	3	3	1	1	0	0	0	0	0	0	0	0	0	0	4	4	1
2006	8	4	3	2	0	0	1	0	0	0	0	0	0	0	0	1	0	0
2007	6	1	2	0	1	0	1	0	0	1	1	0	0	0	0	7	0	2
2008	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
2009	10	0	2	1	0	0	0	0	0	0	0	0	0	0	0	3	1	1
2010	4	3	1	0	2	0	1	0	0	1	0	0	0	0	0	3	1	1
2011	6	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0
2012	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
2013	6	1	0	1	0	0	0	0	0	1	0	0	0	0	0	2	0	0
2014	3	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0
2015	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
2016	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
2017	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Total	**594**	**174**	**106**	**71**	**38**	**6**	**10**	**8**	**1**	**9**	**2**	**3**	**1**	**0**	**0**	**262**	**95**	**41**

Continued

b)

	Lepidochelys olivacea, *olive ridley*			*Chelonia agassizii*, *Chelonia mydas*, eastern Pacific green			*Caretta caretta*, loggerhead			*Eretmochelys imbricata*, hawksbill			*Dermochelys coriacea*, leatherback			Unidentified turtles		
	Purse seine			Purse seine			Purse seine			Purse seine			Purse seine			Purse seine		
Year	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**	**OBJ**	**NOA**	**DEL**
1993	254	338	82	59	214	10	3	26	2	1	1	2	2	-	3	65	78	35
1994	412	85	92	123	159	12	7	7	1	5	2	4	2	2	-	132	25	57
1995	487	82	83	173	223	5	9	24	3	7	2	-	-	-	-	121	46	49
1996	484	60	68	135	83	4	12	18	2	8	-	5	5	-	-	141	38	39
1997	485	179	87	164	144	14	6	14	2	4	2	-	3	1	1	160	134	44
1998	601	87	155	137	12	19	14	5	4	6	-	3	1	2	1	107	17	78
1999	926	99	131	99	15	8	8	4	2	3	5	1	-	-	-	174	24	64
2000	423	197	94	90	17	5	1	6	1	4	1	3	1	1	1	83	53	73
2001	738	126	89	137	23	8	9	1	2	4	1	3	-	-	1	189	41	95
2002	692	93	138	108	11	15	14	5	8	8	1	2	1	1	-	172	31	80
2003	741	143	165	107	25	15	14	4	6	6	1	6	-	1	1	164	40	77
2004	616	107	119	65	38	8	10	11	13	12	4	3	1	4	4	149	26	48
2005	603	412	181	102	124	21	5	15	14	2	2	9	1	1	3	100	70	72
2006	587	333	137	104	119	23	38	19	14	12	11	4	1	3	2	183	64	77
2007	453	492	139	83	55	30	56	38	12	9	3	2	3	2	2	129	240	188
2008	405	29	145	54	20	12	46	5	6	7	-	11	2	3	2	183	18	107
2009	472	30	108	56	12	18	31	5	20	8	-	6	1	-	2	151	15	94
2010	417	121	211	68	16	23	34	24	22	10	-	3	3	-	-	119	23	185
2011	497	96	113	70	88	25	29	45	16	5	5	4	1	1	1	125	30	63
2012	389	53	87	77	38	5	20	19	17	5	-	2	1	1	-	95	19	40
2013	409	21	66	58	13	7	24	9	8	7	-	2	1	2	2	181	14	49
2014	307	19	83	69	16	10	26	1	4	7	1	1	7	1	2	135	24	53
2015	201	49	76	55	12	21	28	6	13	3	1	2	4	2	-	182	113	42
2016	367	49	113	82	34	17	19	21	9	15	3	5	2	1	-	339	62	117
2017	291	25	71	50	22	34	33	22	7	9	3	4	2	1	1	280	43	83
2018	169	5	147	58	25	96	19	8	4	8	2	1	3	1	1	177	22	169
2019	210	30	128	87	13	10	15	46	9	7	2	-	-	-	-	221	153	58
Total	**12,636**	**3,360**	**3,108**	**2,470**	**1,571**	**475**	**530**	**408**	**221**	**182**	**53**	**88**	**48**	**31**	**30**	**4,257**	**1,463**	**2,136**

