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Supplementary information

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Supplementary Notes

Supplementary Note 1: Economic dependence of Pacific Small Island Developing States on tuna

On average, only 2% of the combined jurisdictions of all Pacific Small Island Developing States (SIDS) is comprised of land, with the remaining 98% consisting of the combined area of their territorial waters (and in some cases archipelagic waters) and exclusive economic zones (EEZs)[9]. For this reason, Pacific SIDS are often referred to as 'large ocean developing states' (PIFS 2002)[72]. Furthermore, the EEZs of the 10 tuna-dependent Pacific SIDS are the prime purse-seine fishing grounds in the Western and Central Pacific Ocean (WCPO). Within the Pacific Island region of the WCPO (130°E−120°W and 20°S−20°N), ~90% of the average purse-seine catch for the 10-year period 2009−2018 came from the combined EEZs of these 10 Pacific SIDS (see Supplementary Table 3 for details), with most of the remaining catch from this area coming from the high-seas areas in the WCPO between 20°S and 20°N (see areas I1, I2, I3, I4, I5, I8, I9, H4, H5 in Supplementary Figure 1, and Supplementary Table 4 for catch details). A negligible proportion of the average annual purse-seine catch from the region (~2,000 tonnes) comes from the combined EEZs of the other 12 Pacific SIDS.

As the information in Supplementary Table 2 illustrates, access fees earned from purse-seine fishing operations catching tuna within their EEZs enables nine Pacific SIDS (Cook Islands, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Solomon Islands, Tokelau, and Tuvalu) to derive an average of 9−84% of their government revenue (excluding grants) from tuna. Papua New Guinea (PNG) can also be considered to have a tuna-dependent economy, despite the fact that average annual fishing access fees ($134 million) contribute only 4% of government revenue due to the much larger size of its economy compared to those of other Pacific SIDS (Supplementary Table 2). The dependence of PNG's economy on tuna also stems from the employment opportunities associated with the numerous national canneries processing tuna caught by purse-seine fishing and the extent of industrial tuna fishing that occurs in PNG's waters, which have collectively created 12,000 jobs[1].

Tuna are also caught by longline fleets in the EEZs of the 10 Pacific SIDS, and by pole-and-line fishing in Federated States of Micronesia, Papua New Guinea and Solomon Islands. However, the quantities of fish caught using these methods, and their contributions to national economies, are much lower than for the purse-seine fishery. Information on the respective contribution of purse-seine, longline and pole-and line fishing to license and access fee revenue and GDP of Pacific SIDS can be found in the annual Tuna Fishery Report Card for the Regional Roadmap for Sustainable Pacific Fisheries produced by the Pacific Islands Forum Fisheries Agency (FFA) and the Pacific Community (SPC) (https://fame1.spc.int/en/publications/roadmap-a-report-cards).

Supplementary Note 2: Status of tuna stocks in the Western and Central Pacific Ocean

Regional assessments of tropical tuna stocks within the WCPO are performed under the auspices of the Western and Central Pacific Fisheries Commission (WCPFC) (www.wcpfc.int/about-wcpfc) by the scientific services provider, the Oceanic Fisheries Programme at SPC. For each species of tuna, a stock assessment is generally performed every three years. Assessments are reviewed by the WCPFC's Scientific Committee to provide the best scientific information available.

WCPFC adopted a limit reference point for the key tuna stocks of 20% of the potential spawning (adult) population estimated in the absence of fishing. The Scientific Committee considers that populations below this level pose a risk to stock sustainability. For fishing mortality, the default limit is the level associated with achieving Maximum Sustainable Yield (FMSY). WCPFC had also adopted an interim biomass target reference point for skipjack tuna in 2016, at 50% of the spawning biomass estimated in the absence of fishing. This is currently under review by WCPFC.

The most recent assessments of bigeye tuna[73], skipjack tuna[74] and yellowfin tuna[75] in the WCPO were conducted in 2020, 2019 and 2020, respectively. All assessments include an evaluation of uncertainties in stock dynamics (creating the 'structural uncertainty grid'). The estimated probability that current fishing mortalities exceeded FMSY was low (i.e., no stocks were considered likely to be subject to overfishing). Similarly, the estimated probability that the current spawning biomass of any tuna species is below the level that would cause concern for sustainability is low (i.e., no stocks were considered likely to be in an overfished state). These findings are summarised in the 'Majuro plot' shown in Supplementary Figure 16. In short, good management of purse-seine fishing by the Parties to the Nauru Agreement (PNA), supported by WCPFC's complementary conservation and management measures, has resulted in none of the three tuna species in the WCPO being overfished, and agreement that overfishing is not occurring. This is not the case for stocks of these species in other oceans under the oversight of other regional fisheries management organisations (Supplementary Figure 17).

Given the regular analysis of stock status for the key tuna species, fisheries management agencies in the WCPO are well placed to identify and react to the impacts of climate change. The present strategy of these agencies is to buffer the impacts of climate change on the status of the key tuna stocks by ensuring that target population levels are sufficiently far away from the limit reference points used to maintain stocks at robust levels.

Supplementary Note 3: Co-operative management of tuna by the Parties to the Nauru Agreement

Eight of the tuna-dependent Pacific SIDS[a] co-operate as the Parties to the Nauru Agreement[b] in the management of the tuna within their EEZs to maximize the sustainable benefits derived from these valuable resources. The average total purse-seine catch of tuna from PNA waters, i.e., 1.4 million tonnes of skipjack, yellowfin and bigeye tuna combined per year (Supplementary Table 3), provides ~30% of the global tuna catch[76,77].

The PNA Vessel Day Scheme (VDS)[c] is a zone-based management tool − in legal terms a scheme under the Palau Arrangement − that limits purse-seine fishing effort in the EEZs of Parties in terms of fishing days to an annual Total Allowable Effort (TAE). The TAE is established in accordance with an effort limit for purse-seine fishing in PNA EEZs agreed within a set of broader measures for the conservation and management of tropical tunas (skipjack, yellowfin, and bigeye) by WCPFC. These measures are agreed on a three- or four-year cycle, taking into account advice from the WCPFC

[a] Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands, Tuvalu.
[b] Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest, https://www.pnatuna.com/content/nauru-agreement.
[c] Purse Seine Vessel Day Scheme, https://www.pnatuna.com/content/purse-seine-vds.

Scientific Committee on the management of the major tropical tuna stocks taken in the purse seine-fishery[70].

The TAE is allocated among the eight Parties as a set of Party Allowable Effort limits (PAEs) that constitute national, zone-based, transferable, effort limits for use in each Party's EEZ. Parties have substantial freedom in how they use their PAEs, but are required by the VDS to take all necessary measures to ensure that their PAE is not exceeded.

Tokelau participates in the VDS under a Memorandum of Understanding agreed with PNA. Tokelau brings its own TAE/PAE and is not included in the allocation process, but its days are adjusted in relation to changes to the PNA TAE and are transferable to other Parties under the VDS. For the purpose of this Analysis, reference to PNA includes participation by Tokelau.

Decisions on the VDS are recommended by PNA officials, meeting at least annually, and ratified by annual meetings of PNA Ministers. High-level oversight of the VDS is exercised by PNA Leaders, meeting in occasional summits.

Supplementary Note 4: 'Vessel Day Scheme' provisions for adaptation to climate

The main objective of the VDS is to enable PNA members to maximize their net economic returns from the sustainable use of tuna resources within their EEZs. The design of the VDS to achieve this objective takes into account climate variability in the form of variations in the distribution and abundance of tuna across the equatorial Pacific Ocean associated with El Niño Southern Oscillation (ENSO) events. Its structural elements and provisions are designed to minimise the effects of climatic variability on equitable distribution of access revenue earned from the purse-seine fishery among PNA members[70,71], but they can also assist PNA members to adapt to the effects of climate change. The relevant provisions of the VDS include 'transferability', 'pooling', 'roaming' and the way in which 'Party Allowable Effort' is adjusted[70].

Transferability allows PNA members to trade PAE VDS days among themselves and, consequently, among EEZs, but not among vessel operators. It allows Parties to respond to the effects of ENSO or climate change, on the location of the prime tuna fishing grounds. During La Niña events, the fleets fish in the west of the region, whereas the converse occurs during El Niño episodes. As skipjack and yellowfin tuna are progressively redistributed eastwards (Figure 2), transferability will allow Parties in the west to cushion the impact of climate change by selling days to those in the east.

Pooling involves more than one Party putting their fishing days together into a pool of days that can be used in any of those Parties' EEZs. This not only increases the value of the days because it allows fleets more flexibility to 'follow the fish', it also provides more scope for effort to be adjusted in response to redistribution of tuna due to climate change.

Roaming enables national vessels to fish in other Parties' EEZs beyond their Home Party's EEZ, using fishing days provided from the PAE of their Home Party, outside the provisions of the VDS related to transferability and pooling. Designed primarily to provide support for development of domestic fishing fleets, this arrangement allows for greater flexibility in adjusting effort to short-, medium- and long-term changes in distribution of tuna resources targeted by purse-seine fishing.

PAEs are generally adjusted annually with substantial weighting given to historical (previous 8–10 years) fishing effort within Parties' EEZs (EEZ area is a fixed factor that may also be taken into account). Under this arrangement, the PAE allocations reflect the patterns of fishing effort driven by the influence of ENSO and climate change on the distribution of tuna, and are enabled by the transferability, pooling, and roaming provisions of the VDS. As tuna are redistributed due to climate change (Figure 2), PNA members in the east are expected to accrue a greater number of vessel days, whereas those in the west are expected to lose days. The agreed provisions of the VDS enable the reallocation of fishing effort among the Parties in a non-confrontational way.

Supplementary Note 5: Influence of climate change on the Western Pacific Warm Pool

Several previous studies have used climate models to forecast how the tropical Pacific Ocean is likely to change in the future as a result of increased greenhouse gas (GHG) emissions[10,78-80]. All models used in the Coupled Model Intercomparison Project versions 3 and 5 (CMIP3 & CMIP5) show continued warming of the tropical Pacific Ocean with slightly enhanced warming along the equatorial Pacific, possibly associated with a projected slowdown in the equatorial trade winds. Warming anomalies extend to a depth of many hundreds of metres in the water column. This results in a large eastward shift in the location of the edge of the Western Pacific Warm Pool (hereafter 'warm pool') (as defined by a fixed isotherm, e.g., 28.5 or 29 °C) and an associated deepening of the thermocline[78]. Based on CMIP3 models, the historical area contained within the 29 °C isotherm: 9 Mkm^2 (averaged over 1980−2000) expands to 29−33 Mkm^2 (model ensemble 90% confidence interval) by 2050 (ref 10). Despite the dramatic increase in the extent of the warm pool, there is no corresponding shift in the dynamical edge of this important feature of the tropical Pacific Ocean defined by the maximum salinity gradient[80].

Climate models also project consistent changes in circulation for the tropical Pacific Ocean, with implications for the transport of nutrients and distribution of pelagic species. In the western basin, the New Guinea Coastal Undercurrent – the main Southern Hemisphere, lower-latitude, western boundary current and a major source of dissolved iron for the equatorial Pacific – is projected to increase. In contrast, the Mindanao Current which feeds both the equatorial circulation and the Indonesian Throughflow is projected to decrease[81-83]. Although model agreement is less consistent, the Equatorial Undercurrent that transports large volumes of water and nutrients along the equator from the western Pacific to the eastern Pacific upwelling zone is projected to intensify in the western basin while decreasing slightly in the east.

Projections of subsurface dissolved oxygen (O_2) concentration in the tropical Pacific Ocean are mixed across the models[84,85]. This is a consequence of competing effects of decreased solubility associated with warmer water, changes in circulation, and modified rates of biological remineralisation[85].

Supplementary Note 6: Climate change concerns by Pacific SIDS and initiatives within WCPFC

The Presidents and Prime Ministers of Pacific Islands Forum (PIF) member governments meet every year to discuss their most significant shared problems and priorities. In 2019, in ranking different threats to the security of the PIF region, Pacific Island Leaders "reaffirmed climate change as the single greatest threat to the livelihoods, security and well-being of the peoples of the Pacific"[86].

FFA member governments took this concern to WCPFC in December 2019, pointing out that "climate change places a great risk on the benefits to Small Island Developing States in the Pacific from our region's tuna fisheries. For many of our countries, tuna fisheries are a critical, if not the most critical, renewable resource providing essential social, cultural and economic benefits". They also drew attention to the strong support that Pacific Island Fisheries Ministers had given to assisting fisheries to respond to climate change, including: "work on adaptive management regimes; the securing of baselines and associated maritime boundaries in the face of sea-level rise; and the importance of ensuring tuna stocks are managed at levels that continue to contribute to the food security of Pacific Island communities given the predicted declines in coastal fisheries resources"[87].

FFA members proposed action by WCPFC on several fronts, including "increased focus and attention by the Scientific Committee's Ecosystem and Bycatch Working Group on the implications of climate change for the region's tuna stocks", and "active consideration by the Commission of how, through agreement of appropriate Conservation and Management Measures, it can mitigate the impacts of climate change on Pacific Island countries arising from the influence of climate change on regional tuna stocks"[87].

Following this proposal, WCPFC adopted Resolution 2019-01on Climate Change[88] (see below). WCPFC Resolutions are non-binding, but set the stage to work on the development of a binding Measure. Some FFA members are considering proposing, for example, a requirement for ecosystem and climate indicators to be taken formally into account in WCPFC fishery conservation, management and allocation measures, based on exploratory work led SPC[89].

Under the Resolution 2019-01 on Climate Change, WCPFC resolved to:

1) Consider the potential impacts of climate change on highly-migratory fish stocks in the Convention Area and any related impacts on the economies of Commission Country Members (CCMs) and food security and livelihoods of their people, in particular Small Island Developing States and Participating Territories.
2) Support further development of science on the relationship between climate change and target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks, as well as interrelationships with other factors that affect these stocks and species and estimates of the associated uncertainties.
3) Take into account in its deliberations, including in the development of conservation and management measures, scientific information available from the Scientific Committee on the potential impacts of climate change on target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks.

4) Consider how climate change and fishing activities may be related and address any potential impacts in a manner consistent with the Convention.
5) Consider options to reduce the environmental impacts of the Commission related to headquarters operation and meetings of the Commission and its subsidiary bodies.

Supplementary Note 7: Introduction to SEAPODYM

SEAPODYM (Spatial Ecosystem And POpulation DYnamics Model; www.seapodym.eu) is a numerical model developed for investigating physical-biological interactions between fish populations and the ocean pelagic ecosystem[15,17,65,90-92]. SEAPODYM simulates the change in abundance of a target fish species over time, using their age dimensions in a simplified 3D space (three pelagic layers of the oceanic environment). The model also considers the life-history stages of fish species, from the larval stage to the mature adult stage, and includes a representation of the prey density fields of the modelled species, simulated as functional groups of zooplankton and micronekton[16,62,91,93]. SEAPODYM uses a small number of parameters linking rates of reproduction, mortality, and movement with environmental variables to model the dynamics of target species. Quantitative methods, including global sensitivity analysis, a maximum likelihood estimation (MLE) approach, and statistical validation, have been developed to estimate these parameters[17,64,65].

SEAPODYM has been used extensively to study the population dynamics of tropical tunas and the impact of fishing, environmental variability (including ENSO) and climate change on tuna stocks[10,12,13,17,64-67,94,95].

The numerical modelling of fish population dynamics in SEAPODYM relies on underlying advection-diffusion-reaction equations, approximated by finite differences, and integrated on a latitude-longitude grid over the model domain at a selected temporal and spatial resolution. Fish movements are simulated based on relationships with environmental variables, with rules that change according to the life-history stage of the fish species. Thus, larvae and small juveniles drift passively with currents. At older life-history stages, fish movement has both passive and active components, the latter including directed and non-directional movements at rates dependent on fish size and habitat quality. The model accounts for both natural and fishing mortality.

SEAPODYM considers two habitat indices − spawning and feeding − to describe conditions for reproduction and survival, respectively. For tropical tuna species, the movement of the autonomous part of the population is assumed to be controlled by feeding habitat. Considering tropical tunas as opportunistic spawners, the spawning occurs in the areas where the highest spawning habitat index coincides with non-zero densities of mature tunas. Both habitat indices depend on environmental variables: temperature, O_2, zooplankton (or primary production as a proxy) and the density of micronekton.

The quantitative MLE approach uses the massive number of observations available from the monitoring of industrial tuna catches, e.g., catch/effort and length-frequency records, available at the spatio-temporal resolutions of the model. In addition, recent integration of release-recapture tagging data into the likelihood function has allowed substantial improvements in the estimation of movement and habitat parameters[65]. Once the reference MLE model is achieved for a given species of tuna, and validated with independent data, it provides a quantitative estimation of population dynamics and allows the effects of fishing and environmental variability to be investigated. Based on this robust modelling of tuna stocks and IPCC climate model forcing, it is also possible to project the future distribution and abundance of tropical tuna species.

Supplementary Note 8: Interactions with the BBNJ Agreement

The international, legally-binding instrument for the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction under the United Nations Convention on the Law of the Sea (BBNJ Agreement)[24] addresses:

- marine genetic resources, including questions on the sharing of benefits;
- environmental impact assessments;
- area-based management tools, including marine protected areas; and
- capacity-building and the transfer of marine technology.

The 'General Principles and Approaches' of the latest draft of the BBNJ Agreement (UNGA, 2019)[96] include building ecosystem resilience to the adverse effects of climate change, see Draft Article 5(h).

The BBNJ Agreement also includes recognition of the special requirements of developing States, including SIDS (Draft Articles 11, 42, 43, 51). In particular, there are two requirements potentially related to sustainability and climate justice in the context of tuna-dependent Pacific SIDS.

1) Advance and share scientific knowledge relating to climate change impacts on the ocean, in the following ways:
    - strengthen cooperation in marine scientific research to identify, predict and monitor ocean ecosystems, enable access to genetic tools and technologies; and promote the generation of knowledge and technological innovations (including as an element of benefit-sharing from marine genetic resources);
    - build capacity and technology transfer, for example, information dissemination and awareness-raising, including effects of climate change and ocean acidification [Draft Annex II (b)(iv)]; and development and strengthening of institutional capacity, including at a subregional or regional level [Draft Annex II (d) (ii)]; and
    - institutional mechanisms to evaluate and disseminate scientific knowledge relevant to the impacts of climate change on high-seas biodiversity (Scientific and Technical Body; Clearinghouse mechanism); and provide international fora for cooperation, information exchange and coordination between global, regional, and sectoral organisations on climate change impacts on the high seas and the special requirements of SIDS.

2) Address climate change impacts and alleviate the burden by:
    - providing a mechanism to address cumulative impacts on marine biodiversity in areas beyond national jurisdiction, which may include climate change (warming, deoxygenation, acidification) (Draft Article 25); and
    - establishing area-based management tools, including marine protected areas, to provide climate refugia[97] and boost ecosystem resilience, see Draft Article 14(e).

Supplementary Note 9: Climate justice considerations for tuna-dependent Pacific SIDS

The basis for raising awareness of climate-driven redistribution of tuna as a climate justice issue is that 10 Pacific SIDS have a deep economic dependence on tuna fishing (Supplementary Table 2) but make trivial contributions to GHG emissions. In contrast, the distant-water fishing nations that are responsible for 60% of historical GHG emissions (see below) are likely to benefit from climate change by taking a greater proportion of their tuna catches from high-seas areas, where access fees do not apply.

Based on the 'PRIMAP-hist' national historical emissions time series[98], global emissions were 47 gigatons of CO_2 equivalent in 2016 (this includes Kyoto greenhouse gases, but does not include emissions from land use, land-use change, and forestry). Of these total emissions, 26 gigatons or 55% were from the developed countries that are the 'distant-water fishing nations' (DWFNs) operating in the tropical Pacific Ocean (USA, China, EU, Japan, South Korea, and Taiwan). When the historical emissions from 1850 to 2016 are considered, these DWFNs have accounted for 60% of the total.

Pacific SIDS contribute trivial amounts of GHG due to their small population size and low per capita emissions. For example, Kiribati is the second lowest emitter in the world. According to Kiribati's 2nd National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), Kiribati's emissions in per capita terms are 7% of the global average and 2% of the USA average.

Supplementary Note 10: Provisions for sustaining tuna-dependent economies

10.1 *The international legal framework*

Several international legal instruments govern the conservation, management and utilisation of tuna resources that occur within the maritime jurisdiction of Pacific SIDS and the adjacent high seas. The climate change impacts on these tuna resources need to be considered within these existing global and regional legal frameworks. The relevant international instruments include:

- The United Nations Convention on the Law of the Sea 1982 (The Law of the Sea Convention);
- The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish stocks (UN Fish Stocks Agreement); and
- The Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPF Convention).

Climate change and its likely impacts on fisheries were not considered during the negotiation of the above international legal instruments. Accordingly, there are no provisions in these instruments that specifically address the migration of tunas from the EEZs of Pacific SIDS to the high seas as a result of climate change. However, these international legal instruments, especially the Law of the Sea Convention and the UN Fish Stocks Agreement, enshrined a number of principles that may be drawn upon in addressing the impacts of climate change on the distribution of migratory fish stocks and the economies that depend on these resources. The relevant principles include international cooperation, equity, and long-term conservation and sustainable use of fish stocks.

Below, we summarise how the application of these principles will ensure continued involvement of Pacific SIDS in the conservation and long-term sustainable management of tuna resources in their region. We also show how these principles may minimise impacts on the revenue Pacific SIDS derive from exercising their sovereign rights to the existing resources in their EEZs, as those resources move progressively to the high seas as a result of climate change.

10.1.1 The Law of the Sea Convention

The Law of the Sea Convention is the principal international legal instrument governing marine fisheries conservation and utilisation. The Law of the Sea Convention was negotiated during the Third United Nations Conference on the Law of the Sea from 1973−1982.

For the regulation of maritime activities, the Law of the Sea Convention adopts a zonal approach which divides the sea into various maritime zones of jurisdiction, including internal waters, archipelagic waters, territorial seas, exclusive economic zones (EEZ) and the high seas. Fisheries located within the internal waters, archipelagic waters and territorial seas fall within the sovereignty of coastal States[99]. In respect of fisheries in the EEZ, coastal States have certain sovereign rights and duties as explained under 'EEZ' below.

EEZ

Part V of the Law of the Sea Convention established the concept of the EEZ, which is defined as an area beyond and adjacent to the territorial sea, extending not more than 200 nautical miles from the baseline from which the breadth of the territorial sea is measured (Law of the Sea Convention, Article 57). The EEZ regime was revolutionary in the sense that it brought under national jurisdiction large tracts of ocean that had previously belonged to the regime of the high seas. With respect to fisheries, the EEZ regime transferred property rights over the majority of the world's then active fisheries from the international commons to the jurisdiction of coastal States.