Table J-3. Estimated purse-seine catches by set type in metric tons (t) of sharks for size-class 6 vessels with a carrying capacity >363 t (1993–2019) and minimum reported longline (LL) catches of sharks (gross-annual removals in t) (1993–2018, *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 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) para buques de clase 6 con una capacidad de acarreo >363 t (1993–2019) y capturas palangreras (LL) mínimas reportadas de tiburones (extracciones anuales brutas en t) (1993-2018, *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 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	398	12	16	15,072	3	-	<1	19	<1	<1	<1	12,064	28	3	1	1,360
2019	392	13	25	*	5	<1	<1	*	<1	<1	<1	*	26	4	6	*
Total	**11,224**	**2,420**	**1,448**	**153,569**	**1,478**	**111**	**64**	**2,143**	**18**	**23**	**9**	**145,326**	**411**	**123**	**126**	**25,789**

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	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	*	11	2	<1	*	1	-	<1	*	5	<1	<1	*
Total	**645**	**68**	**21**	**13,394**	**379**	**96**	**25**	**731**	**59**	**4**	**5**	**-**	**719**	**146**	**52**	**2,096**

Continued

	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	-	<1	<1	<1	850
2015	<1	2	1	463	<1	1	<1	859	<1	-	<1	11	<1	<1	<1	283
2016	<1	2	3	1,045	<1	<1	4	944	<1	1	<1	547	<1	<1	1	96
2017	<1	<1	<1	582	<1	<1	<1	1,148	-	<1	<1	1,677	<1	<1	<1	153
2018	<1	2	<1	464	<1	<1	<1	32	<1	<1	<1	1,683	<1	<1	<1	39
2019	<1	<1	<1	*	<1	<1	<1	*	-	-	<1	*	<1	<1	<1	*
Total	**22**	**65**	**43**	**28,138**	**17**	**108**	**53**	**6,203**	**5**	**28**	**12**	**4,357**	**14**	**69**	**45**	**3,775**

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	-	-	-	-	-	-	-	-	84	19	14	271	623	437	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	2,775	-	-	-	51	-	-	-	4,067	24	<1	<1	2,075	540	78	56	29,076
2015	<1	<1	<1	3,118	-	-	-	79	-	-	-	621	18	3	3	10,593	645	151	58	39,821
2016	1	<1	<1	2,475	-	-	-	91	-	-	-	538	19	3	<1	2,245	602	50	78	37,877
2017	<1	<1	-	3,107	-	-	-	95	-	-	-	986	16	1	<1	1,263	766	21	27	42,174
2018	2	<1	<1	2,882	-	-	-	86	-	-	-	729	5	<1	<1	1,157	460	21	20	36,612
2019	<1	<1	<1	*	-	-	-	*	-	-	-	*	6	<1	<1	*	465	23	34	*
Total	**44**	**26**	**4**	**34,103**	**-**	**-**	**-**	**496**	**-**	**-**	**-**	**15,378**	**931**	**316**	**287**	**92,333**	**15,965**	**3,603**	**2,194**	**527,829**

Table J-4. Estimated purse-seine catches by set type in metric tons (t) of rays for size-class 6 vessels with a carrying capacity >363 t (1993–2019) and minimum reported longline (LL) catches of rays (gross-annual removals in t) (1993–2018, *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 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) para buques de clase 6 con una capacidad de acarreo >363 t (1993–2019) y capturas palangreras (LL) mínimas reportadas de rayas (extracciones anuales brutas en t) (1993-2018, *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 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	-	5	4	<1	-
2019	<1	5	<1	-	2	12	4	-	<1	-	<1	-	3	<1	1	-	<1	5	3	-
Total	**11**	**172**	**53**	**-**	**45**	**170**	**160**	**-**	**2**	**15**	**9**	**124**	**16**	**64**	**53**	**-**	**51**	**272**	**201**	**-**

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	-
Total	**100**	**1,210**	**411**	**-**	**9**	**41**	**16**	**-**	**3**	**27**	**6**	**16**	**0**	**52**	**5**	**-**	**238**	**2,024**	**914**	**140**

Table J-5. Estimated purse-seine catches by set type in metric tons (t) of large fishes for size-class 6 vessels with a carrying capacity >363 t (1993–2019) and minimum reported longline (LL) catches of large fishes (gross-annual removals in t) (1993–2018, *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 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) para buques de clase 6 con una capacidad de acarreo >363 t (1993–2019) y capturas palangreras (LL) mínimas reportadas de peces grandes (extracciones anuales brutas en t) (1993-2018, *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 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	1,777	9	<1	3,340	517	2	<1	287	15	<1	<1	-	6	2	-	-	3	<1	<1	-
2015	1,167	8	<1	1,201	357	1	<1	291	15	<1	-	-	6	<1	-	-	9	8	<1	-
2016	949	7	<1	447	318	2	<1	321	26	<1	<1	-	12	<1	<1	-	4	<1	8	-
2017	1,555	11	<1	1,804	335	<1	<1	318	18	<1	<1	-	12	5	<1	-	4	12	-	-
2018	1,483	5	5	3,499	230	<1	<1	313	20	<1	-	-	62	<1	-	-	9	<1	-	-
2019	1,207	29	<1	*	201	<1	<1	*	21	<1	<1	*	12	4	<1	*	5	<1	-	*
Total	**34,811**	**521**	**30**	**161,918**	**10,379**	**41**	**10**	**4,023**	**1,289**	**19**	**<1**	**-**	**344**	**174**	**<1**	**2**	**89**	**359**	**9**	**1**

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	-	-	-	-	-	-	1,057
2016	7	5	<1	11	10	7	<1	275	2	-	-	-	<1	<1	-	-	-	-	-	741
2017	4	4	-	-	8	4	<1	<1	5	-	<1	-	<1	-	-	-	-	-	-	826
2018	2	-	-	-	5	2	<1	-	3	<1	-	-	<1	<1	-	-	-	-	-	1,024
2019	3	<1	-	*	2	6	<1	*	2	-	<1	*	<1	-	-	*	-	-	<1	*
Total	**516**	**339**	**5**	**162**	**156**	**334**	**34**	**362**	**91**	**<1**	**<1**	**-**	**9**	**41**	**<1**	**8**	**-**	**<1**	**<1**	**8,740**

Continued

	Gempylidae				Bramidae															
	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	1,849	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	-	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	2,327	25	2	6,114
2015	-	-	-	322	<1	-	-	172	<1	<1	-	7	2	<1	-	1,367	1,568	30	2	4,516
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	1,944	36	1	4,926
2018	-	-	-	227	-	-	-	125	<1	-	-	<1	-	-	-	222	1,816	9	6	5,411
2019	-	-	-	*	-	-	-	*	<1	-	-	*	<1	<1	<1	*	1,455	41	1	*
Total	**<1**	**-**	**-**	**4,924**	**<1**	**<1**	**-**	**1,226**	**56**	**298**	**1**	**400**	**75**	**24**	**13**	**26,877**	**47,816**	**2,151**	**100**	**208,643**