Within the EEZ, the Law of the Sea Convention grants to each coastal State "sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living of the waters superjacent to the sea-bed and of the sea-bed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone..." [Law of the Sea Convention, Article 56(1)].

The sovereign rights of costal States in their EEZs come with significant conservation obligations. Coastal States must take into account the best scientific evidence available to them to ensure through proper conservation and management measures that the living resources in the EEZ are not endangered by over-exploitation. To discharge their conservation obligations, coastal States are required, among other things, to:

- determine the allowable catch of the living resources in their EEZs;
- determine their capacity to harvest the allowable catch, and
- allocate the surplus of the allowable catch to the nationals of other States through access agreements, where coastal States do not have the capacity to harvest the allowable catch.

Conservation and management measures in the EEZ are to be designed "to maintain or restore populations of harvested species at levels which produce the maximum sustainable yield as qualified by relevant environmental and economic factors, including the economic needs of coastal fishing communities and the special requirements of developing States, and fishing patterns".

It is important to observe that the EEZ is a hybrid zone within which other states continue to enjoy specified established freedoms of the high seas − navigation and overflight, the laying of pipelines and other associated uses.

Under the EEZ regime, the Law of the Sea Convention has specific provisions, relating respectively to straddling fish stocks and highly migratory species, that apply to tunas. These provisions oblige coastal States and States whose nationals fish on the high seas for these species to cooperate through appropriate international organizations (establishing such organisations where necessary) with a view to ensuring conservation and promoting the objective of optimum utilization of such species within the region.

<u>The High Seas</u>

Beyond the EEZ, the Law of the Sea Convention creates the high seas, defined as "all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters or in the archipelagic waters of an archipelagic State" (Law of the Sea Convention, Article 86). On the high seas, the Law of the Sea Convention upholds the freedom of the high seas, which includes the freedom of fishing (Article 87, Law of the Sea Convention). However, the freedom of fishing on the high seas is subject to the treaty obligations of the fishing States and "the rights and duties as well as the interests of coastal States in the EEZ" (Article 116, Law of the Sea Convention).

Importantly, the Law of the Sea Convention imposes a duty on all States to cooperate through the establishment of subregional or regional fisheries organizations to ensure the conservation of the living resources on the high seas (Law of the Sea Convention, Articles 117 and 118). In discharging their conservation and management obligations on the high seas, States are required to determine the allowable catch and establish other conservation and management measures for the living resources. Conservation and management measures on the high seas are to be guided by: the best scientific evidence available; the need to restore populations of harvested species at levels which can produce the maximum sustainable yield as qualified by environmental and economic factors; the special requirements of developing States; fishing patterns; the interdependence of stocks; existing general recommended regional or subregional standards; and available catch and effort information and statistics [Law of the Sea Convention, Article 119(2)].

10.1.2 The UN Fish Stocks Agreement

The provisions of the Law of the Sea Convention on straddling stocks and highly migratory fish stocks were fashioned on the premise that EEZ claimant States, and States fishing for such stocks in the adjacent high seas, would be diligent in their conservation of these stocks and in their obligation to cooperate. Within a decade of negotiating the Law of the Sea Convention, it became obvious to the international community that additional legal mechanisms were required to supplement and strengthen the Convention with regard to the conservation and utilisation of straddling stocks and highly migratory species. The response by the international community was the development and ratification of the UN Fish Stocks Agreement.

Under this Agreement, States fishing for straddling stocks or highly migratory stocks are obliged to give effect to their duty to cooperate by joining the appropriate regional fisheries management organisation or by agreeing to apply its conservation and management measures. This obligation is supported by a rule that only those States that are members of the relevant regional fisheries management organisation (RFMO) or agree to apply its conservation and management measures can have access to the resources to which the measures apply [UN Fish Stocks Agreement Article 8(4)]. The Agreement also prescribes that conservation and management measures shall be compatible across the high seas and waters under national jurisdiction, without prejudice to the sovereign rights of coastal States (Article 7). The special requirements of developing States must also be considered, requiring, among other things, that conservation and management measures do not apply a disproportionate burden of conservation action onto developing States (Article 24). In this context, it is also important to note that the United Nations Sustainable Development Goal 14.7 aims to increase the economic benefits to SIDS and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism, by 2030 (UN 2015)[100].

10.1.3 The WCPF Convention

Because international law classifies tunas as either straddling stocks or highly migratory species, it has become customary to establish RFMOs to manage them throughout their geographical range. Before the UN Fish Stocks Agreement in 1995, a number of such RFMOs were established in all oceans of the world except the Western and Central Pacific Ocean. Following the conclusion of the UN Fish Stocks Agreement, the imperative to establish an RFMO in the WCPO became paramount. This was achieved through the 'Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPF Convention) 2004'. The primary objective of the WCPF Convention is to ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the WCPO in accordance with the 1982 United Nations Convention on the Law of the Sea and the 1995 UN Fish Stocks Agreement. The WCPF Convention re-iterates the major principles under the UN Fish Stocks Agreement, including international cooperation and long-term sustainability.

10.2 *Possible legal pathways for achieving sustained economies and climate justice*

The potential impact of climate change on the continuation of the current sustainable management of tuna resources in the WCPF Convention area is a matter of international concern and requires international cooperation, consistent with the international legal framework. The RFMO for the WCPO, the Western and Central Pacific Fisheries Commission, has already begun to consider this issue and adopted a Resolution on Climate Change in 2019 (see Supplementary Note 6).

It is now apparent that climate-driven redistribution of tuna from EEZs to high-seas areas will have implications for the principle of 'freedom of fishing' on the high seas. At present, the right to fish is conditional and expressly subject to conditions concerning the conservation and management of the living resources not only in the EEZ, but also on the high seas. Within the regulatory area of the WCPFC, the fundamental principles are the duty to cooperate, long-term conservation and sustainable use, compatibility across the range of the stocks, and consideration for the special requirements of developing States. There are obvious practical reasons why the duty to cooperate and the commitment to long-term conservation and sustainable use are fundamental applicable principles. It is in the nature of straddling or highly migratory stocks to move in response to changes in water temperature, food supply, shorter-term climate variability, longer-term climate change (including its effects on the ecosystems that support such stocks) or other factors – both known and unknown.

However, such stocks cannot be managed sustainably if, in the years in which they are concentrated in the high seas, they are overfished by distant water fleets and, in the years in which they are concentrated in EEZs, they are overfished by vessels authorised by the relevant coastal States. More generally, these stocks cannot be managed sustainably if the applicable conservation and management measures differ substantially between areas of high seas and areas under the jurisdiction of coastal States. They must be managed under a stable conservation and sustainable use regime that is not jeopardised in circumstances where a stock moves for a short or long period of time between the waters of coastal States and the high seas. The UN Fish Stocks Agreement and the WCPF Convention underscore this point by requiring compatibility of conservation and management measures between EEZs and the high seas.

In some respects, the overall situation has elements that are similar to a major hydrocarbon reserve that straddles the EEZs of two or more countries. Unilateral exploitation by one country could affect or even negate the rights of the other country or countries and lead to serious dispute. What is needed is a negotiated unitisation agreement. A major difference is that a hydrocarbon reserve is a finite resource, whereas a straddling or highly migratory fish stock is a potentially indefinitely renewable resource if managed sustainably. But this difference only strengthens the case for a negotiated outcome, preferably, the negotiation of a conservation and management measure by the WCPFC that takes account of all the interests involved. There may be many ways of achieving long-term equitable distribution of returns to both coastal States and DWFNs, possibly including some variation of the PNA Vessel Day Scheme (see Supplementary Note 4). Whatever system is developed must avoid any incentive for overfishing in either EEZs or the high seas.

Negotiation of such a conservation and management measure for tropical Pacific tuna will necessarily involve a number of coastal States, DWFNs and other entities with a complex set of interests. To be effective, these negotiations should result in the four outcomes described below.

a) Total allowable levels of fishing effort/catches that are consistent with the objective of long-term conservation of Pacific tuna resources.
b) Recognition of the special requirements of developing States, and the need to ensure conservation and management measures do not apply a disproportionate burden of conservation action onto developing States.
c) Recognition of the respective dependence of coastal States and DWFNs on tuna resources.
d) Procedures ensuring that short-term actions inconsistent with the long-term conservation objective are not incentivised, but actively discouraged.

With respect to points b) and c) above, it is important to note that these could be achieved through the mechanism for allocating rights to fish in the high seas that WCPFC has initiated (see Supplementary Note 11). To be a viable pathway to sustained economies and climate justice, the WCPFC allocation process will need to develop criteria that encompass the potential consequences of climate change on the reasonable expectations of all members.

The PNA member countries within FFA have a long and successful history of influencing WCPFC to protect and advance their interests and ensure that WCPFC's Conservation and Management Measures (CMMs) do not apply a disproportionate burden to Pacific SIDS. Examples of this successful advocacy can be seen in the 2008 decision to close two high-seas pockets to purse-seine fishing[d] and subsequent decisions to further expand restrictions on the use of drifting fish aggregating devices in high-seas areas[e].

In addition to the point made in the main text about South Korea's acknowledgement of the dependence of Pacific SIDS on tuna and proposal to continue to pay access fees when fishing in high-seas areas, other distant-water fishing nations operating purse-seine vessels in the region have demonstrated that they are willing to consider new management arrangements for climate-driven changes to fish stocks occurring outside EEZs elsewhere. For example, USA, Japan, China, and the EU are all signatories to the International Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean: www.dfo-mpo.gc.ca/international/agreement-accord-eng.htm.

If negotiation within the WCPFC fails, a Conciliation Commission, utilising the dispute settlement mechanism under the WCPF Convention and international law, could greatly assist the process of devising a lasting solution that incorporates an appropriate level of flexibility and stability. The effectiveness of such a Conciliation Commission has been demonstrated by the Timor Sea Conciliation Commission involving Australia and Timor Leste (see Permanent Court of Arbitration, under the Timor Sea Treaty between Timor Leste and Australia, Case No. 2015-42).

Given that the threat to the continued effectiveness of the current regime stems from human-induced climate change attributable primarily to activities in States other than Pacific SIDS, it would also seem useful to consider in this context the principles developed by the International Law Commission on the allocation of loss in the case of transboundary harm arising out of hazardous activities, including Principle 7 on the development of specific regional arrangements concerning compensation and response measures (UNGA Resolution 61/36), in which the General Assembly of the United Nations took note of the principles and commended them to the attention of Governments.

[d] See WCPFC 2008 Annual Report
[e] See WCPFC Conservation and Management Measure 2018-01

Supplementary Note 11: Allocation of high-seas fishing rights

The WCPF Convention explicitly identifies allocation as a function for WCPFC and provides a non-exclusive list of criteria to be considered (Article 10.3). Nevertheless, until relatively recently, WCPFC had not made progress on allocation due to disagreements between coastal States and DWFNs over the area of application, and whether any such allocation should include fisheries within EEZs[101]. In the absence of formal decisions on allocation, WCPFC adopted a series of CMMs that distributed fishing opportunities among members, while explicitly declaring that these did not confer any allocation of rights or prejudice future decisions[f]. Given the lack of a formalized allocation framework, these short-term decisions were primarily achieved through the adoption of flag-based limits founded on historical fishing with exemptions to developing States, for which historical fishing measures were not appropriate, to ensure they did not bear a disproportionate conservation burden.

However, in 2017, WCPFC reached consensus on a compromise for allocating long-term rights[34]. In particular, the Commission agreed to begin a process to establish hard limits first for high-seas purse-seine fisheries, then for longline fisheries, and a framework to allocate these limits for the high seas. A prime objective of these hard limits will be to achieve WCPFC's objectives for tuna stocks, for example, keeping the biomass for skipjack tuna around an adopted Target Reference Point. However, because the principles outlined by WCPFC for the guidance of this allocation framework (WCPF Convention Article 10.3) include environmental justice criteria, such as resource dependence and the special circumstances of developing States, this process has strong potential to enshrine values intrinsic to climate justice[35]. Addressing the disproportionate impacts of projected tuna migrations represents a merging of WCPFC's commitment to the allocation process with its commitment to consider the impacts of climate change and may present the most tractable approach to ensuring climate justice. The adoption and equitable allocation of high-seas limits to replace the current sets of limits based on historical fishing will also remove the need for exemptions for fleets from Pacific SIDS, thereby addressing the risks posed by unmanaged high-seas effort and ensuring the future sustainability and value of the fishery.

Supplementary Note 12: Loss and damage provisions

The use of loss and damage mechanisms is gaining increased attention due to the severe impacts of climate change on developing countries. For example, in 2014, about 900 extreme weather events caused damage estimated at USD100 billion, with 60 per cent occurring in developing countries[g]. As a result, there is increasing, widespread international recognition that the current ambitions for adaptation and mitigation may not be effective for managing the consequences of global warming. The loss and damage debate has thus become an additional pillar of the international climate negotiations under UNFCCC. The topic has grown in importance since the Conference of the Parties in Warsaw (COP 19 in 2013) and the establishment of the Warsaw International Mechanism for Loss and Damage associated with climate change impacts (WIM). The Paris Agreement further underlined the

[f] See for example, paragraphs 8, 9, 28, and 42 of WCPFC (2018) CMM 2018-01 Conservation and Management Measure for Bigeye, Yellowfin and Skipjack Tuna in the Western and Central Pacific Ocean. Fifteenth Regular Session of the Western and Central Pacific Fisheries Commission. Honolulu, USA, 10-14 December 2018. WCPFC.
[g] www.munichre.com/topics-online/en/climate-change-and-natural-disasters/natural-disasters/insurances-catch-breath-2014.html

importance of this issue, with a stand-alone provision on loss and damage (Article 8, Paragraphs 48−52 in the Decision Text). Accordingly, all Parties to UNFCCC are requested to develop and implement concrete and effective climate risk management (CRM) instruments and measures to avert, minimize, or – when the limits of adaptation are reached – effectively address residual loss and damage caused by climate-related extreme events and slow onset changes.

Supplementary Note 13: United Nations Climate Security Mechanism

The Climate Security Mechanism of the United Nations was established to assist the UN and its membership to better understand the complex security implications of climate change, and effectively inform responses. The Climate Security Expert Network (CSEN),[h] which is comprised of experts from around the world, was established to support this mechanism and the Group of Friends on Climate and Security in the UN system by: synthesising scientific knowledge and expertise, advising on options for building resilience to climate-security risks, and helping to strengthen a shared understanding of the challenges and opportunities of addressing climate-related security risks across a range of stakeholders.

CSEN's members bring regional and thematic expertise from across the globe to develop important knowledge products and consultation processes supporting the climate security efforts of the UN and other stakeholders. Through support of the Climate Diplomacy effort – a partnership between Adelphi and the German Federal Foreign Office – the CSEN has recently developed a series of in-depth assessments of climate-fragility risks and factsheets, which are available from CSEN online.

The Climate Fragility Risk Brief and Fact Sheet on the Pacific Islands Region[102], summarises the top five climate fragility challenges facing Pacific Island countries and advises on key entry points to address these challenges. The potential economic, employment and food security losses for Pacific SIDS associated with the projected changes in the distribution of tuna as a result of climate change are among the top challenges. The Climate Fragility Risk Brief for the region also highlights the modelling of climate-driven redistribution of tuna by SPC, Conservation International, and partners to inform the efforts of Pacific SIDS to build the necessary resilience and deal with the associated potential loss and damage. Specific recommendations include increased funding for improved modelling capacity and applied science, and exploring ways to retain the present-day benefits that Pacific SIDS receive from tuna fisheries regardless of climate-driven redistribution of stocks. The security risks posed to Pacific SIDS by climate-driven tuna redistribution was also highlighted in an open debate on climate change and security within the United Nations Security Council in July 2020, see presentation by Coral Pasisi at http://webtv.un.org/watch/maintenance-of-international-peace-and-security-climate-and-securitysecurity-council-open-vtc/6174906506001.

[h] https://climate-security-expert-network.org/start

Supplementary Methods

Summary of projected climates from NEMO-PISCES outputs

Outputs from the NEMO-PISCES framework[i] based on all Earth System Models (ESMs) (see Methods) except MPI showed an increase in epipelagic temperature in the WCPO and EPO, starting in the early 2030s (Supplementary Figure 3). There was, however, more variation among NEMO-PISCES outputs based on ESMs regarding projections for primary production. Although use of all ESMs predicteds a slight and consistent decrease in primary production in the WCPO, there were notable differences for the EPO. PISCES-NEMO outputs based on MIROC and MPI produced a stable increase of primary production in the EPO until the late 2040s, whereas those based on GFDL and IPSL predicted a transition to lower primary production from the beginning of climate projections. In general, the decrease of primary producers in WCPO and EPO lead to a consistent thickening of the euphotic layers.

The effects of the RCP8.5 emissions scenario on SST and primary production (Supplementary Figure 3) were cascaded to the forage organisms and micronekton consumed by tuna. In general, there was a decline in biomass of forage and several functional groups of micronekton in the WCPO under all ESMs, whereas forage and all functional micronekton groups increased in the EPO until the late 2040s under two of the ESMs (MIROC and MPI) (Supplementary Figure 4).

Sensitivity analyses

To account for uncertainty in decreased primary production associated with CMIP5 coupled ocean-biogeochemical models in SEAPODYM, we added one member to the simulation ensemble to include a gradual increase in primary production in warm tropical waters with SST >27°C, resulting in an increase of 10% relative to 2010 by the end of the century. We tested the sensitivity of our results for O_2 concentration by keeping the oxygen fields to their historical values. This enabled one more member of the simulation ensemble to use the climatological distribution of O_2 concentration instead of the model projections predicting a decrease of O_2 levels within tuna habitats.

We also investigated the effect of possible phenotypic plasticity within tuna populations as they respond to changing ocean temperatures. For that scenario, the estimated optimal spawning temperature increases linearly by 2°C at the end of the 21st Century, i.e., roughly following the temperature increase in the tropics under the RCP8.5 scenario.

For ocean acidification, we included the functional relationship based on the laboratory experiments with yellowfin tuna[103] to describe additional larval mortality due to decreasing pH. The uncertainty associated with laboratory experiments was integrated through three different parameterizations – low, medium, and high impact[13].

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[i] www.nemo-ocean.eu

The rationale for performing additional sensitivity runs is explained below. The population dynamics of tropical tuna species are known to be highly sensitive to projected changes in primary production in the WCPO, and to the decline in O_2 concentration in the EPO[12,67], however, long-term trends projected with coarse resolution coupled with physical-biogeochemical models show high uncertainty for these two variables. There are two apparent reasons for this. First, the CMIP5 coupled ocean-biogeochemical models projecting a decrease of primary production under RCP8.5 (ref 104) lack a number of processes that may change such projections, for example, mesoscale activity inducing stronger mixing[105] and a possible warming-induced increase in phytoplankton growth through intensification of the microbial loop[106]. Second, O_2 projections in the CMIP5 outputs are highly variable and uncertain[107]. Although decreasing trends in O_2 concentration have been detected from historical datasets[108], their origin (in terms of possible observation errors, natural variability or climate change) is not yet clear. There is general agreement, however, that increasing the resolution of ESMs should provide a better representation of observed changes in O_2 (refs 109,110).

Supplementary Figure 11 shows average biomass for each tuna species in the WCPO and EPO for each sensitivity analysis scenario across four models. The thick grey line shows the multi-model mean biomass from the main projection simulation (REF). The SP scenario (10% increase of primary production in tropical region bounded by 27°C isotherm) confirms the high sensitivity of tropical tunas to primary production identified in previous studies[12,62]. An increase in primary production leads to larger stocks in the WCPO and EPO than those predicted by the reference forcing models. Except for skipjack tuna in the WCPO, the SP scenario results in increasing tuna stocks during the first half of the century even within the most pessimistic emission scenario.

The SO scenario, which assumes constant O_2 concentration at historical levels, highlights the critical role of oxygen in the EPO, and for tuna species accessing deeper pelagic layers, i.e., yellowfin and bigeye tuna. In the reference climate forcing, O_2 levels are decreasing in the epipelagic layer and increasing in both mesopelagic layers considered in SEAPODYM. Yellowfin tuna, which has a wider range of favourable habitat than skipjack tuna, both in horizontal and vertical dimensions, clearly benefits from the absence of trends in O_2 concentrations. However, in the EPO, the simulation for skipjack tuna, the species with the highest oxygen demands (preferred values $\geq$ 3.8ml/l), shows no difference in biomass, or a slight and episodical reduction in biomass, under the SO scenario. In contrast, bigeye tuna which can tolerate oxygen levels as low as 0.5ml/l (ref 111) seems to be sensitive to this scenario and would have a lower biomass. These unlikely outcomes, however, might be an artefact of the simulation design for the sensitivity analysis, which uses monthly climatology of historical O_2 distributions, and should be interpreted with caution.

To examine the role that phenotypic plasticity within tuna populations may play on adaptation to changing ocean temperatures, we ran one additional scenario (ST) where preferred temperature for spawning increased by 1°C at mid-century. Adaptation to warmer temperatures in spawning grounds seems to be beneficial only to skipjack tuna in the WCPO. For skipjack tuna in the EPO, as well as for other tunas across the Pacific, the ST scenario leads to decreased tuna stock levels compared to simulations with reference forcing. This negative effect could be explained by two mechanisms. First, the constant rate of adaptation assumed through linear increase of preferred spawning temperature might not correspond to the rate of change of temperature in each climate model forcing. Second, the temperature increase in known spawning grounds of skipjack tuna is accompanied by decreasing ocean productivity, effectively shrinking the areas suitable for larval survival in terms of food availability. Under such circumstances, adaptation to higher temperatures would drive skipjack tuna to spawn in less-productive zones, making this scenario less beneficial than in the absence of adaptation.

Finally, we tested the effect of interannual variability on the estimated relative change in tuna biomass under the simulated RCP4.5 scenario. To do this, we modified the method to simulate a synthetic RCP4.5 scenario over the time period 2011−2055 by reusing the RCP8.5 forcing. We generated another full time-series of environmental forcing, repeating the three 16-year cycles (2011−2026, 2019−2034 and 2030−2045) to ensure that CO_2 concentrations in the mid-century were similar to those in the RCP4.5 scenario. This sensitivity run was expected to result in a stronger impact on tuna biomass due to the use of forcing with a high rate of change in ocean conditions. However, it also enabled removal of the effect of interannual variability by comparing 2046−2055 to 2001−2010, the periods that have the same atmospheric variability in underlying ESM models. This method resulted in similar changes but with greater magnitude in the 10 Pacific SIDS, e.g., the average biomass of skipjack tuna in PNG and Solomon Islands is predicted to decrease by 25% and 16%, respectively, compared to the more moderate reductions by 19% and 10% in the reference simulation (Supplementary Table 7). The increase in average biomass in the EEZs of Pacific SIDS in the central Pacific Ocean, e.g., in Kiribati (Phoenix Islands) and Cook Islands, are computed as 16% and 13%, respectively, in these simulations compared to 8% and 9% as reported in Supplementary Table 7. Thus, the direct use of the forcing fields from the RCP8.5 scenario in this method gives more variable metrics, suggesting that the model projections are more sensitive to the method to generate a surrogate RCP4.5 forcing than to the effect of interannual variability.

Limitations of RCP2.6 modelling

The simulations under the surrogate RCP2.6 forcing do not follow the expected pattern, i.e., there is a surprisingly large effect on tuna biomass, especially for skipjack tuna relative to RCP4.5 (Supplementary Figure 15). A possible explanation for the large shifts in tuna distribution projected by the surrogate RCP2.6 modelling is that the main assumption of independence in the rate of change for the 'time-shift' procedure is particularly fragile when the rates of change of forcing variables are significantly different between two simulations. This was the case for RCP2.6 and RCP8.5.

Another factor undermining the use of RCP8.5 forcing to imitate RCP2.6 is that the atmospheric variability in NEMO-PISCES forcings was repeated from the historical reanalysis during the projected time period. The time window from RCP8.5 simulations equivalent to RCP2.6 atmospheric CO_2 levels used to generate surrogate RCP2.6 forcings was 2011−2029 for the first four decades and 2021−2030 for the last decade (Supplementary Figure 14). As a result, the years of RCP8.5 simulation used to compute monthly climatological time series in RCP2.6 during the last decade, are characterised by the atmospheric variability between 1989 and 1998, a period known for a sequence of ENSO events, including the strongest El Niño on record in 1997−1998. As shown in Supplementary Figure 13, adult skipjack tuna responded by shifting eastward during this period. According to the classification of ENSO[112], the resulting environmental conditions in the surrogate RCP2.6 forcing can be classified as a mixed-type El Niño. Therefore, such forcing fields represent an artificial thermal anomaly resulting in the greatest spatial shifts in tuna distributions and strong local impacts.

For the reasons outlined above, the uncertainty associated with using the time-shift method to estimate the effects of RCP2.6 is too high to have an acceptable level of confidence that it is a reasonable representation of the likely effects of this representative concentration pathway on the distribution of tropical Pacific tuna.

Supplementary References

The section lists all references from the main text (1−71) (some of which are referred to in the supplementary information), followed by references cited only in the supplementary information (72−112).

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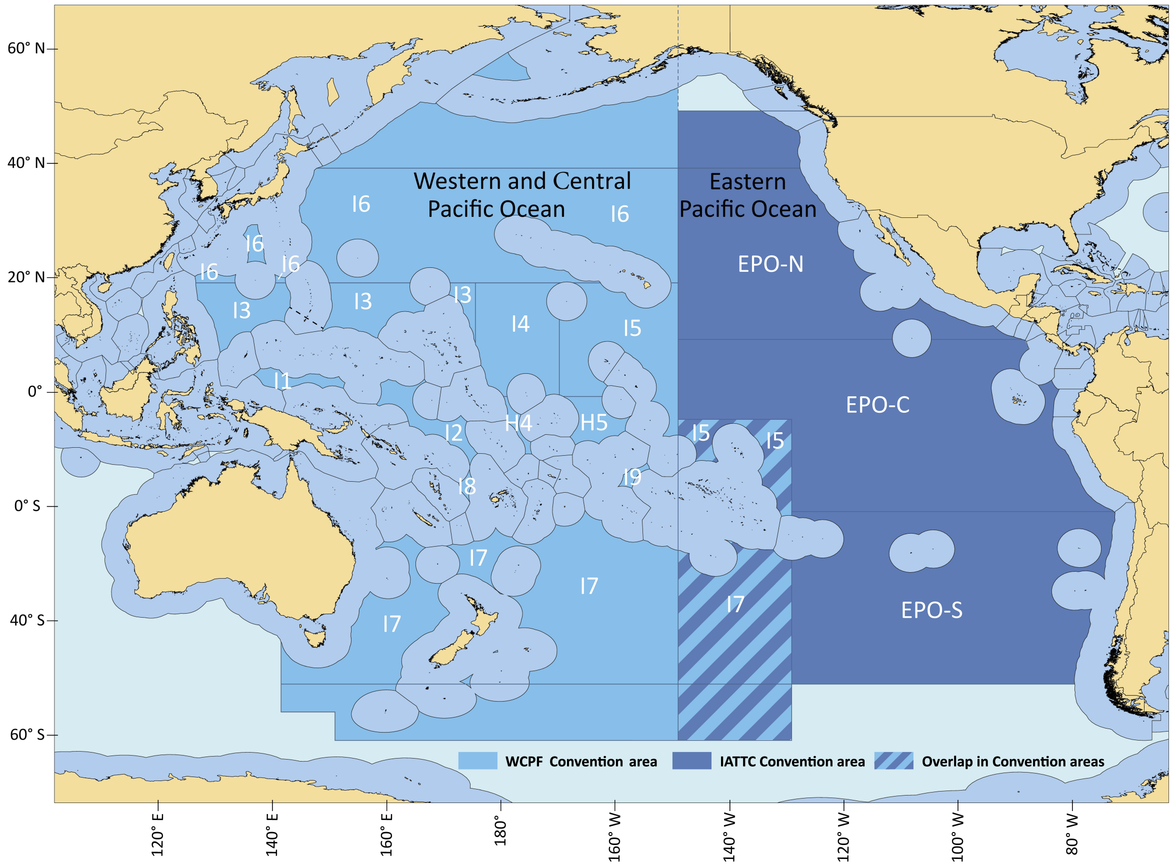
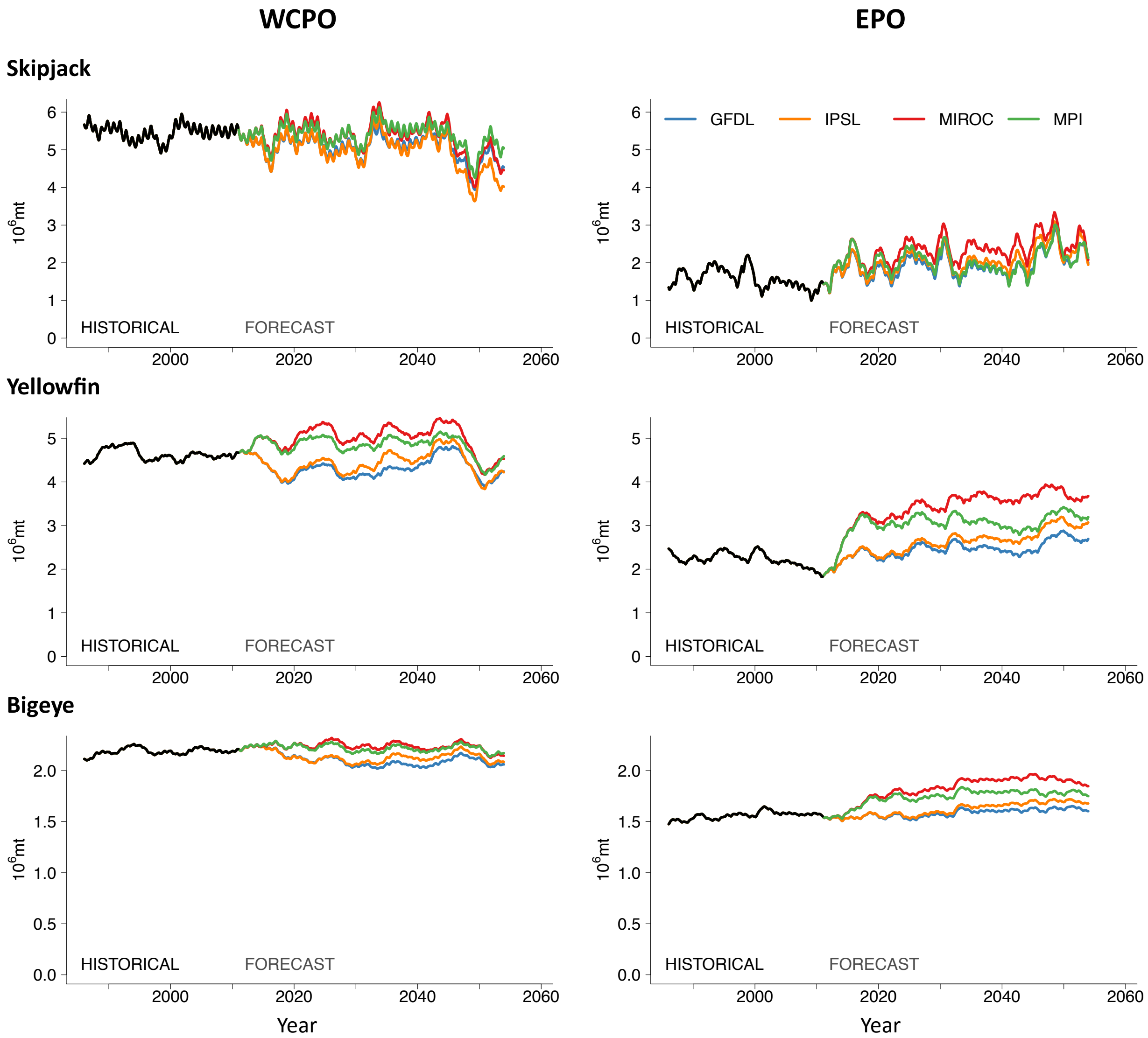
Supplementary Figures



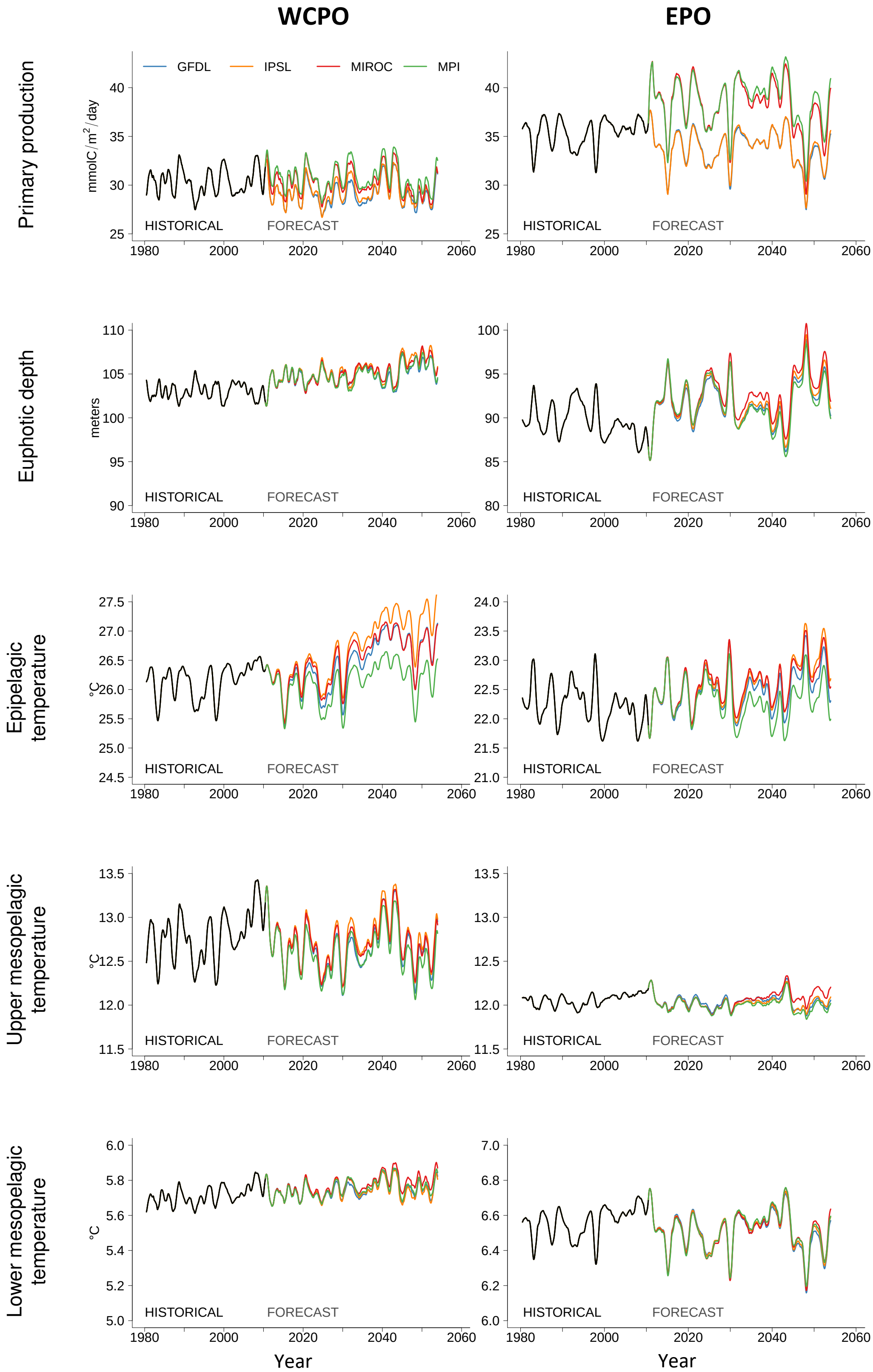
Supplementary Figure 1. Map of the Pacific Ocean basin showing the locations of the high-seas areas referred to in this study. The exclusive economic zones for all Pacific Small Island Developing States, and other coastal States, are also shown.

High-seas areas in the Western and Central Pacific Fisheries (WCPF) Convention Area. **I1**: 'Doughnut hole' between Papua New Guinea and Federated States of Micronesia; **I2**: Doughnut hole between Federated States of Micronesia, Solomon Islands, Kiribati, Marshall Islands, Nauru and Tuvalu; **I3**: Area east of the Philippines to Guam above Federated States of Micronesia, and around Marshall Islands, up to 20°N and west of 175°E; **I4**: Area around Marshall Islands and Kiribati from the Equator up to 20°N and east of 175°E to 170°W; **I5**: Area around Line Islands group of Kiribati from the Equator up to 20°N, east of 170°W to 150°W and south of the Equator to 20°S from 155°W; **I6**: Remainder of Western and Central Pacific Convention Area in the Northern Hemisphere as far as 40°N **I7**: Remainder of Western and Central Pacific Convention Area in the Southern Hemisphere as far as 50°S; **I8**: Area bordered by Fiji, Solomon Islands and Vanuatu; **I9**: International waters between Cook Islands and French Polynesia; **H4**: Area between Tuvalu, Phoenix Islands Group of Kiribati and Tokelau, from the equator to 10°S and east of 175°E to 170°W; **H5**: Area between Phoenix Islands and Line Islands Groups in Kiribati, from the Equator to 10°S, east of 170°W to 155°W.

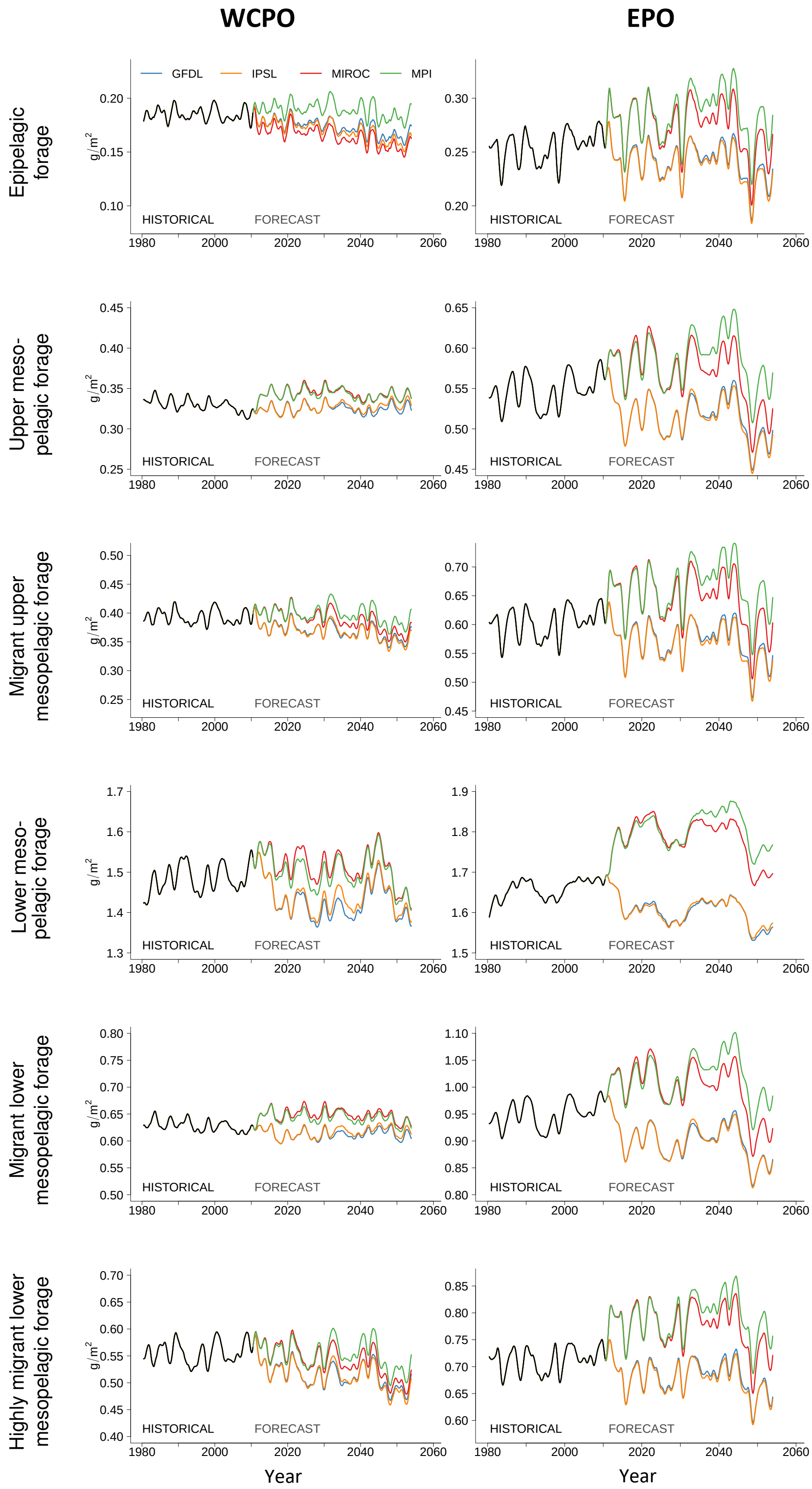
High-seas areas in the Inter-American Tropical Tuna Commission (IATTC) Convention Area. **EPO-C:** Area east of Americas, as far as 150ºW, bound by 10ºN and 20ºS and Area I5; **EPO-S**: Area east of Americas, as far as 130ºW, below EPO-C and above to 50ºS; **EPO-N**: Area east of Americas, as far as 150ºW, above EPO-C and below 40ºN.



Supplementary Figure 2. Total biomass of adult skipjack, yellowfin and bigeye tuna predicted by SEAPODYM in the Western and Central Pacific Ocean (WCPO) (120ºE–150ºW; 45ºS–50ºN) and Eastern Pacific Ocean (EPO) (150ºW–70ºW; 45ºS–50ºN) during the historical time period (1980–2010), and forecast time period (2011–2053) based on four climate model forcings under the RCP8.5 emissions scenario.

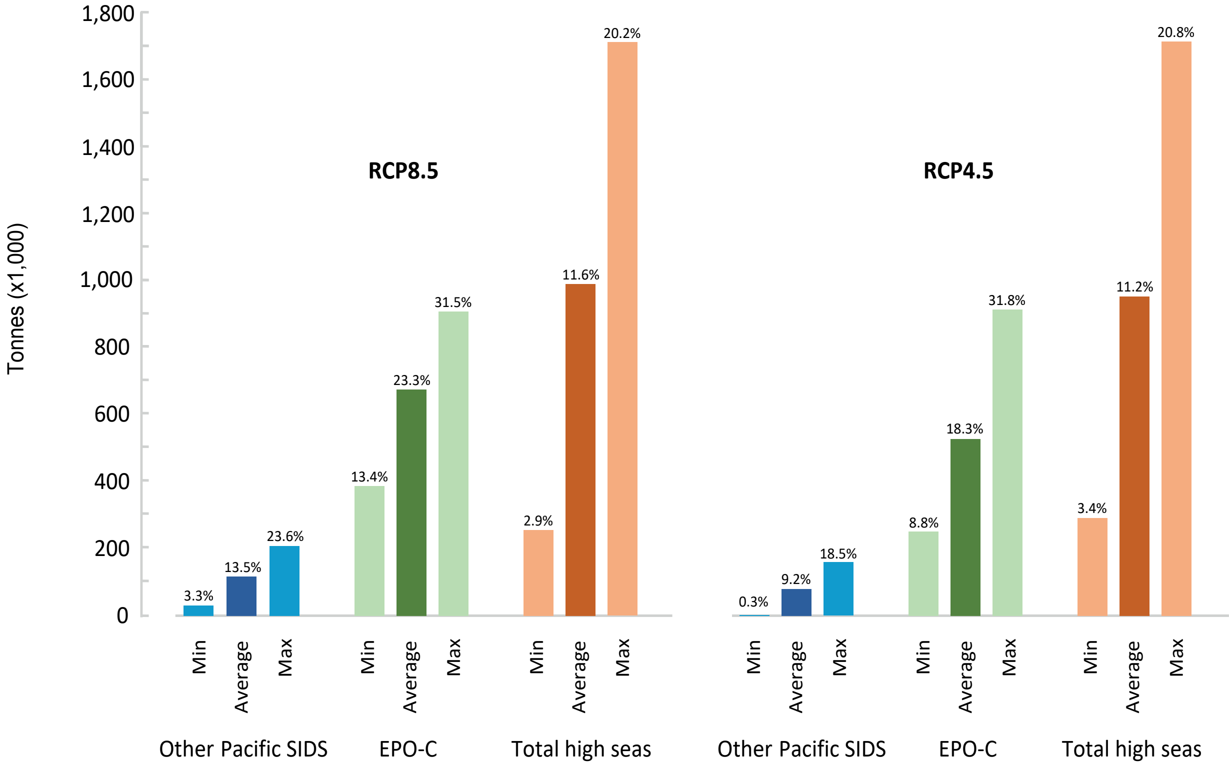


Supplementary Figure 3. Mean values of key environmental forcing variables in the tropical Western and Central Pacific Ocean (WCPO) (120ºE–150ºW, 20ºS–20ºS) and tropical Eastern Pacific Ocean (EPO) (150ºW–70ºW, 20ºS–20ºN). The historical simulation of NEMO-PISCES models (black line) and forecasts from four climate models: GFDL-derived (blue), IPSL-derived (orange), MIROC-derived (red) and MPI-derived (green), are plotted as 12-month moving averages. Note the difference in the y axes for some variables for the two ocean areas.