Table J-6. Estimated purse-seine catches by set type in metric tons (t) of small forage fishes for size-class 6 vessels with a carrying capacity >363 t (1993–2019) and minimum reported longline (LL) catches of small forage fishes (gross-annual removals in t) (1993–2018, *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 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) para buques de clase 6 con una capacidad de acarreo >363 t (1993–2019) y capturas palangreras (LL) mínimas reportadas de peces forrajeros pequeños (extracciones anuales brutas en t) (1993-2018, *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 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	-	-	-	-	-	-	-	-	<1	-	-	55	8	25	-
1997	2,734	623	25	-	219	<1	<1	-	<1	<1	-	-	-	-	-	-	<1	-	-	-	151	12	2	-
1998	1,033	168	32	-	801	2	1	-	2	-	-	-	<1	-	-	-	<1	-	-	-	91	15	3	-
1999	2,589	473	29	-	551	3	<1	-	<1	-	-	-	<1	-	-	-	<1	<1	-	-	85	3	2	-
2000	1,210	181	19	-	168	<1	9	-	<1	-	-	-	-	-	-	-	<1	-	-	-	68	8	6	-
2001	641	38	-	-	426	1	-	-	<1	-	-	-	-	-	-	-	<1	-	-	-	27	2	<1	-
2002	1,382	234	248	-	453	<1	-	-	8	<1	<1	-	-	-	-	-	<1	-	-	-	25	3	<1	-
2003	944	278	16	-	157	4	<1	-	23	<1	<1	-	<1	-	-	-	<1	-	-	-	75	1	1	-
2004	834	115	24	-	914	7	2	-	79	<1	<1	-	<1	<1	-	-	<1	<1	-	-	22	1	<1	-
2005	1,606	309	6	-	129	<1	<1	-	12	<1	<1	-	6	<1	<1	-	2	<1	<1	-	<1	9	<1	-
2006	1,300	591	19	-	145	<1	<1	-	68	<1	<1	-	7	1	-	-	2	<1	<1	-	5	1	<1	-
2007	868	336	18	-	544	1	<1	-	47	<1	-	-	2	5	-	-	<1	<1	<1	-	4	<1	<1	-
2008	759	619	2	-	276	7	2	-	16	-	<1	-	3	<1	-	-	10	<1	-	-	2	<1	<1	-
2009	303	165	1	-	174	1	<1	-	48	<1	-	-	<1	<1	-	-	<1	<1	<1	-	1	<1	<1	-
2010	474	234	<1	-	69	<1	<1	-	39	-	-	-	4	<1	<1	-	1	<1	-	-	<1	-	<1	-
2011	677	97	11	-	31	<1	-	-	18	-	<1	-	2	<1	<1	-	<1	<1	-	-	<1	<1	<1	-
2012	173	179	1	-	110	<1	-	-	16	-	-	-	13	12	-	-	<1	<1	-	-	4	2	<1	-
2013	385	77	-	-	228	<1	<1	-	5	-	<1	-	4	-	<1	-	<1	4	<1	-	2	<1	1	-
2014	297	30	<1	-	325	<1	<1	-	8	-	-	-	3	<1	<1	-	<1	<1	-	-	1	<1	<1	-
2015	177	64	-	-	140	4	<1	-	8	-	-	-	6	-	-	-	<1	<1	-	-	1	<1	<1	-
2016	189	23	<1	-	416	2	<1	-	10	-	-	-	21	-	<1	<1	<1	<1	-	-	3	1	<1	77
2017	131	172	-	-	83	<1	-	-	7	<1	<1	-	3	-	-	-	<1	<1	-	-	<1	<1	-	-
2018	276	172	-	-	54	<1	<1	-	<1	-	-	-	5	<1	-	-	<1	-	-	-	<1	<1	<1	-
2019	182	94	<1	-	57	<1	<1	-	<1	<1	-	-	5	8	<1	-	<1	<1	-	-	<1	5	-	-
Total	**22,552**	**5,967**	**495**	**-**	**7,164**	**46**	**15**	**-**	**416**	**<1**	**<1**	**-**	**84**	**28**	**1**	**<1**	**21**	**6**	**<1**	**-**	**1,182**	**96**	**52**	**77**