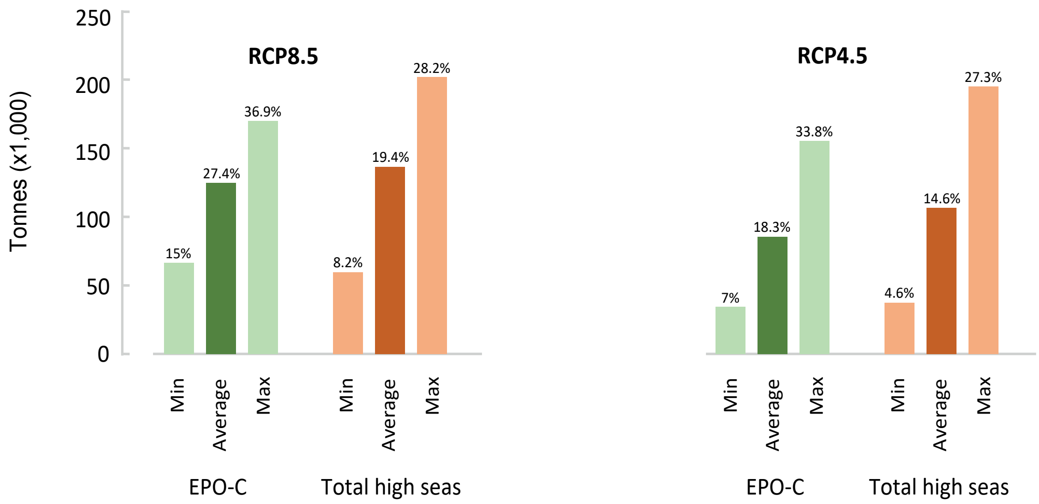


Supplementary Figure 4. Mean values of tuna prey (epipelagic forage and six functional groups of micronekton) in the tropical Western and Central Pacific Ocean (WCPO) (120ºE–150ºW, 20ºS–20ºS) and tropical Eastern Pacific Ocean (EPO) (150º W–70ºW, 20ºS–20ºN). The historical simulation (black line) and forecasts from four NEMO-PISCES models: GFDL-derived (blue), IPSL-derived (orange), MIROC-derived (red) and MPI-derived (green), are plotted as 12-month moving averages. Note the differences in y axes for all variables between the two ocean areas (see Methods for details).

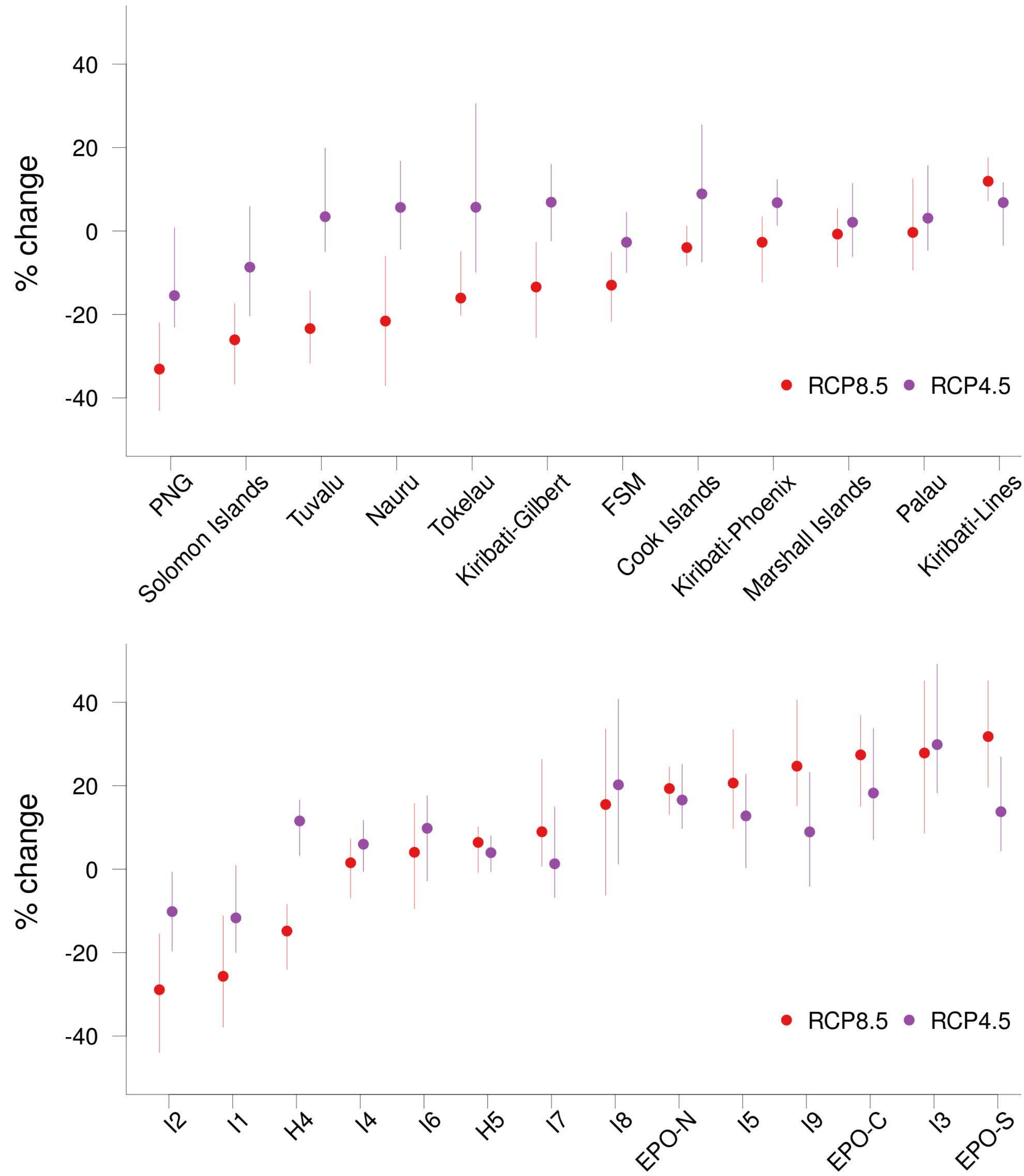
a) Change in biomass



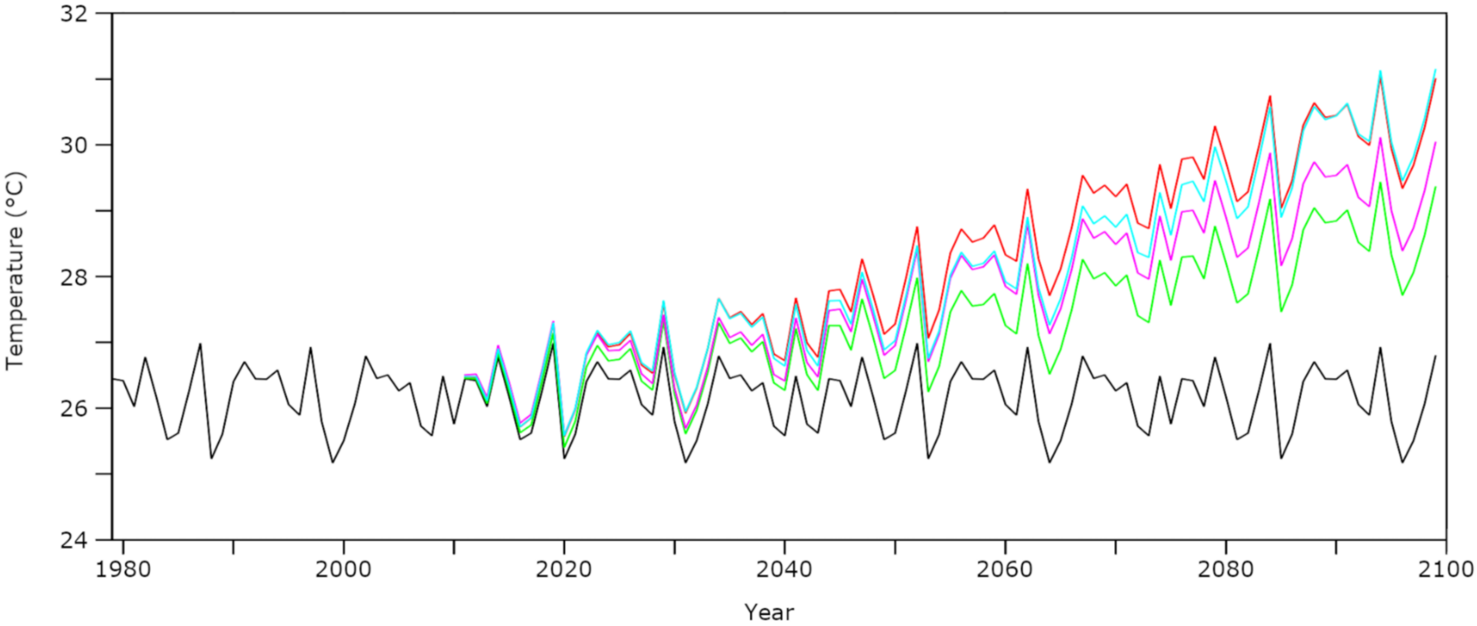
b) Change in catch



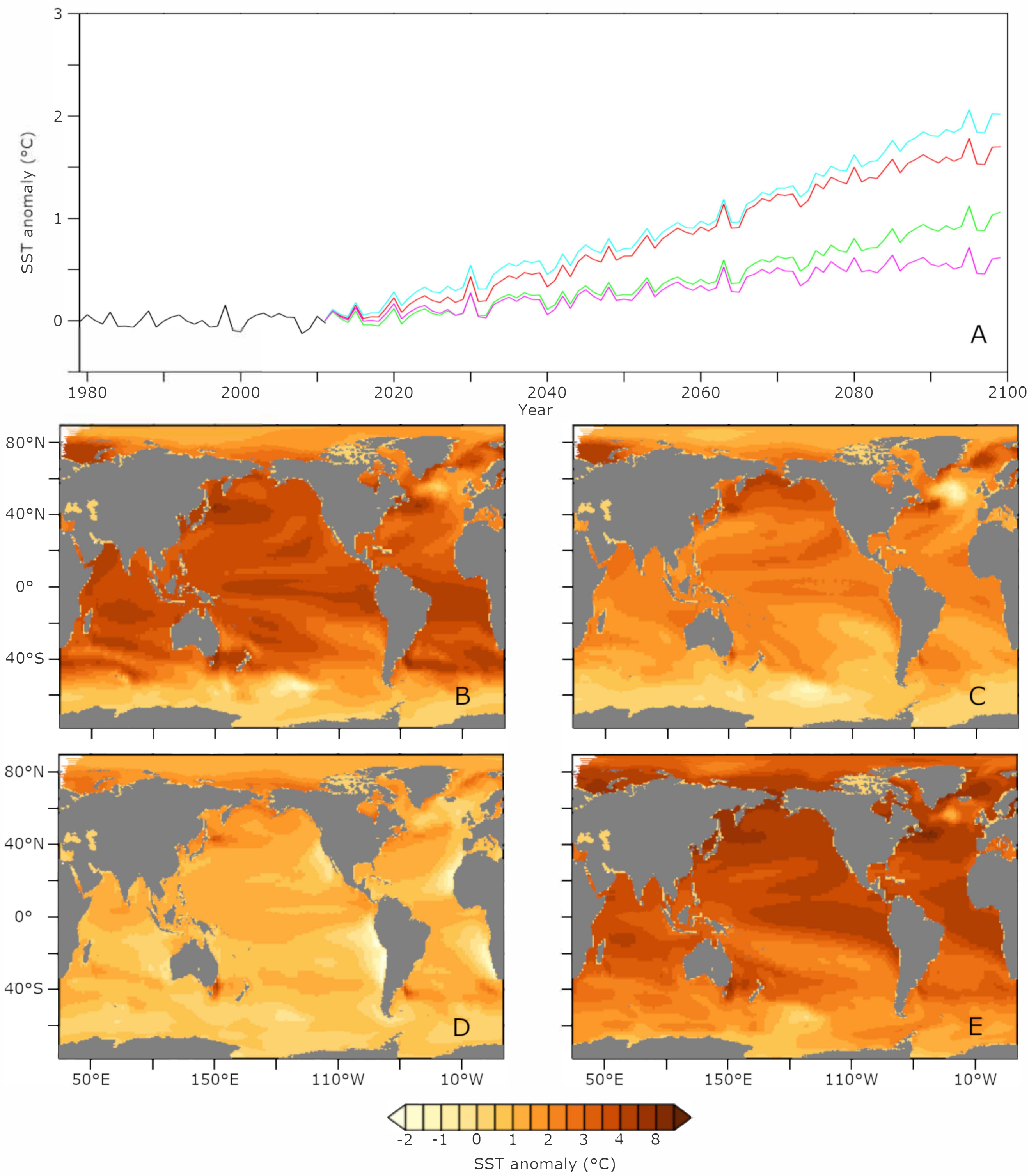
Supplementary Figure 5. a) Projected average (and maximum/minimum) changes of total biomass of skipjack, yellowfin and bigeye tuna in the combined exclusive economic zones (EEZs) of other Pacific Small Island Developing States (Other Pacific SIDS) (i.e., American Samoa, Fiji, French Polynesia, Guam, New Caledonia, Niue, Northern Mariana Islands, Pitcairn Islands, Samoa, Tonga, Vanuatu, Wallis and Futuna), high-seas area EPO-C, and in all high-seas areas combined, by 2050 under RCP8.5 and RCP4.5 relative to 2011–2020 (see also Supplementary Tables 6, 8, 9, 10); and **b)** projected average (and maximum/minimum) changes in purse-seine catch in high-seas area EPO-C, and in all high-seas areas combined, by 2050 under RCP8.5 and RCP4.5 relative to 2011–2020 (see also Supplementary Tables 12, 14).



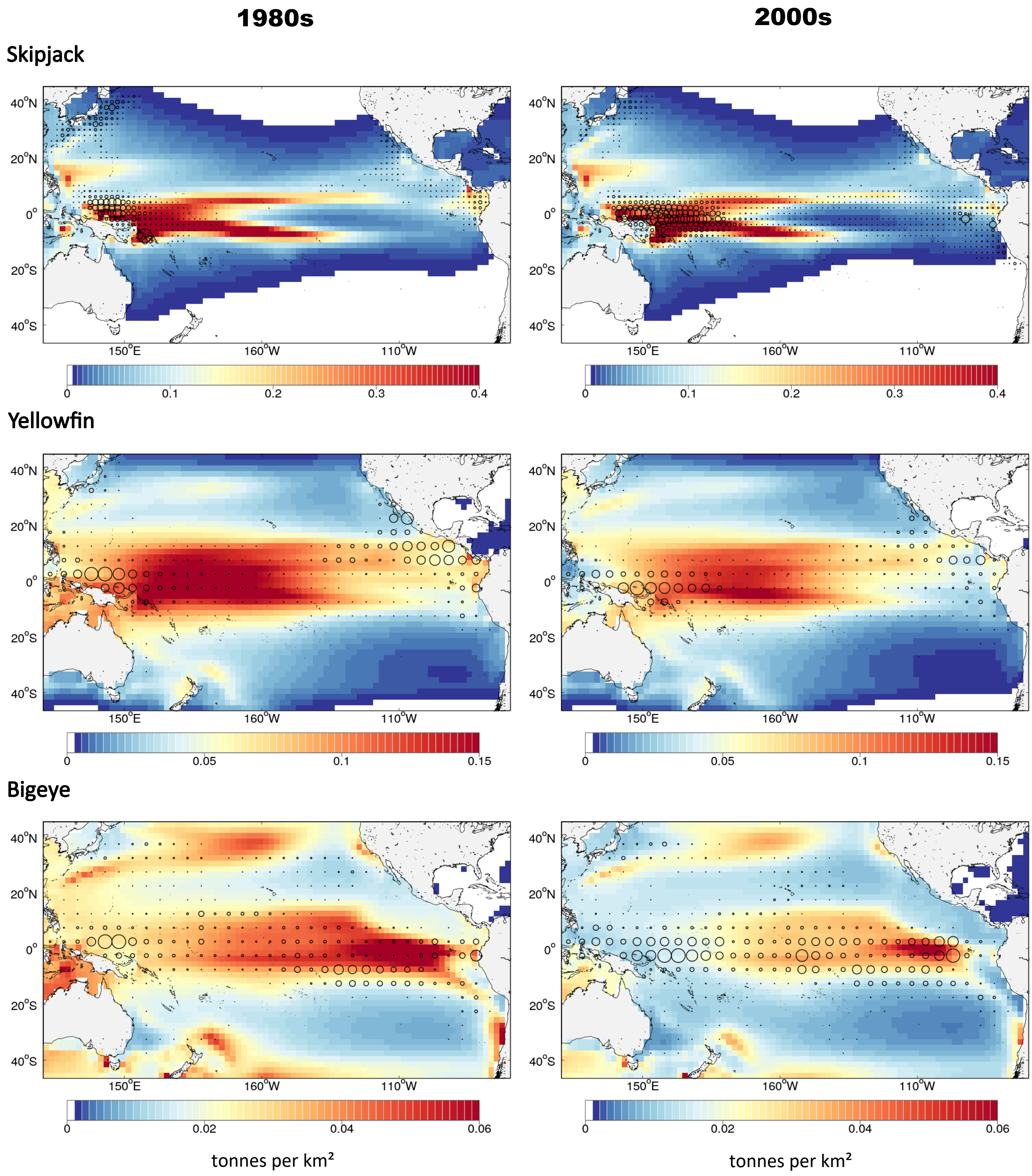
Supplementary Figure 6. Mean percentage change (circles) in purse-seine catch under the RCP8.5 and RCP4.5 emission scenarios by 2050, relative to the period 2011–2020 in the individual exclusive economic zones (EEZs) of the 10 tuna-dependent Pacific Small Island Developing States (top); and high-seas areas in the Western and Central Pacific Ocean and Eastern Pacific Ocean (see Supplementary Figure 1) (bottom). The range of percentage changes in purse-seine catch for each EEZ and high-seas areas derived from the four global climate models is also shown (see also Supplementary Tables 11–14).



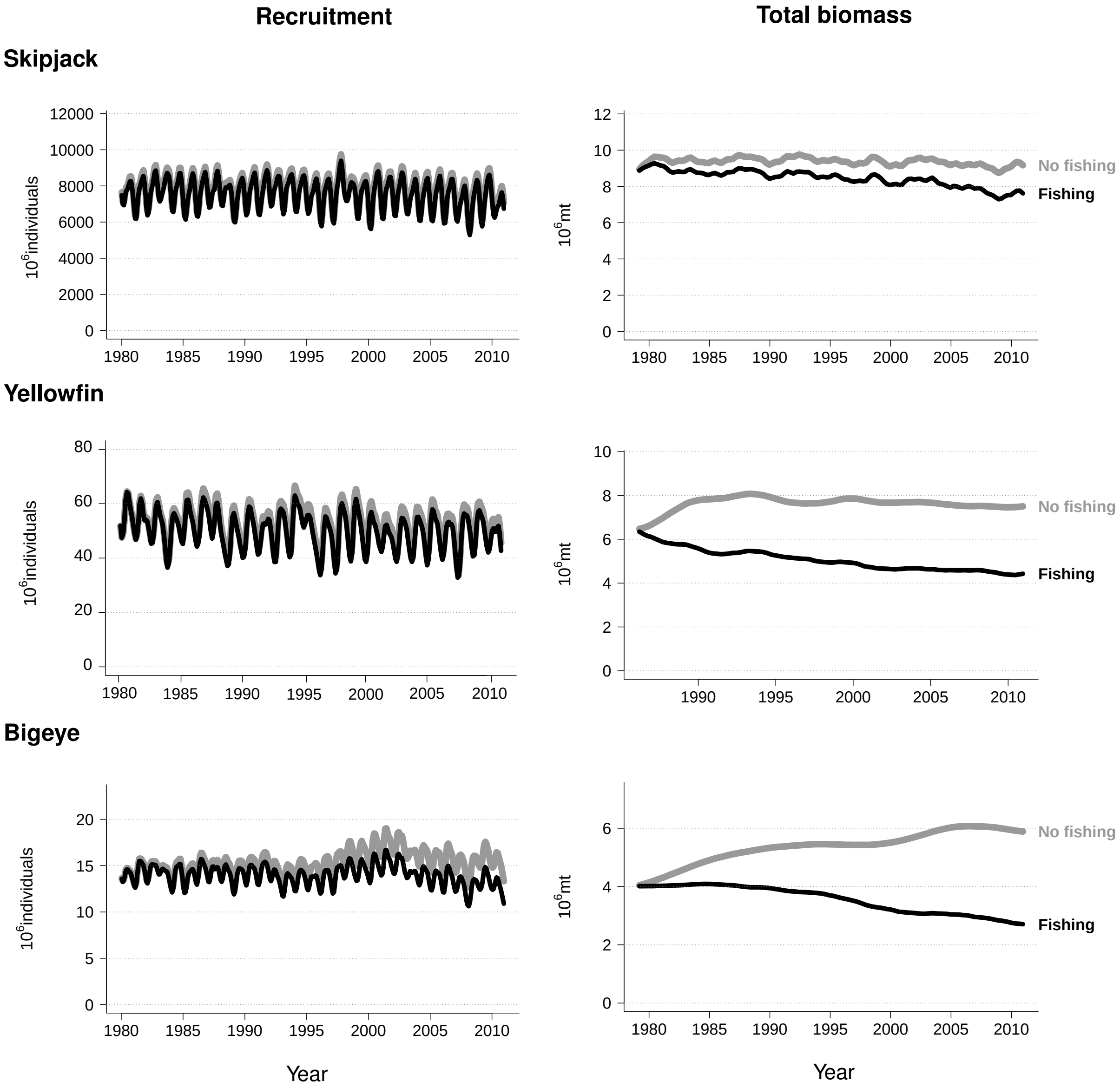
Supplementary Figure 7. Example of an atmospheric variable reconstructed by the pseudo-anomaly method. Time-series of the annual, mean air temperature at 2 m (averaged over the nino3.4 (5ºN–5ºS, 170ºW–120ºW box) (https://climatedataguide.ucar.edu/climate-data/nino-sst-indices-nino-12-3-34-4-oni-and-tni) for the DFS5.2 forcing set (black), and forcing built following the correction method for the IPSL (red), GFDL (green), MIROC (blue) and MPI (pink) Earth System Models.



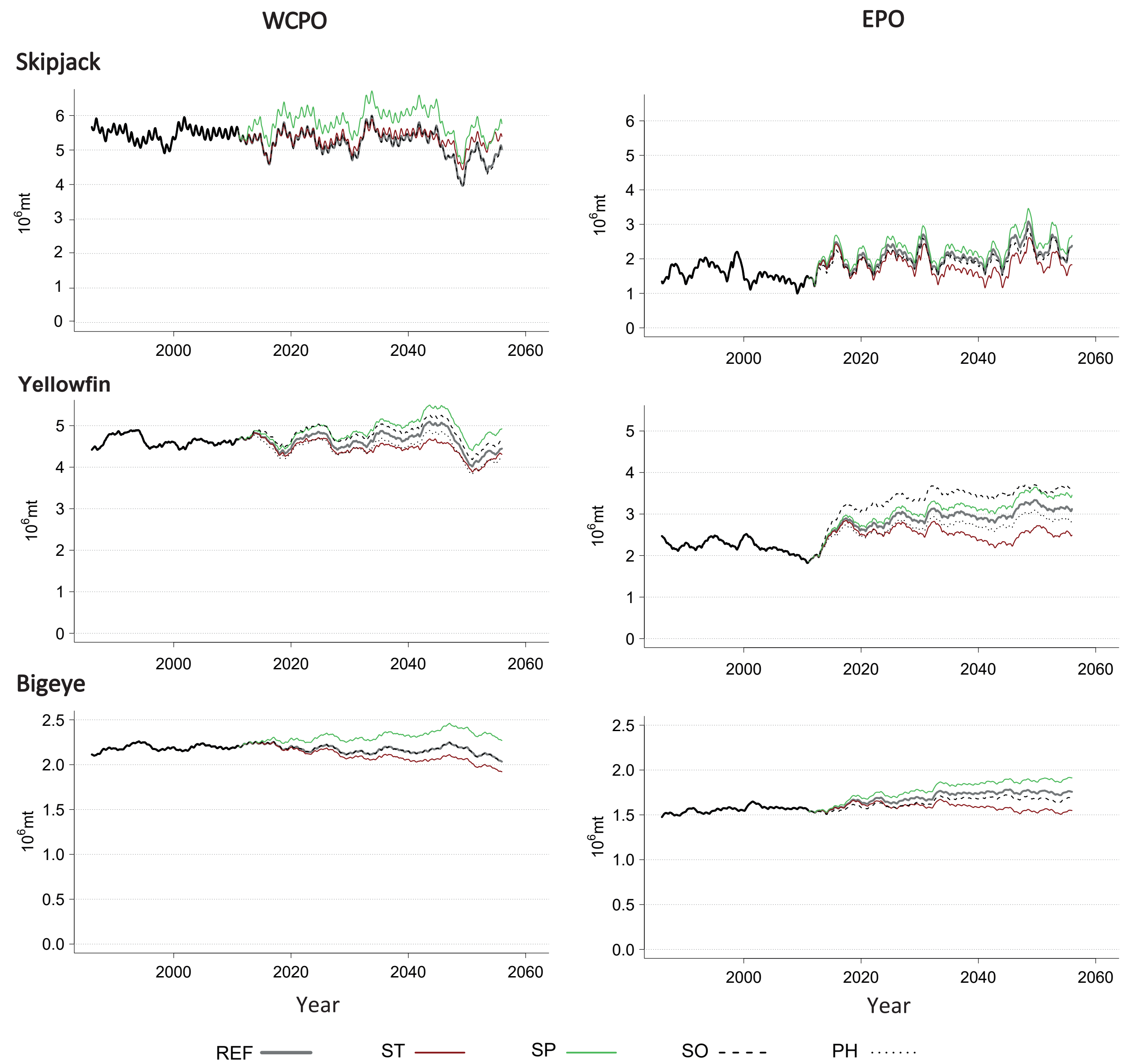
Supplementary Figure 8. (A) Time evolution of sea surface temperature (SST) anomalies (°C) referenced to the historical period 1979–2010 (black) for the four forced NEMO-PISCES simulations derived from IPSL (red), GFDL (green), MIROC (blue) and MPI (pink). Spatial variation in SST warming during the period 2090–2099, relative to historical mean temperatures (1979–2010), from the NEMO-PISCES simulations derived from ESM forcings from IPSL (B), GFDL (C), MPI (D) and MIROC (E) are also shown.



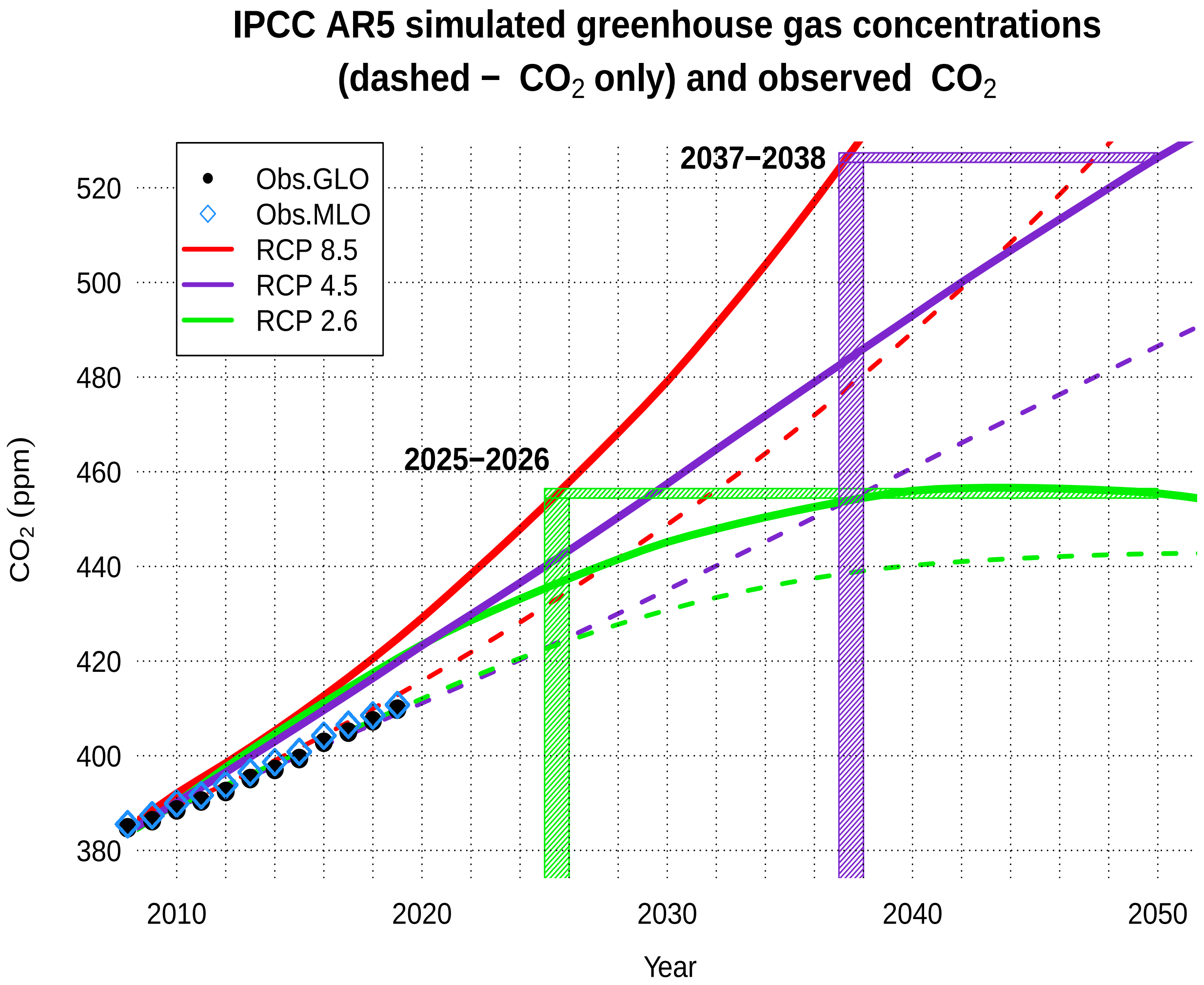
Supplementary Figure 9. Comparison of predicted average total biomass distributions (tonnes/km^2) for the three tropical tuna species produced by SEAPODYM for the first (1980–1989) and last (2000–2009) decades of the historical time series of catch data for these species from the entire Pacific Ocean basin, and the distribution of catches for each species. Circles show the distribution of observed catches, with catch proportional to the size of the circles for each species, but not among species.



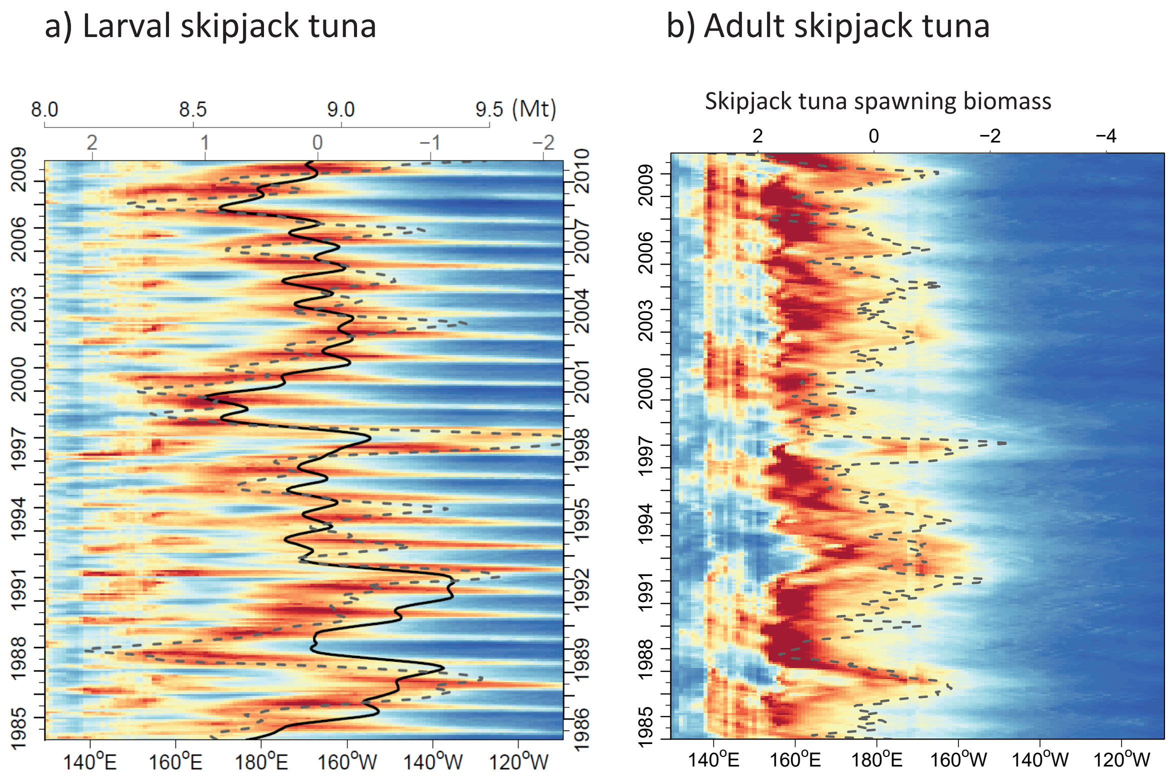
Supplementary Figure 10. Predictions from reference models of skipjack, yellowfin and bigeye tuna recruitment (small juveniles, 0–3 months of age) (left), and total biomass computed as the sum of young immature fish and mature adult fish over the Pacific Ocean model domain (right). Curves in all panels represent simulations with observed fishing pressure (black) and with the absence of fishing (grey).



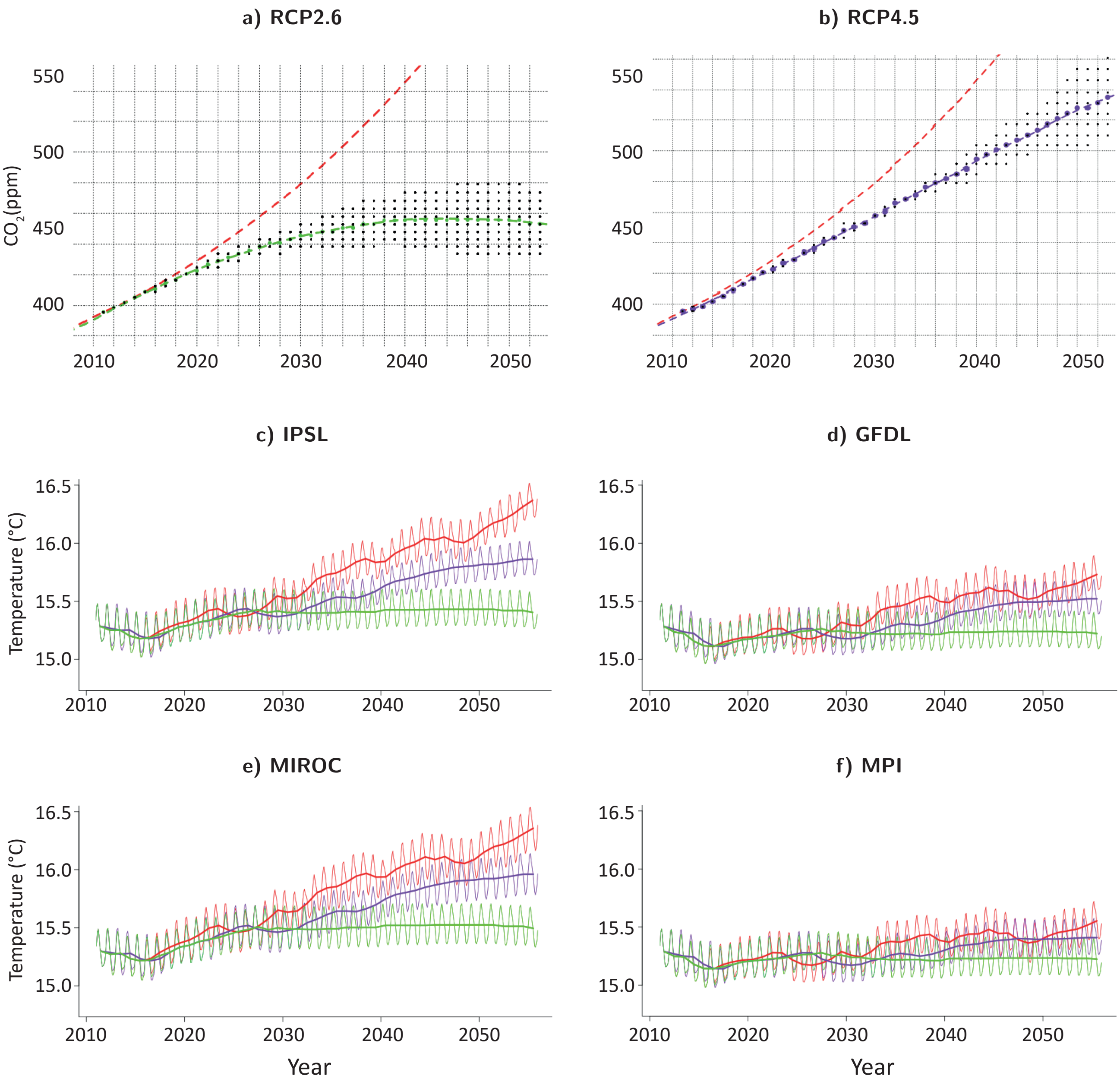
Supplementary Figure 11. Total biomass (in metric tonnes, mt x 10^6) of adult skipjack, yellowfin and bigeye tuna predicted by SEAPODYM in the Western and Central Pacific Ocean (WCPO) (120ºE–150ºW; 45ºS–50ºN) and Eastern Pacific Ocean (EPO) (150ºW–70ºW; 45ºS–50ºN) during the historical time period (1980–2010) and forecast time period (2011–2053) by 'uncertainty' scenario (Supplementary Table 21): REF = mean of four climate-derived (IPSL, GFDL, MIROC and MPI) NEMO-PISCES ocean simulations; ST = genetic adaptation to increasing temperature; SP = 10% increase of primary production in tropical region defined by 27°C isotherm; SO = no change in dissolved oxygen content over forecast period, and PH = negative impact of ocean acidification of larval survival (for yellowfin tuna only). All simulations were run under the RCP8.5 emissions scenario.



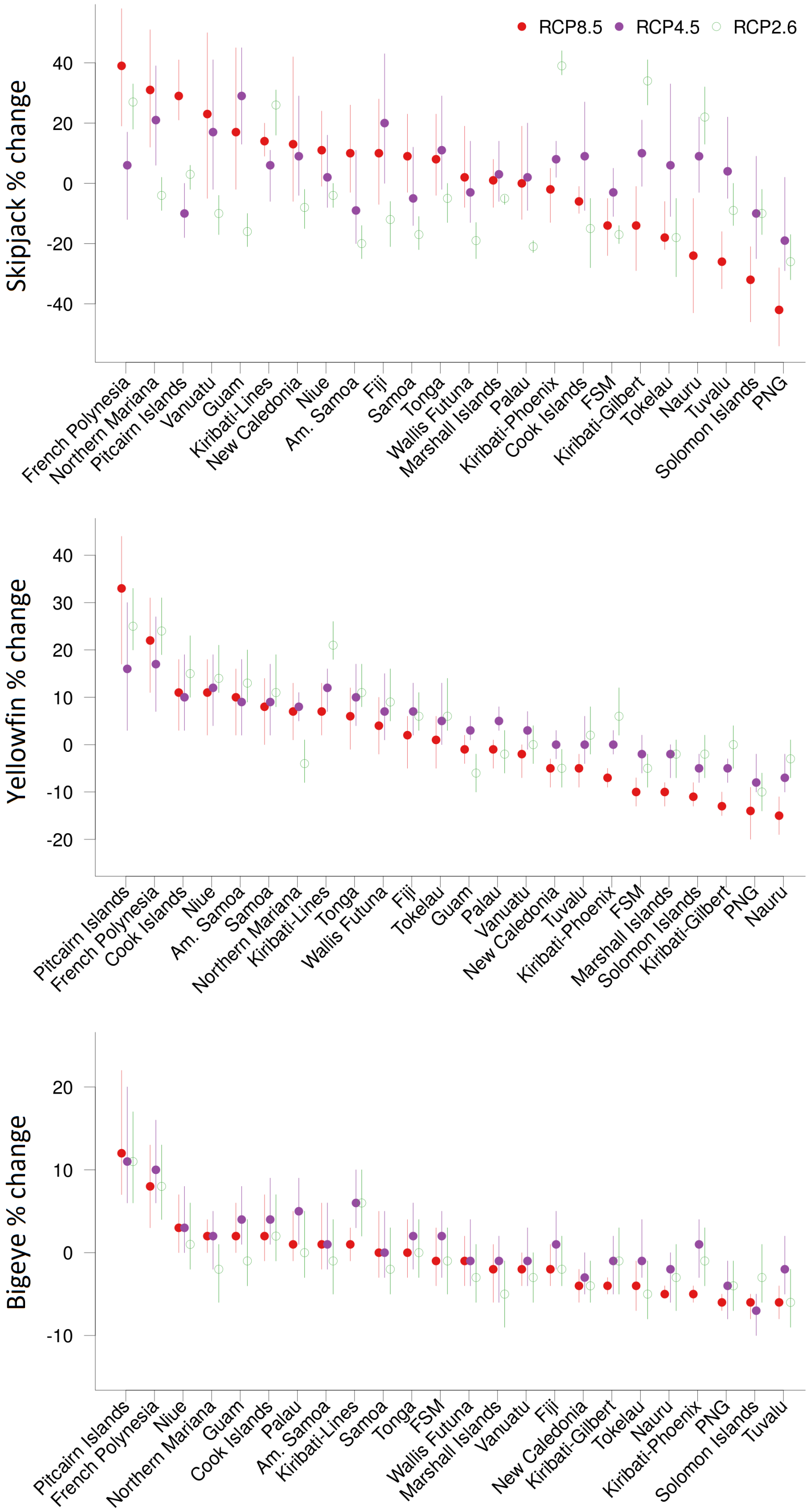
Supplementary Figure 12. IPCC (AR5) simulations of total greenhouse gas (GHG) concentrations (CO_2-eq) (solid lines) and carbon dioxide (CO_2) (dashed lines) under RCP8.5 (red), RCP4.5 (purple), and RCP2.6 (green) emission scenarios. Black dots represent the observed global mean of atmospheric CO_2 concentrations (Obs.GLO) and blue diamonds show the respective Mauna Loa observations for CO_2 (Obs.MLO). The green shaded areas mark the year when the total GHG concentrations under RCP8.5 equal those under RCP2.6 in 2050; and the purple shaded areas mark the year when the total GHG concentrations under RCP8.5 equal those under RCP4.5 in 2050.



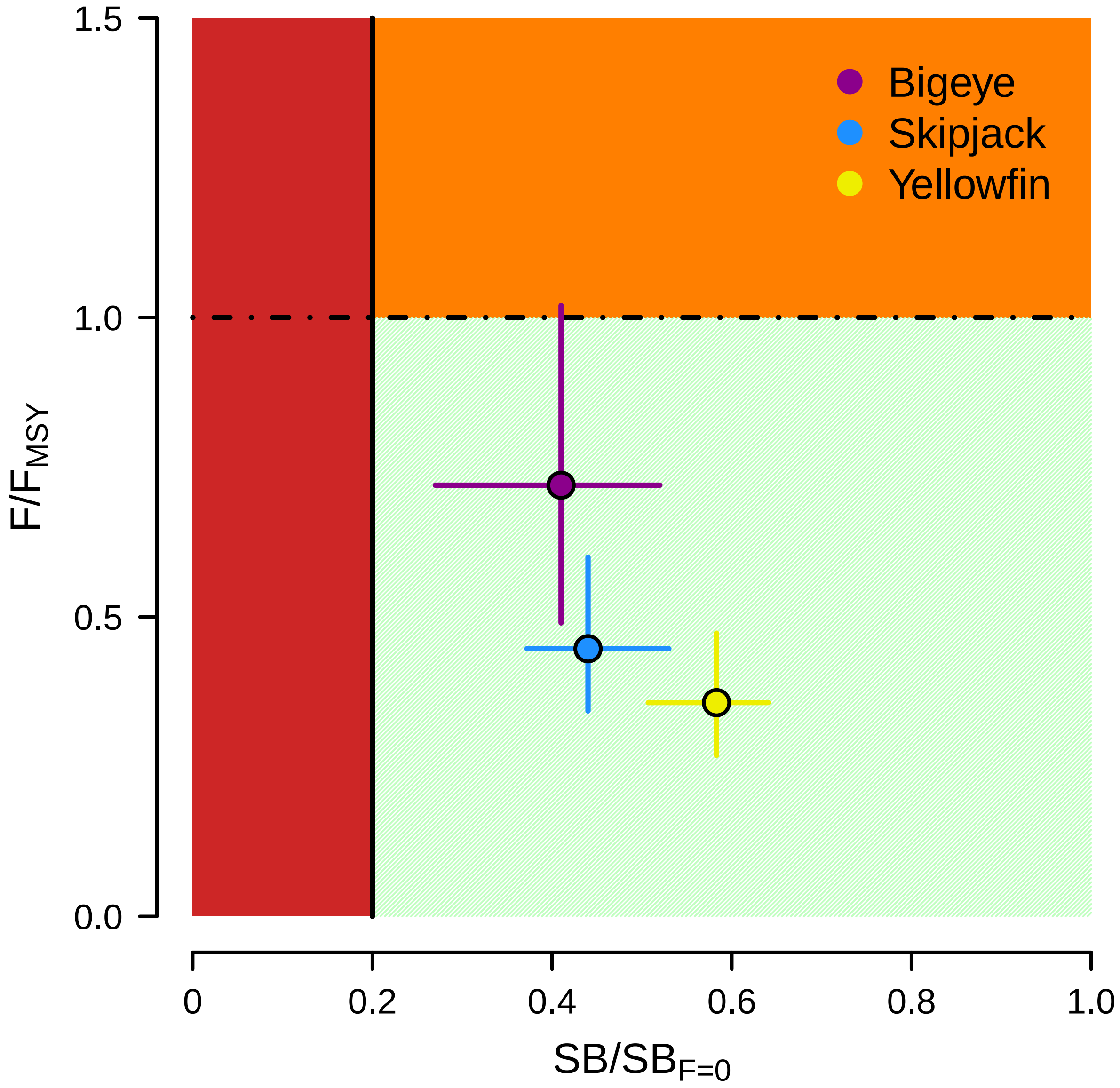
Supplementary Figure 13. Hovmöller diagrams showing simulated temporal-spatial variation of (a) larval skipjack tuna density, and (b) adult skipjack tuna density, in the equatorial Pacific (10°S–10°N) between 1985 and 2010. Densities are depicted with colours ranging from blue (near zero values), to dark red (maximum values). Both panels are overlaid with the 3-month moving average of the Southern Oscillation Index (SOI) (grey dashed line), with SOI values depicted on the upper *x* axis. Panel (a) is also overlaid with the total skipjack biomass (solid line), which has been time-lagged and drawn on the secondary *y* axis on the right, and quantified in tonnes (x 10^6) on the upper *x* axis.



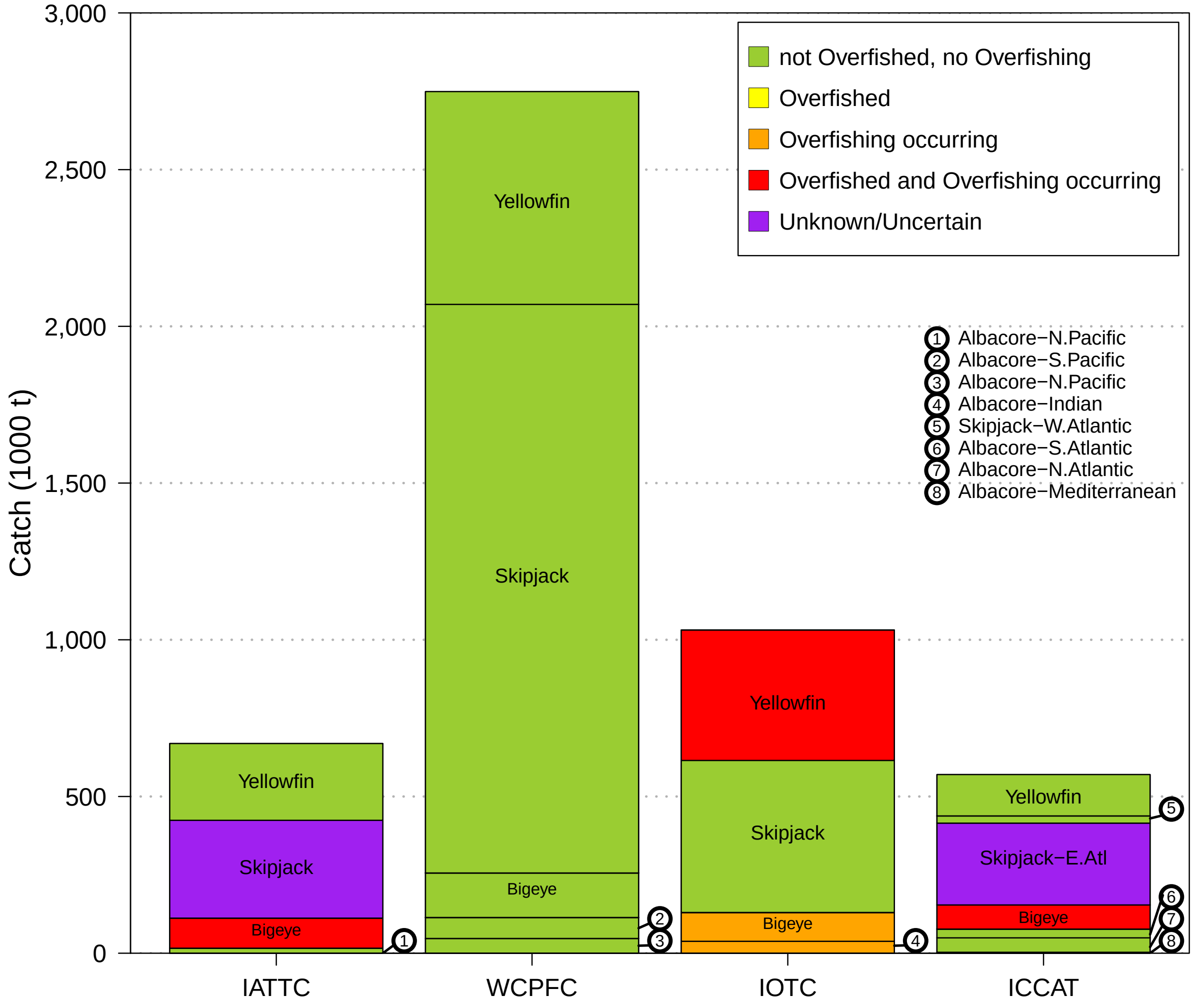
Supplementary Figure 14. The mapping of years between (a) RCP2.6 and RCP8.5, and (b) RCP4.5 and RCP8.5, forcings based on equivalent CO_2-eq concentration to compute smoothed time series for RCP2.6 and RCP4.5 scenarios (see Methods for details); and average ocean temperatures in the epipelagic layer under RCP8.5 forcing (red) and surrogate RCP4.5 (purple) and RCP2.6 (green) forcings in the four climate models (c-f). Thin lines show monthly dynamics and thick lines correspond to the annual average.



Supplementary Figure 15. Percentage change in biomass of skipjack tuna (top), yellowfin tuna (middle) and bigeye tuna (bottom) in the EEZs of Pacific Small Island Developing States in 2050, simulated with ocean forcings under the RCP8.5 emissions scenario (red), and surrogate RCP4.5 (purple) and RCP2.6 (green) scenarios. Circles depict average biomass change projected for each EEZ based on four Earth System Models (ESMs), with the vertical bars showing the range in biomass change from the four ESMs.



Supplementary Figure 16. 'Majuro' plot summarizing the stock status for skipjack, yellowfin and bigeye tuna in the Western and Central Pacific Ocean in 2020 in terms of spawning potential depletion relative to unfished levels ($SB/SB_{F=0}$) and fishing mortality (F) relative to the level required for maximum sustainable yield $F_{(MSY)}$. For each tuna stock, the point represents the median stock status calculated across the grid of assessment runs included by the Scientific Committee of the Western and Central Pacific Fisheries Commission within the 'structural uncertainty grid'. The 'cross hairs' represent the 80 percentile ranges of $SB/SB_{F=0}$ and F/F_{MSY} estimates within that grid, as included in management advice (source: Oceanic Fisheries Programme, Pacific Community).



Supplementary Figure 17. Catch (5-year average) and stock status of skipjack (SKJ), yellowfin (YFT), bigeye (BET) and albacore (ALB) tuna reported by all tuna regional fisheries management organisations for October 2020. IATTC = Inter-American Tropical Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; IOTC = Indian Ocean Tuna Commission; ICCAT = International Commission for the Conservation of Atlantic Tunas (source: Oceanic Fisheries Programme, Pacific Community).

Supplementary Table 1. Average total catch (in tonnes) for all tuna species, by all fishing methods, from the combined exclusive economic zones (EEZs) of Pacific Small Island Developing States (Pacific SIDS) between 2009 and 2018. Pacific SIDS have been divided into the eight Parties to the Nauru Agreement (PNA) plus Tokelau (Box 1) and 'Other Pacific SIDS'. The average total tuna catch from the EEZ of each Pacific SIDS for the 10-year period, and the average percentage (%) of the total regional tuna catch taken from each EEZ, are also shown. For Kiribati, data are presented for the total EEZ for the nation, and for each of three separate EEZ areas comprising the total EEZ (source: Oceanic Fisher2ies Programme, Pacific Community, May 2020).

EEZ*	Year										Average total catch	%
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
PNA Members (plus Tokelau)												
FSM[1]	131,886	159,230	161,963	189,270	217,330	143,096	170,786	199,889	195,570	288,997	185,802	12.24
Kiribati	328,734	204,767	214,315	556,320	296,695	735,059	642,118	413,012	384,064	401,081	417,617	27.52
Gilbert Islands	(191,807)	(119,985)	(144,460)	(430,840)	(187,711)	(438,353)	(315,385)	(334,131)	(264,455)	(287,947)	(271,507)	(17.89)
Phoenix Islands	(21,852)	(22,804)	(28,078)	(39,426)	(32,001)	(60,318)	(184,399)	(32,854)	(30,290)	(34,567)	(48,659)	(3.21)
Line Islands	(115,075)	(61,978)	(41,777)	(86,054)	(76,982)	(236,387)	(142,334)	(46,028)	(89,319)	(78,567)	(97,450)	(6.42)
Marshall Islands	16,971	26,200	25,663	32,493	46,153	87,102	38,165	89,093	33,153	36,468	43,146	2.84
Nauru	61,672	109,355	103,310	50,983	163,812	179,776	67,193	115,738	82,316	174,916	110,907	7.31
Palau	2,178	2,924	2,898	3,904	3,415	4,903	1,509	6,571	19,450	11,317	5,907	0.39
PNG[2]	486,102	733,397	626,478	586,094	592,134	339,386	191,135	341,527	383,992	369,451	464,970	30.64
Solomon Islands	140,375	182,422	176,773	97,695	129,322	89,724	132,107	162,812	173,652	91,898	137,678	9.07
Tokelau	7,239	4,018	19,659	21,083	15,981	27,433	46,840	8,143	34,845	38,475	22,371	1.47
Tuvalu	64,506	67,948	61,130	71,276	54,820	98,289	78,426	119,969	57,808	91,825	76,600	5.05
Sub-total	**1,239,664**	**1,490,262**	**1,392,188**	**1,609,118**	**1,519,661**	**1,704,768**	**1,368,278**	**1,456,756**	**1,364,850**	**1,504,428**	**1,464,997**	**96.53**

Other Pacific SIDS												
American Samoa	3,993	3,569	3,271	5,249	2,885	4,169	3,026	3,223	3,849	3,190	3,642	0.24
Cook Islands	6,492	6,559	11,048	30,754	15,971	20,473	25,053	11,732	23,515	36,083	18,768	1.24
Fiji	8,370	9,895	7,333	6,845	5,475	7,423	12,175	10,733	12,159	9,127	8,953	0.59
French Polynesia	6,877	6,249	6,026	7,266	6,670	7,170	7,316	6,940	6,278	7,072	6,786	0.45
Guam	173	165	196	155	251	192	324	256	262	301	228	0.01
New Caledonia	120	162	120	163	175	117	42	96	27	136	116	0.01
CNMI[3]	2,147	2,472	2,358	2,319	2,290	2,422	2,487	2,316	2,362	2,270	2,344	0.15
Niue	293	223	0		420	283	282	110	15	426	228	0.02
Pitcairn Islands	0	0	0	0	0	0	0	0	0	0	0	0.00
Samoa	3,545	3,351	2,749	3,251	2,052	1,352	2,311	3,652	3,320	2,112	2,769	0.18
Tonga	271	128	243	1,345	2,344	740	1,736	2,939	1,849	1,184	1,278	0.08
Vanuatu	7,566	3,800	8,716	6,186	8,536	6,887	6,043	8,910	12,047	6,621	7,531	0.50
Wallis & Futuna	132	0	24	0		167	0	0	0		40	0.00
Sub-total	**39,978**	**36,571**	**42,085**	**63,533**	**47,070**	**51,395**	**60,794**	**50,905**	**65,683**	**68,521**	**52,654**	**3.47**
TOTAL	**1,279,642**	**1,526,833**	**1,434,273**	**1,672,651**	**1,566,731**	**1,756,163**	**1,429,072**	**1,507,661**	**1,430,533**	**1,572,949**	**1,517,651**	**100.00**

*Includes area covered by the EEZ and archipelagic waters where they exist

1. Federated States of Micronesia; 2. Papua New Guinea; 3. Commonwealth of Northern Marinas Islands

Supplementary Table 2. Average, and standard deviation (SD), tuna-fishing access fees, total national government revenue (excluding grants), and percentage of government revenue derived from tuna-fishing access fees, for the 10 Pacific Small Island Developing States (Pacific SIDS) where most purse-seine fishing occurs in the Western and Central Pacific Ocean, for the 4-year period (2015 to 2018). The area (km^2) of the exclusive economic zone (EEZ) of each Pacific SIDS is also shown (source: Pacific Islands Forum Fisheries Agency).

Pacific SIDS	Access fees (USD millions)						Non-aid government revenue (USD millions)[1]						Percentage gov't revenue derived from access and licensing fees						EEZ area (km^2)*
	2015	**2016**	**2017**	**2018**	**Mean**	**SD**	**2015**	**2016**	**2017**	**2018**	**Mean**	**SD**	**2015**	**2016**	**2017**	**2018**	**Mean**	**SD**	
Cook Is	8	13	18	15	13.5	4.2	120	122	132	130	126.1	6.0	6.7	10.7	13.6	11.5	10.6	2.9	1,947,760
FSM	65	63	73	72	68.4	5.1	117	119	151	215	150.6	45.9	55.7	52.9	48.2	33.6	47.6	9.8	2,939,300
Kiribati	149	107	130	127	128.3	17.2	191	156	183	197	181.7	18.2	78.2	68.7	71.0	64.5	70.6	5.7	3,550,000[2]
Marshall Is	27	32	33	32	31.0	2.7	50	63	80	71	66.1	12.8	54.0	50.8	41.3	45.1	47.8	5.7	2,004,888
Nauru	22	28	36	32	29.5	6.0	58	94	112	130	98.6	30.5	37.6	29.9	32.1	24.7	31.1	5.4	293,079
Palau	6	5	9	8	7.1	1.9	71	75	78	77	75.2	3.0	8.5	6.7	11.6	11.0	9.4	2.3	605,506
PNG	118	149	111	159	134.3	23.3	3669	2891	3163	3720	3360.8	401.7	3.2	5.2	3.5	4.3	4.0	0.9	2,446,757
Solomon Is	40	34	45	47	41.3	6.1	403	388	445	480	429.0	41.7	9.8	8.7	10.1	9.8	9.6	0.6	1,553,444
Tokelau	11	16	13	14	13.4	2.1	12	18	18	16	16.0	2.9	91.7	87.9	72.4	84.6	84.2	8.4	318,990
Tuvalu	18	25	21	38	25.6	9.0	40	53	49	48	47.4	5.4	45.1	47.2	43.1	80.2	53.9	17.6	719,174
Total	**464**	**472**	**489**	**546**	**492.4**	**37.0**	**4,731**	**3,979**	**4,411**	**5,082**	**4,550.6**	**469.4**							**16,378,898**

Supplementary Table 3. Average (mean ± standard deviation) annual catch (tonnes) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and all three species of tuna combined, taken by purse-seine fishing over the 10-year period (2009–2018) in the exclusive economic zones (EEZs) of 10 Pacific Island Small Developing States; note that Kiribati has three EEZ areas (source: Oceanic Fisheries Programme, Pacific Community, May 2020).

Tuna species	**Year**	**Pacific Island Small Developing State EEZ***													**Total**
		Cook Islands	**FSM[1]**	**Kiribati EEZ areas**				**RMI[2]**	**Nauru**	**Palau**	**PNG[3]**	**Solomon Islands**	**Tokelau**	**Tuvalu**	
				Gilbert	**Phoenix**	**Line**	**Total**								
SKJ	2009	660	103,279	149,552	99,067	10,071	258,690	10,434	49,956	678	335,605	88,495	5,913	56,593	910,304
	2010	209	128,633	76,191	49,700	11,022	136,913	13,682	81,891	273	518,133	131,870	3,459	56,766	1,071,829
	2011	1,355	116,283	98,084	26,063	13,730	137,877	17,482	80,197	0	461,595	124,243	17,593	45,701	1,002,326
	2012	11,031	154,285	299,420	69,028	21,010	389,458	18,583	39,147	507	425,565	56,913	17,517	57,596	1,170,601
	2013	6,209	184,767	143,931	62,712	14,628	221,271	33,378	129,015	301	426,845	80,825	13,703	45,250	1,141,564
	2014	11,484	111,683	359,575	189,474	33,673	582,722	65,796	148,165	902	223,145	36,034	24,138	85,491	1,289,559
	2015	16,050	105,107	242,671	126,676	151,641	520,988	23,368	50,134	183	107,868	75,110	42,478	69,977	1,011,261
	2016	5,917	158,084	254,856	39,320	18,780	312,956	70,918	80,135	2,199	207,202	91,968	4,159	98,751	1,032,289
	2017	15,026	148,957	178,585	73,215	21,459	273,259	21,359	56,606	8,261	236,994	113,417	28,662	44,742	947,282
	2018	27,187	231,641	232,617	64,500	24,872	321,989	24,895	146,497	3,503	239,337	47,498	32,749	77,764	1,153,060
	Mean	**9,513**	**144,272**	**203,548**	**79,976**	**32,089**	**315,612**	**29,990**	**86,174**	**1,681**	**318,229**	**84,637**	**19,037**	**63,863**	**1,073,008**
	SD	**8,479**	**40,676**	**90,049**	**47,975**	**42,597**	**180,621**	**21,208**	**40,966**	**2,557**	**134,404**	**32,166**	**13,018**	**18,559**	**115,602**
YFT	2009	80	19,034	18,866	6,931	1,917	27,714	2,032	9,872	272	131,693	27,684	971	5,345	224,697
	2010	45	19,291	25,531	6,857	2,575	34,963	3,232	23,977	63	191,250	25,550	423	6,647	305,442
	2011	48	32,564	18,591	9,508	3,249	31,348	2,546	14,453	0	146,453	31,623	913	7,461	267,407
	2012	1,368	22,466	101,556	10,851	5,500	117,907	3,164	8,257	220	140,960	18,094	1,878	6,763	321,078
	2013	1,428	22,468	27,742	7,702	4,573	40,017	4,899	26,393	7	146,802	26,440	1,351	5,326	275,131
	2014	1,060	19,461	55,009	31,827	12,776	99,612	9,731	23,555	1,801	104,346	20,366	2,074	7,517	289,523
	2015	1,293	50,323	47,592	11,482	15,810	74,884	7,598	14,532	2	72,242	23,156	1,289	5,119	250,438
	2016	939	27,827	56,298	3,169	1,966	61,433	11,261	31,958	1,557	118,169	55,774	665	10,725	320,307
	2017	2,799	36,853	69,162	12,546	3,749	85,457	4,899	22,126	4,249	132,006	41,930	3,462	7,114	340,896
	2018	2,014	42,886	39,462	9,635	4,559	53,656	4,986	24,395	1,245	116,568	21,166	3,588	7,424	277,928
	Mean	**1,107**	**29,317**	**45,981**	**11,051**	**5,667**	**62,699**	**5,435**	**19,952**	**942**	**130,049**	**29,178**	**1,661**	**6,944**	**287,285**
	SD	**896**	**11,016**	**26,024**	**7,792**	**4,746**	**38,562**	**3,123**	**7,726**	**1,355**	**31,174**	**11,546**	**1,104**	**1,625**	**35,507**

	2009	35	3,250	6,792	3,780	2,226	12,798	697	1,835	0	14,761	2,269	343	1,380	37,368
	2010	10	5,278	2,671	3,216	2,401	8,288	596	3,397	11	20,917	5,658	132	1,651	45,938
	2011	5	4,248	12,716	4,134	3,485	20,335	1,666	8,486	0	15,496	4,784	658	3,436	59,112
	2012	458	5,323	15,423	3,244	3,251	21,918	1,956	3,354	11	15,263	2,239	686	1,518	52,726
	2013	727	4,865	8,868	4,796	4,724	18,388	1,585	8,222	2	17,137	3,399	749	1,683	56,758
BET	2014	815	3,588	13,969	5,840	3,802	23,611	2,856	7,760	1	9,917	1,494	981	2,874	53,896
	2015	320	5,214	10,345	2,685	4,455	17,485	691	2,441	1	8,897	1,908	368	1,687	39,011
	2016	393	6,562	12,567	1,515	1,680	15,762	3,112	3,609	53	10,058	3,377	186	4,066	47,178
	2017	1,055	5,355	11,117	3,343	4,083	18,543	1,621	3,563	188	8,396	3,379	1,422	1,472	44,994
	2018	781	6,295	10,975	4,145	5,122	20,242	1,006	4,006	63	6,698	2,104	1,410	2,966	45,570
	Mean	**460**	**4,998**	**10,544**	**3,670**	**3,523**	**17,737**	**1,578**	**4,667**	**33**	**12,754**	**3,061**	**693**	**2,273**	**48,255**
	SD	**375**	**1,060**	**3,708**	**1,180**	**1,139**	**6,028**	**881**	**2,492**	**59**	**4,589**	**1,334**	**463**	**972**	**16,745**
	2009	775	125,563	175,210	109,778	14,214	299,202	13,163	61,664	950	482,059	118,449	7,227	63,318	1,172,369
	2010	264	153,203	104,393	59,773	15,998	180,164	7,511	109,265	347	730,300	163,078	4,014	65,064	1,423,209
	2011	1,407	153,094	129,391	39,705	20,464	189,560	21,693	103,136	0	623,544	160,649	19,164	56,599	1,328,845
	2012	12,858	182,074	416,399	83,123	29,761	529,283	23,703	50,758	738	581,788	77,246	20,081	65,877	1,544,406
	2013	8,364	212,100	180,541	75,210	23,925	279,676	39,862	163,631	310	590,784	110,663	15,802	52,259	1,473,453
All tuna species	2014	13,358	134,732	428,553	227,141	50,251	705,945	78,383	179,480	2,704	337,408	57,894	27,194	95,882	1,632,979
	2015	17,662	160,645	300,608	140,843	171,906	613,357	31,657	67,107	185	189,007	100,174	44,134	76,783	1,300,711
	2016	7,249	192,474	323,721	44,004	22,426	390,151	85,291	115,702	3,809	335,429	151,118	5,010	113,541	1,399,774
	2017	18,879	191,165	258,864	89,104	29,291	377,259	27,880	82,295	12,698	377,397	158,726	33,546	53,328	1,333,173
	2018	29,981	280,822	283,054	78,280	34,553	395,887	,886	174,898	4,812	362,603	70,768	37,747	88,154	1,476,559
	Mean	**11,080**	**178,587**	**260,073**	**94,696**	**41,279**	**396,048**	**37,003**	**110,794**	**2,655**	**461,032**	**116,877**	**21,392**	**73,080**	**1,408,548**
	SD	**9,478**	**45,079**	**112,491**	**55,304**	**47,054**	**214,849**	**24,858**	**47,659**	**3,907**	**167,503**	**40,097**	**14,044**	**20,289**	**132,245**

*Includes area covered by the EEZ and archipelagic waters where they exist; 1. Federated States of Micronesia; 2. Republic of Marshall Islands; 3. Papua New Guinea

Supplementary Table 4. Annual average (mean ± standard deviation) catch (tonnes) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and all three species of tuna combined, taken by purse-seine fishing over the 10-year period (2009–2018) from high-seas areas in the Western and Central Pacific Ocean, and Eastern Pacific Ocean (Supplementary Figure 1) (source: Oceanic Fisheries Programme, Pacific Community, May 2020).

Tuna species	Year	High-seas areas														Total
		I1	I2	I3	I4	I5	I6	I7	I8	I9	H4	H5	EPO-N	EPO-C	EPO-S	
SKJ	2009	17,543	164,867	0	17,300	14,954	16,799	0	0	0	36,743	18,385	2,457	237,466	1,548	528,062
	2010	578	1,881	0	4,013	8,845	28,771	0	0	0	9,828	10,970	3,252	169,348	795	238,281
	2011	0	1,088	170	13,472	8,063	15,993	0	0	0	4,620	7,441	7,929	266,548	793	326,117
	2012	130	530	20	8,517	7,936	21,006	71	0	94	8,196	25,874	9,045	263,449	341	345,209
	2013	9,453	11,399	0	9,195	11,803	15,802	0	15	122	5,537	12,516	9,621	259,034	155	344,652
	2014	19,370	1,214	205	7,917	13,104	28,006	0	0	24	18,581	44,258	5,389	246,195	1,691	385,954
	2015	15,897	1,147	40	17,049	33,499	14,107	57	0	0	18,270	156,393	7,403	294,847	94	558,803
	2016	14,189	1,350	6	51,532	37,033	1,928	0	0	0	35,938	13,386	5,089	272,644	3,364	436,459
	2017	15,750	774	10	18,810	7,414	9,192	0	0	0	30,758	29,307	12,478	279,057	6,547	410,096
	2018	12,370	2,046	0	17,352	27,288	2,988	0	0	0	15,839	72,965	8,057	257,433	4,985	421,323
	Mean	**10,528**	**18,630**	**45**	**16,516**	**16,994**	**15,459**	**13**	**2**	**24**	**18,431**	**39,150**	**7,072**	**254,602**	**2,031**	**399,495**
	SD	**7,597**	**51,483**	**77**	**13,292**	**11,285**	**9,112**	**27**	**5**	**45**	**12,185**	**45,695**	**3,056**	**34,033**	**2,222**	**95,088**
YFT	2009	2,333	32,140	5	4,244	4,803	70	0	0	0	1,700	1,436	76,470	165,564	1,390	290,155
	2010	28	436	0	1,023	2,015	374	0	0	0	1,122	1,515	98,047	129,480	1,438	235,478
	2011	0	196	3	2,002	1,507	2,405	0	0	0	1,092	3,031	74,508	133,305	319	218,369
	2012	11	100	0	3,112	2,078	290	20	0	23	1,204	4,374	63,172	140,474	22	214,880
	2013	2,799	2,476	0	2,770	3,172	225	0	5	38	444	1,926	93,516	126,251	33	233,655
	2014	5,543	171	5	1,336	3,816	317	0	0	1	2,316	13,908	93,446	146,000	409	267,268
	2015	7,667	267	0	3,132	6,349	685	7	0	0	1,300	9,971	69,398	176,302	72	275,150
	2016	7,916	229	1	4,721	2,092	95	0	0	0	2,293	1,063	79,284	153,549	342	251,585
	2017	8,094	141	0	7,685	1,462	499	0	0	0	6,107	4,134	61,627	140,750	372	230,871
	2018	7,757	309	0	1,965	8,005	107	0	0	0	1,783	14,063	61,450	165,753	998	262,190
	Mean	**4,215**	**3,647**	**1**	**3,199**	**3,530**	**507**	**3**	**1**	**6**	**1,936**	**5,542**	**77,092**	**147,743**	**540**	**247,960**
	SD	**3,551**	**10,037**	**2**	**1,969**	**2,227**	**694**	**6**	**2**	**13**	**1,574**	**5,143**	**13,844**	**16,997**	**539**	**25,233**

BET	2009	266	6,571	0	1,614	2,606	112	0	0	0	557	931	9	59,593	1,964	74,223
	2010	11	126	0	645	1,909	211	0	0	0	233	948	12	48,119	998	53,212
	2011	0	115	6	2,078	1,727	498	0	0	0	617	702	0	44,960	204	50,907
	2012	3	35	0	1,784	2,565	362	0	0	14	305	1,017	0	54,935	113	61,133
	2013	485	924	0	2,218	3,166	222	0	2	14	277	1,723	3	51,416	298	60,748
	2014	478	61	0	402	2,369	685	0	0	2	556	3,026	35	52,815	400	60,829
	2015	993	45	0	688	2,460	156	12	0	0	498	2,224	0	65,264	101	72,441
	2016	435	103	1	3,533	2,048	6	0	0	0	609	439	4	57,710	25	64,913
	2017	1,087	24	0	3,279	2,348	7	0	0	0	889	2,728	48	63,810	805	75,025
	2018	2,117	64	0	1,038	5,870	192	0	0	0	715	4,519	2	54,571	2,313	71,401
	Mean	**588**	**807**	**1**	**1,728**	**2,707**	**245**	**1**	**0**	**3**	**526**	**1,826**	**11**	**55,319**	**722**	**64,483**
	SD	**660**	**2,043**	**2**	**1,082**	**1,182**	**215**	**4**	**1**	**6**	**206**	**1,295**	**17**	**6,467**	**813**	**8,610**
All tuna species	2009	20,142	203,578	5	23,158	22,363	16,981	0	0	0	39,000	20,752	78,936	462,622	4,902	892,439
	2010	617	2,443	0	5,681	12,769	29,356	0	0	0	11,183	13,433	101,311	346,946	3,231	526,970
	2011	0	1,399	179	17,552	11,297	18,896	0	0	0	6,329	11,174	82,437	444,813	1,316	595,392
	2012	144	665	20	13,413	12,579	21,658	91	0	131	9,705	31,265	72,217	458,858	476	621,222
	2013	12,737	14,799	0	14,183	18,141	16,249	0	22	174	6,258	16,165	103,140	436,701	486	639,055
	2014	25,391	1,446	210	9,655	19,289	29,008	0	0	27	21,453	61,192	98,870	445,010	2,500	714,051
	2015	24,557	1,459	40	20,869	42,308	14,948	76	0	0	20,068	168,588	76,801	536,412	267	906,393
	2016	22,540	1,682	8	59,786	41,173	2,029	0	0	0	38,840	14,888	84,377	483,903	3,731	752,957
	2017	24,931	939	10	29,774	11,224	9,698	0	0	0	37,754	36,169	74,153	483,616	7,724	715,992
	2018	22,244	2,419	0	20,355	41,163	3,287	0	0	0	18,337	91,547	69,509	477,758	8,296	754,915
	Mean	**15,330**	**23,083**	**47**	**21,443**	**23,231**	**16,211**	**17**	**2**	**33**	**20,893**	**46,517**	**84,175**	**457,664**	**3,293**	**711,939**
	SD	**11,007**	**63,558**	**79**	**15,143**	**13,162**	**9,346**	**35**	**7**	**64**	**13,281**	**49,904**	**12,529**	**48,323**	**2,924**	**122,602**

Supplementary Table 5a. ***Average*** projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in exclusive economic zones of 10 Pacific Small Island Developing States (Pacific SIDS) under RCP8.5 by 2050. Change in tonnes is also shown.

Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP8.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
Cook Islands	106,593	79,372	38,968	224,933	47.4	35.3	17.3	-6	+11	+2	+1.4	228,048	+ 3,115
FSM	341,280	299,670	97,815	738,765	46.2	40.6	13.2	-14	-10	-1	-10.7	660,041	-78,724
Kiribati–Gilbert Is	336,009	134,529	35,998	506,536	66.3	26.6	7.1	-14	-13	-4	-13.0	440,566	-65,970
Kiribati–Phoenix Is	202,849	80,528	24,810	308,187	65.8	26.1	8.1	-2	-7	-5	-3.5	297,253	-10,934
Kiribati–Line Is	250,078	141,321	57,758	449,157	55.7	31.5	12.9	+14	+7	+1	+10.1	494,638	+ 45,481
Marshall Islands	178,892	198,363	60,664	437,919	40.9	45.3	13.9	+1	-10	-2	-4.4	418,658	-19,261
Nauru	92,146	30,347	7,976	130,469	70.6	23.3	6.1	-24	-15	-5	-20.7	103,403	-27,066
Palau	62,544	58,943	22,194	143,681	43.5	41.0	15.4	0	-1	+1	-0.3	143,314	-367
PNG	554,428	248,820	71,292	874,540	63.4	28.5	8.2	-42	-14	-6	-31.1	602,568	- 271,972
Solomon Islands	267,111	138,747	40,297	446,155	59.9	31.1	9.0	-32	-11	-6	-23.1	342,999	- 103,156
Tokelau	63,731	30,688	11,113	105,532	60.4	29.1	10.5	-18	+1	-4	-11.0	93,923	-11,609
Tuvalu	117,569	55,562	18,089	191,220	61.5	29.1	9.5	-26	-5	-6	-18.0	156,789	-34,431
Total	**2,573,230**	**1,496,890**	**486,974**	**4,557,094**	**56.5**	**32.8**	**10.7**					**3,982,199**	**- 574,895 (-12.6%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 5b. ***Maximum*** (i.e., maximum negative/minimum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of the 10 Pacific Small Island Developing States (Pacific SIDS) under RCP8.5 by 2050. Change in tonnes is also shown.

Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP8.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
Cook Islands	106,593	79,372	38,968	224,933	47.4	35.3	17.3	-10	+3	-1	-3.9	216,265	-8,668
FSM	341,280	299,670	97,815	738,765	46.2	40.6	13.2	-24	-13	-4	-16.9	613,988	-124,777
Kiribati–Gilbert Is	336,009	134,529	35,998	506,536	66.3	26.6	7.1	-29	-15	-5	-23.6	387,114	-119,422
Kiribati–Phoenix Is	202,849	80,528	24,810	308,187	65.8	26.1	8.1	-13	-9	-6	-11.4	273,081	-35,106
Kiribati–Line Is	250,078	141,321	57,758	449,157	55.7	31.5	12.9	+9	+2	-1	+5.5	473,913	+24,756
Marshall Islands	178,892	198,363	60,664	437,919	40.9	45.3	13.9	-8	-13	-6	-10.0	394,181	-43,738
Nauru	92,146	30,347	7,976	130,469	70.6	23.3	6.1	-43	-19	-5	-35.1	84,681	- 45,788
Palau	62,544	58,943	22,194	143,681	43.5	41.0	15.4	-12	-5	-1	-7.4	133,007	-10,674
PNG	554,428	248,820	71,292	874,540	63.4	28.5	8.2	-54	-20	-7	-40.5	520,394	-354,146
Solomon Islands	267,111	138,747	40,297	446,155	59.9	31.1	9.0	-46	-13	-8	-32.3	302,023	-144,132
Tokelau	63,731	30,688	11,113	105,532	60.4	29.1	10.5	-22	-5	-7	-15.5	89,199	-16,333
Tuvalu	117,569	55,562	18,089	191,220	61.5	29.1	9.5	-35	-9	-8	-24.9	143,623	-47,597
Total	**2,573,230**	**1,496,890**	**486,974**	**4,557,094**	**56.5**	**32.8**	**10.7**					**3,631,469**	**- 925,625 (-20.3%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 5c. ***Minimum*** (i.e., minimum negative/maximum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of the 10 Pacific Small Island Developing States (Pacific SIDS) under RCP8.5 by 2050. Change in tonnes is also shown.

Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP8.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
Cook Islands	106,593	79,372	38,968	224,933	47.4	35.3	17.3	-1	+18	+7	+7.1	240,882	+15,949
FSM	341,280	299,670	97,815	738,765	46.2	40.6	13.2	-5	-7	+3	-4.8	703,659	-35,106
Kiribati–Gilbert Is	336,009	134,529	35,998	506,536	66.3	26.6	7.1	-1	-10	-3	-3.5	488,643	-17,893
Kiribati–Phoenix Is	202,849	80,528	24,810	308,187	65.8	26.1	8.1	+5	-5	-4	+1.7	313,311	+5,124
Kiribati–Line Is	250,078	141,321	57,758	449,157	55.7	31.5	12.9	+20	+13	+3	+15.6	519,277	+70,120
Marshall Islands	178,892	198,363	60,664	437,919	40.9	45.3	13.9	+8	-8	+1	-0.2	436,968	-951
Nauru	92,146	30,347	7,976	130,469	70.6	23.3	6.1	-5	-11	-4	-6.3	122,204	-8,265
Palau	62,544	58,943	22,194	143,681	43.5	41.0	15.4	+19	+1	+5	+9.5	157,263	+13,582
PNG	554,428	248,820	71,292	874,540	63.4	28.5	8.2	-28	-9	-5	-20.7	693,342	-181,198
Solomon Islands	267,111	138,747	40,297	446,155	59.9	31.1	9.0	-21	-8	-5	-15.5	376,947	-69,208
Tokelau	63,731	30,688	11,113	105,532	60.4	29.1	10.5	-6	+6	-1	-2.0	103,438	-2,094
Tuvalu	117,569	55,562	18,089	191,220	61.5	29.1	9.5	-16	-2	-4	-10.8	170,574	-20,646
Total	**2,573,230**	**1,496,890**	**486,974**	**4,557,094**	**56.5**	**32.8**	**10.7**					**4,326,508**	**-230,586 (-5.1%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 6a. ***Average*** projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and in total biomass, in high-seas areas under RCP8.5 by 2050. Change in tonnes is also shown.

High-seas area	Reference biomass (tonnes)				Relative abundance (%)			% change in reference biomass under RCP8.5 in 2050				Biomass in 2050 (tonnes)	Change in biomass (tonnes)
	SKJ	YFT	BET	TOTAL	SKJ*	YFT*	BET*	SKJ	YFT	BET	TOTAL**		
I1	81,609	45,234	15,605	142,448	57.3	31.8	11.0	-34	-8	-3	-22.3	110,614	-31,834
I2	267,205	96,116	27,397	390,718	68.4	24.6	7.0	-33	-13	-6	-26.2	288,401	-102,317
I3	278,796	169,837	74,682	523,315	53.3	32.5	14.3	+29	+3	+2	+16.7	610,755	+ 87,440
I4	282,157	267,491	90,847	640,495	44.1	41.8	14.2	+3	-3	-4	-0.5	637,301	-3,194
I5	337,986	331,911	149,952	819,849	41.2	40.5	18.3	+26	+9	+2	+14.7	940,596	+ 120,747
I6	218,353	438,615	439,387	1,096,355	19.9	40.0	40.1	+4	+9	-3	+3.2	1,131,383	+35,028
I7	34,044	253,788	301,782	589,614	5.8	43.0	51.2	+10	+9	-2	+3.4	609,824	+20,210
I8	3,969	7,550	2,899	14,418	27.5	52.4	20.1	+23	0	-2	+5.9	15,273	+855
I9	3,487	5,917	3,201	12,605	27.7	46.9	25.4	+29	+18	+4	+17.5	14,809	+2,204
H4	50,735	19,144	6,161	76,040	66.7	25.2	8.1	-16	-6	-6	-12.7	66,404	- 9,636
H5	135,924	63,112	21,508	220,544	61.6	28.6	9.8	+8	-2	-2	+4.2	229,726	+ 9,182
EPO-N	209,308	325,252	211,984	746,544	28.0	43.6	28.4	+12	+20	+11	+15.2	860,030	+113,486
EPO-C	853,639	1,230,664	799,917	2,884,220	29.6	42.7	27.7	+32	+26	+10	+23.3	3,557,349	+673,129
EPO-S	18,127	91,127	217,864	327,118	5.5	27.9	66.6	+36	+41	+13	+22.1	399,328	+72,210
Total	**2,775,339**	**3,345,758**	**2,363,186**	**8,484,283**	**32.7**	**39.4**	**27.9**					**9,471,793**	**+987,510 (+11.6%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 6b. ***Maximum*** (i.e., maximum negative/minimum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and in total biomass, in high-seas areas under RCP8.5 by 2050. Change in tonnes is also shown.

High-seas area	Reference biomass (tonnes)				Relative abundance (%)			% change in reference biomass under RCP8.5 in 2050				Biomass in 2050 (tonnes)	Change in biomass (tonnes)
	SKJ	YFT	BET	TOTAL	SKJ*	YFT*	BET*	SKJ	YFT	BET	TOTAL**		
I1	81,609	45,234	15,605	142,448	57.3	31.8	11.0	-50	-12	-6	-33.1	95,279	-47,169
I2	267,205	96,116	27,397	390,718	68.4	24.6	7.0	-51	-16	-8	-39.4	236,873	-153,845
I3	278,796	169,837	74,682	523,315	53.3	32.5	14.3	+9	-1	0	+4.5	546,708	+23,393
I4	282,157	267,491	90,847	640,495	44.1	41.8	14.2	-7	-7	-6	-6.9	596,569	-43,926
I5	337,986	331,911	149,952	819,849	41.2	40.5	18.3	+13	+3	-2	+6.2	870,745	+50,896
I6	218,353	438,615	439,387	1,096,355	19.9	40.0	40.1	-10	+3	-6	-3.2	1,061,315	-35,040
I7	34,044	253,788	301,782	589,614	5.8	43.0	51.2	+1	+2	-6	-2.2	576,923	-12,691
I8	3,969	7,550	2,899	14,418	27.5	52.4	20.1	-7	-5	-4	-5.3	13,647	-771
I9	3,487	5,917	3,201	12,605	27.7	46.9	25.4	+19	+7	+1	+8.8	13,714	+1,109
H4	50,735	19,144	6,161	76,040	66.7	25.2	8.1	-26	-10	-7	-20.4	60,503	-15,537
H5	135,924	63,112	21,508	220,544	61.6	28.6	9.8	0	-6	-4	-2.1	215,897	-4,647
EPO-N	209,308	325,252	211,984	746,544	28.0	43.6	28.4	+2	+14	+6	+8.4	808,984	+62,440
EPO-C	853,639	1,230,664	799,917	2,884,220	29.6	42.7	27.7	+16	+17	+5	+13.4	3,270,011	+385,791
EPO-S	18,127	91,127	217,864	327,118	5.5	27.9	66.6	+23	+25	+6	+12.2	367,141	40,023
Total	**2,775,339**	**3,345,758**	**2,363,186**	**8,484,283**	**32.7**	**39.4**	**27.9**					**8,734,310**	**+250,027 (+2.9%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 6c. ***Minimum*** (i.e., minimum negative/maximum positive) projected percentage changes in biomass (relative to 2011−2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and in total biomass, in high-seas areas under RCP8.5 by 2050. Change in tonnes is also shown.

High-seas area	Reference biomass (tonnes)				Relative abundance (%)			% change in reference biomass under RCP8.5 in 2050				Biomass in 2050 (tonnes)	Change in biomass (tonnes)
	SKJ	YFT	BET	TOTAL	SKJ*	YFT*	BET*	SKJ	YFT	BET	TOTAL**		
I1	81,609	45,234	15,605	142,448	57.3	31.8	11.0	-15	-3	-1	-9.7	128,694	-13,754
I2	267,205	96,116	27,397	390,718	68.4	24.6	7.0	-17	-10	-5	-14.4	334,312	-56,406
I3	278,796	169,837	74,682	523,315	53.3	32.5	14.3	+47	+7	+5	28.0	669,972	+146,657
I4	282,157	267,491	90,847	640,495	44.1	41.8	14.2	+9	+3	-1	+5.1	673,005	+32,510
I5	337,986	331,911	149,952	819,849	41.2	40.5	18.3	+41	+20	+4	25.7	1,030,804	+210,955
I6	218,353	438,615	439,387	1,096,355	19.9	40.0	40.1	+16	+17	+1	+10.4	1,210,250	+ 113,895
I7	34,044	253,788	301,782	589,614	5.8	43.0	51.2	+30	+18	+6	+12.6	663,616	+74,002
I8	3,969	7,550	2,899	14,418	27.5	52.4	20.1	+48	+4	0	+15.3	16,625	+2,207
I9	3,487	5,917	3,201	12,605	27.7	46.9	25.4	+48	+27	+9	+28.2	16,164	+3,559
H4	50,735	19,144	6,161	76,040	66.7	25.2	8.1	-9	-4	-4	-7.3	70,462	-5,578
H5	135,924	63,112	21,508	220,544	61.6	28.6	9.8	+12	+1	-1	+7.6	237,271	+16,727
EPO-N	209,308	325,252	211,984	746,544	28.0	43.6	28.4	+19	+25	+18	+21.3	905,783	+159,239
EPO-C	853,639	1,230,664	799,917	2,884,220	29.6	42.7	27.7	+43	+35	+14	+31.5	3,794,006	+909,786
EPO-S	18,127	91,127	217,864	327,118	5.5	27.9	66.6	+48	+63	+24	+36.2	445,516	+ 118,398
Total	**2,775,339**	**3,345,758**	**2,363,186**	**8,484,283**	**32.7**	**39.4**	**27.9**					**10,196,479**	**+1,712,196 (+20.2%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 7a. *Average* projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of the 10 Pacific Small Island Developing States (Pacific SIDS) under RCP4.5 by 2050. Change in tonnes is also shown.

Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP4.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
Cook Islands	106,593	79,372	38,968	224,933	47.4	35.3	17.3	+9	+10	+4	+8.5	244,022	+19,089
FSM	341,280	299,670	97,815	738,765	46.2	40.6	13.2	-3	-2	+2	-1.9	724,490	- 4,276
Kiribati–Gilbert Is	336,009	134,529	35,998	506,536	66.3	26.6	7.1	+10	-5	-1	+5.2	533,050	+26,514
Kiribati–Phoenix Is	202,849	80,528	24,810	308,187	65.8	26.1	8.1	+8	0	+1	+5.3	324,663	+16,476
Kiribati–Line Is	250,078	141,321	57,758	449,157	55.7	31.5	12.9	+6	+12	+6	+7.9	484,586	+ 35,429
Marshall Islands	178,892	198,363	60,664	437,919	40.9	45.3	13.9	+3	-2	-1	+0.2	438,712	+793
Nauru	92,146	30,347	7,976	130,469	70.6	23.3	6.1	+9	-7	-2	+4.6	136,478	+6,009
Palau	62,544	58,943	22,194	143,681	43.5	41.0	15.4	+2	+5	+5	+3.7	148,989	+5,308
PNG	554,428	248,820	71,292	874,540	63.4	28.5	8.2	-19	-8	-4	-14.6	746,441	-128,099
Solomon Islands	267,111	138,747	40,297	446,155	59.9	31.1	9.0	-10	-5	-7	-8.2	409,686	-36,469
Tokelau	63,731	30,688	11,113	105,532	60.4	29.1	10.5	+6	+5	-1	+5.0	110,779	+5,247
Tuvalu	117,569	55,562	18,089	191,220	61.5	29.1	9.5	+4	0	-2	+2.3	195,561	+4,341
Total	**2,573,230**	**1,496,890**	**486,974**	**4,557,094**	**56.5**	**32.8**	**10.7**					**4,497,457**	**-59,637 (-1.3%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 7b. ***Maximum*** (i.e., maximum negative/minimum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of the 10 Pacific Small Island Developing States (Pacific SIDS) under RCP4.5 by 2050. Change in tonnes is also shown.

Pacific SIDS	Reference biomass (tonnes)				Relative abundance (%)			% change in reference biomass under RCP4.5 in 2050				Biomass in 2050 (tonnes)	Change in biomass (tonnes)
	SKJ	YFT	BET	TOTAL	SKJ*	YFT*	BET*	SKJ	YFT	BET	TOTAL**		
Cook Islands	106,593	79,372	38,968	224,933	47.4	35.3	17.3	-9	+3	+1	-3.0	218,110	-6,823
FSM	341,280	299,670	97,815	738,765	46.2	40.6	13.2	-11	-6	-3	-7.9	680,310	-58,455
Kiribati–Gilbert Is	336,009	134,529	35,998	506,536	66.3	26.6	7.1	-1	-8	-5	-3.1	490,614	-15,922
Kiribati–Phoenix Is	202,849	80,528	24,810	308,187	65.8	26.1	8.1	+2	-2	-3	0.6	309,889	+1,702
Kiribati–Line Is	250,078	141,321	57,758	449,157	55.7	31.5	12.9	-6	+7	+3	-0.8	445,778	-3,379
Marshall Islands	178,892	198,363	60,664	437,919	40.9	45.3	13.9	-6	-7	-6	-6.5	409,660	-28,259
Nauru	92,146	30,347	7,976	130,469	70.6	23.3	6.1	-3	-10	-6	-4.8	124,191	-6,278
Palau	62,544	58,943	22,194	143,681	43.5	41.0	15.4	-9	+3	+1	-2.5	140,042	-3,639
PNG	554,428	248,820	71,292	874,540	63.4	28.5	8.2	-29	-10	-8	-21.9	683,171	-191,369
Solomon Islands	267,111	138,747	40,297	446,155	59.9	31.1	9.0	-25	-8	-10	-18.4	364,248	-81,907
Tokelau	63,731	30,688	11,113	105,532	60.4	29.1	10.5	-11	0	-3	-7.0	98,188	-7,344
Tuvalu	117,569	55,562	18,089	191,220	61.5	29.1	9.5	-5	-4	-5	-4.7	182,215	-9,005
Total	**2,573,230**	**1,496,890**	**486,974**	**4,557,094**	**56.5**	**32.8**	**10.7**					**4,146,415**	**-410,679 (-9.0%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 7c. ***Minimum*** (i.e., minimum negative/maximum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of the 10 Pacific Small Island Developing States (Other Pacific SIDS) under RCP4.5 by 2050. Change in tonnes is also shown.

Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP4.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
Cook Islands	106,593	79,372	38,968	224,933	47.4	35.3	17.3	+27	+19	+9	+21.1	272,301	+47,368
FSM	341,280	299,670	97,815	738,765	46.2	40.6	13.2	+5	+2	+5	+3.8	766,713	+27,948
Kiribati–Gilbert Is	336,009	134,529	35,998	506,536	66.3	26.6	7.1	+21	-3	+2	+13.3	573,782	+67,246
Kiribati–Phoenix Is	202,849	80,528	24,810	308,187	65.8	26.1	8.1	+14	+3	+4	+10.3	339,994	+31,807
Kiribati–Line Is	250,078	141,321	57,758	449,157	55.7	31.5	12.9	+11	+16	+10	+12.4	505,053	+55,896
Marshall Islands	178,892	198,363	60,664	437,919	40.9	45.3	13.9	+14	0	+2	+6.0	464,177	+26,258
Nauru	92,146	30,347	7,976	130,469	70.6	23.3	6.1	+22	-2	0	+15.1	150,134	+19,665
Palau	62,544	58,943	22,194	143,681	43.5	41.0	15.4	+20	+8	+9	+13.4	162,903	+19,222
PNG	554,428	248,820	71,292	874,540	63.4	28.5	8.2	+2	-2	-1	+0.6	879,939	+5,399
Solomon Islands	267,111	138,747	40,297	446,155	59.9	31.1	9.0	+9	-2	-5	+4.3	465,405	+19,250
Tokelau	63,731	30,688	11,113	105,532	60.4	29.1	10.5	+33	+13	+4	+24.1	130,997	+25,465
Tuvalu	117,569	55,562	18,089	191,220	61.5	29.1	9.5	+22	+6	+2	+15.5	220,781	+29,561
Total	**2,573,230**	**1,496,890**	**486,974**	**4,557,094**	**56.5**	**32.8**	**10.7**					**4,932,179**	**+375,085 (+8.2%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 8a. *Average* projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and in total biomass, in high-seas areas under RCP4.5 by 2050. Change in tonnes is also shown.

High-seas area	Reference biomass (tonnes)				Relative abundance (%)			% change in reference biomass under RCP4.5 in 2050				Biomass in 2050 (tonnes)	Change in biomass (tonnes)
	SKJ	YFT	BET	TOTAL	SKJ*	YFT*	BET*	SKJ	YFT	BET	TOTAL**		
I1	81,609	45,234	15,605	142,448	57.3	31.8	11.0	-17	0	0	-9.7	128,574	-13,874
I2	267,205	96,116	27,397	390,718	68.4	24.6	7.0	-11	-7	-5	-9.6	353,227	-37,491
I3	278,796	169,837	74,682	523,315	53.3	32.5	14.3	+31	+6	+3	+18.9	622,172	+98,857
I4	282,157	267,491	90,847	640,495	44.1	41.8	14.2	+7	+4	0	+4.8	670,946	+30,451
I5	337,986	331,911	149,952	819,849	41.2	40.5	18.3	+13	+16	+7	+13.1	927,390	+107,541
I6	218,353	438,615	439,387	1,096,355	19.9	40.0	40.1	+10	+9	-1	+5.2	1,153,272	+56,917
I7	34,044	253,788	301,782	589,614	5.8	43.0	51.2	0	+8	0	+3.4	609,917	+20,303
I8	3,969	7,550	2,899	14,418	27.5	52.4	20.1	+28	+5	0	+10.3	15,907	+1,489
I9	3,487	5,917	3,201	12,605	27.7	46.9	25.4	+8	+14	+6	+10.3	13,904	+1,299
H4	50,735	19,144	6,161	76,040	66.7	25.2	8.1	+13	+1	0	+8.9	82,827	+6,787
H5	135,924	63,112	21,508	220,544	61.6	28.6	9.8	+4	+4	+3	+3.9	229,151	+8,607
EPO-N	209,308	325,252	211,984	746,544	28.0	43.6	28.4	+12	+17	+10	+13.6	848,152	+101,608
EPO-C	853,639	1,230,664	799,917	2,884,220	29.6	42.7	27.7	+17	+22	+14	+18.3	3,412,073	+527,853
EPO-S	18,127	91,127	217,864	327,118	5.5	27.9	66.6	+14	+18	+10	+12.5	367,845	+40,727
Total	**2,775,339**	**3,345,758**	**2,363,186**	**8,484,283**	**32.7**	**39.4**	**27.9**					**9,435,358**	**+951,075 (+11.2%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 8b. ***Maximum*** (i.e., maximum negative/minimum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and in total biomass, in high-seas areas under RCP4.5 by 2050. Change in tonnes is also shown.

High-seas area	Reference biomass (tonnes)				Relative abundance (%)			% change in reference biomass under RCP4.5 in 2050				Biomass in 2050 (tonnes)	Change in biomass (tonnes)
	SKJ	YFT	BET	TOTAL	SKJ*	YFT*	BET*	SKJ	YFT	BET	TOTAL**		
I1	81,609	45,234	15,605	142,448	57.3	31.8	11.0	-28	-2	-5	-17.2	117,913	-24,535
I2	267,205	96,116	27,397	390,718	68.4	24.6	7.0	-22	-10	-9	-18.1	319,856	-70,862
I3	278,796	169,837	74,682	523,315	53.3	32.5	14.3	+19	+4	-1	+11.3	582,333	+59,018
I4	282,157	267,491	90,847	640,495	44.1	41.8	14.2	0	-1	-5	-1.1	633,278	-7,217
I5	337,986	331,911	149,952	819,849	41.2	40.5	18.3	-2	+11	+1	+3.8	851,099	+31,250
I6	218,353	438,615	439,387	1,096,355	19.9	40.0	40.1	-3	+4	-6	-1.4	1,080,986	-15,369
I7	34,044	253,788	301,782	589,614	5.8	43.0	51.2	-9	+3	-6	-2.3	576,057	-13,557
I8	3,969	7,550	2,899	14,418	27.5	52.4	20.1	+2	+1	-4	+0.3	14,457	+39
I9	3,487	5,917	3,201	12,605	27.7	46.9	25.4	-7	+4	+2	+0.4	12,662	+57
H4	50,735	19,144	6,161	76,040	66.7	25.2	8.1	+4	-2	-4	+1.8	77,440	+1,400
H5	135,924	63,112	21,508	220,544	61.6	28.6	9.8	-1	+2	0	0.0	220,447	-97
EPO-N	209,308	325,252	211,984	746,544	28.0	43.6	28.4	+7	+10	+5	+7.7	804,320	+57,776
EPO-C	853,639	1,230,664	799,917	2,884,220	29.6	42.7	27.7	+3	+14	+7	+8.8	3,138,116	+ 253,896
EPO-S	18,127	91,127	217,864	327,118	5.5	27.9	66.6	+4	+5	+5	+4.9	343,293	+16,175
Total	**2,775,339**	**3,345,758**	**2,363,186**	**8,484,283**	**32.7**	**39.4**	**27.9**					**8,772,255**	**+287,972 (+3.4%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 8c. ***Minimum*** (i.e., minimum negative/maximum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and in total biomass, in high-seas areas under RCP4.5 by 2050. Change in tonnes is also shown.

High-seas area	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP4.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
I1	81,609	45,234	15,605	142,448	57.3	31.8	11.0	0	+3	+2	+1.2	144,117	+1,669
I2	267,205	96,116	27,397	390,718	68.4	24.6	7.0	0	-4	-2	-1.1	386,325	-4,393
I3	278,796	169,837	74,682	523,315	53.3	32.5	14.3	+51	+10	+7	+31.4	687,712	+164,397
I4	282,157	267,491	90,847	640,495	44.1	41.8	14.2	+13	+10	+3	+10.3	706,650	+66,155
I5	337,986	331,911	149,952	819,849	41.2	40.5	18.3	+25	+22	+10	+21.0	992,361	+172,512
I6	218,353	438,615	439,387	1,096,355	19.9	40.0	40.1	+18	+14	+1	+9.6	1,201,459	+105,104
I7	34,044	253,788	301,782	589,614	5.8	43.0	51.2	+15	+18	+8	+12.7	664,545	+74,931
I8	3,969	7,550	2,899	14,418	27.5	52.4	20.1	+56	+10	+3	+21.3	17,483	+3,065
I9	3,487	5,917	3,201	12,605	27.7	46.9	25.4	+25	+22	+11	+20.0	15,131	+2,526
H4	50,735	19,144	6,161	76,040	66.7	25.2	8.1	+18	+7	+4	+14.1	86,759	+10,719
H5	135,924	63,112	21,508	220,544	61.6	28.6	9.8	+8	+8	+7	+7.9	237,972	+17,428
EPO-N	209,308	325,252	211,984	746,544	28.0	43.6	28.4	+16	26	+16	+20.4	898,516	+151,972
EPO-C	853,639	1,230,664	799,917	2,884,220	29.6	42.7	27.7	+35	+36	+22	+31.8	3,802,014	+ 917,794
EPO-S	18,127	91,127	217,864	327,118	5.5	27.9	66.6	+27	+37	+19	+24.5	407,123	+80,005
Total	**2,775,339**	**3,345,758**	**2,363,186**	**8,484,283**	**32.7**	**39.4**	**27.9**					**10,248,168**	**+1,763,885 (+20.8%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 9a. ***Average*** projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of other Pacific Small Island Developing States (Other Pacific SIDS) under RCP8.5 by 2050. Change in tonnes is also shown.

Other Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP8.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL***		
American Samoa	10,291	21,262	9,239	40,792	25.2	52.1	22.6	+10	+10	+1	+8.0	44,040	+3,248
Fiji	22,430	50,460	22,257	95,147	23.6	53.0	23.4	+10	+2	-2	+3.0	97,954	+ 2,807
French Polynesia	109,222	127,431	85,269	321,922	33.9	39.6	26.5	+39	+22	+8	+24.1	399,375	+77,453
Guam	19,096	14,368	5,689	39,153	48.8	36.7	14.5	+17	-1	+2	+8.2	42,369	+ 3,216
New Caledonia	18,682	49,159	21,226	89,067	21.0	55.2	23.8	+13	-5	-4	-1.0	88,189	- 878
Niue	2,989	9,692	5,579	18,260	16.4	53.1	30.6	+11	+11	+3	+8.6	19,822	+1,562
Northern Mariana Is	61,047	37,202	19,499	117,748	51.8	31.6	16.6	+31	+7	+2	+18.6	139,667	+21,919
Pitcairn Islands	2,055	7,428	9,425	18,908	10.9	39.3	49.8	+29	+33	+12	+22.1	23,086	+4,178
Samoa	1,038	2,433	1,000	4,471	23.2	54.4	22.4	+9	+8	0	+6.4	4,759	+288
Tonga	8,420	24,704	13,283	46,407	18.1	53.2	28.6	+8	+6	0	+4.6	48,563	+ 2,156
Vanuatu	16,478	34,920	13,418	64,816	25.4	53.9	20.7	+23	-2	-2	+4.4	67,639	+ 2,823
Wallis Futuna	6,581	13,742	5,206	25,529	25.8	53.8	20.4	+2	+4	-1	+2.5	26,158	+629
Total	**278,329**	**392,801**	**211,090**	**882,220**	**31.5**	**44.5**	**23.9**					**1,001,621**	**+119,401 (13.5%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 9b. ***Maximum*** (i.e., maximum negative/minimum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of other Pacific Small Island Developing States (Other Pacific SIDS) under RCP8.5 by 2050. Change in tonnes is also shown.

Other Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP8.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
American Samoa	10,291	21,262	9,239	40,792	25.2	52.1	22.6	-3	+2	-2	-0.2	40,724	- 68
Fiji	22,430	50,460	22,257	95,147	23.6	53.0	23.4	-7	-5	-4	-5.2	90,164	-4,983
French Polynesia	109,222	127,431	85,269	321,922	33.9	39.6	26.5	+19	+11	+3	+11.6	359,250	+37,328
Guam	19,096	14,368	5,689	39,153	48.8	36.7	14.5	-2	-4	0	-2.4	38,196	-957
New Caledonia	18,682	49,159	21,226	89,067	21.0	55.2	23.8	-6	-9	-6	-7.7	82,248	-6,819
Niue	2,989	9,692	5,579	18,260	16.4	53.1	30.6	-1	+2	0	+0.9	18,424	+164
Northern Mariana Is	61,047	37,202	19,499	117,748	51.8	31.6	16.6	+12	+1	0	+6.5	125,446	+7,698
Pitcairn Islands	2,055	7,428	9,425	18,908	10.9	39.3	49.8	+21	+17	+7	+12.5	21,262	+2,354
Samoa	1,038	2,433	1,000	4,471	23.2	54.4	22.4	-3	0	-3	-1.4	4,410	- 61
Tonga	8,420	24,704	13,283	46,407	18.1	53.2	28.6	-4	-1	-3	-2.1	45,425	-982
Vanuatu	16,478	34,920	13,418	64,816	25.4	53.9	20.7	-5	-7	-4	-5.9	61,011	-3,805
Wallis Futuna	6,581	13,742	5,206	25,529	25.8	53.8	20.4	-8	-2	-4	-4.0	24,519	- 1,010
Total	**278,329**	**392,801**	**211,090**	**882,220**	**31.5**	**44.5**	**23.9**					**911,078**	**+28,858 (3.3%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 9c. ***Minimum*** (i.e., minimum negative/maximum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of other Pacific Small Island Developing States (Other Pacific SIDS) under RCP8.5 by 2050. Change in tonnes is also shown.

Other Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP8.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
American Samoa	10,291	21,262	9,239	40,792	25.2	52.1	22.6	+26	+16	+6	+16.3	47,424	+6,632
Fiji	22,430	50,460	22,257	95,147	23.6	53.0	23.4	+28	+6	+1	+10.0	104,678	+9,531
French Polynesia	109,222	127,431	85,269	321,922	33.9	39.6	26.5	+58	+31	+13	+35.4	435,859	+113,937
Guam	19,096	14,368	5,689	39,153	48.8	36.7	14.5	+45	+2	+6	+23.6	48,375	+9,222
New Caledonia	18,682	49,159	21,226	89,067	21.0	55.2	23.8	+42	-3	-2	+6.7	95,014	+5,947
Niue	2,989	9,692	5,579	18,260	16.4	53.1	30.6	+24	+18	+7	+15.6	21,112	+2,852
Northern Mariana Is	61,047	37,202	19,499	117,748	51.8	31.6	16.6	+51	+13	+4	+31.2	154,498	+36,750
Pitcairn Islands	2,055	7,428	9,425	18,908	10.9	39.3	49.8	+41	+44	+22	+32.7	25,092	+6,184
Samoa	1,038	2,433	1,000	4,471	23.2	54.4	22.4	+23	+14	+5	+14.1	5,100	+629
Tonga	8,420	24,704	13,283	46,407	18.1	53.2	28.6	+23	+12	+4	+11.7	51,839	+5,432
Vanuatu	16,478	34,920	13,418	64,816	25.4	53.9	20.7	+50	0	0	+12.7	73,055	+8,239
Wallis Futuna	6,581	13,742	5,206	25,529	25.8	53.8	20.4	+19	+10	+2	+10.7	28,258	+ 2,729
Total	**278,329**	**392,801**	**211,090**	**882,220**	**31.5**	**44.5**	**23.9**					**1,090,305**	**+208,085 (+23.6%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 10a. ***Average*** projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in exclusive economic zones of other Pacific Small Island Developing States (Other Pacific SIDS) under RCP4.5 by 2050. Change in tonnes is also shown.

Other Pacific SIDS	Reference biomass (tonnes)				Relative abundance (%)			% change in reference biomass under RCP4.5 in 2050				Biomass in 2050 (tonnes)	Change in biomass (tonnes)
	SKJ	YFT	BET	TOTAL	SKJ*	YFT*	BET*	SKJ	YFT	BET	TOTAL**		
American Samoa	10,291	21,262	9,239	40,792	25.2	52.1	22.6	-9	+9	+1	+2.6	41,872	+1,080
Fiji	22,430	50,460	22,257	95,147	23.6	53.0	23.4	+20	+7	+1	+8.7	103,388	+ 8,241
French Polynesia	109,222	127,431	85,269	321,922	33.9	39.6	26.5	+6	+17	+10	+11.4	358,665	36,743
Guam	19,096	14,368	5,689	39,153	48.8	36.7	14.5	+29	+3	+4	+15.8	45,349	+ 6,196
New Caledonia	18,682	49,159	21,226	89,067	21.0	55.2	23.8	+9	0	-3	+1.2	90,112	+1,045
Niue	2,989	9,692	5,579	18,260	16.4	53.1	30.6	+2	+12	+3	+7.6	19,650	+ 1,390
Northern Mariana Is	61,047	37,202	19,499	117,748	51.8	31.6	16.6	+21	+8	+2	+13.7	133,934	+16,186
Pitcairn Islands	2,055	7,428	9,425	18,908	10.9	39.3	49.8	-10	+16	+11	+10.7	20,928	+ 2,020
Samoa	1,038	2,433	1,000	4,471	23.2	54.4	22.4	-5	+9	0	+3.7	4,638	+167
Tonga	8,420	24,704	13,283	46,407	18.1	53.2	28.6	+11	+10	+2	+7.9	50,069	+3,662
Vanuatu	16,478	34,920	13,418	64,816	25.4	53.9	20.7	+17	+3	-1	+5.7	68,531	+3,715
Wallis Futuna	6,581	13,742	5,206	25,529	25.8	53.8	20.4	-3	+7	-1	+2.8	26,241	+712
Total	**278,329**	**392,801**	**211,090**	**882,220**	**31.5**	**44.5**	**23.9**					**963,377**	**+81,157 (+9.2%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 10b. ***Maximum*** (i.e., maximum negative/minimum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of other Pacific Small Island Developing States (Other Pacific SIDS) under RCP4.5 by 2050. Change in tonnes is also shown.

Other Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP4.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
American Samoa	10,291	21,262	9,239	40,792	25.2	52.1	22.6	-20	+2	-2	-4.5	38,974	-1,818
Fiji	22,430	50,460	22,257	95,147	23.6	53.0	23.4	0	+2	-2	+0.6	95,711	+564
French Polynesia	109,222	127,431	85,269	321,922	33.9	39.6	26.5	-12	+7	+6	+0.3	322,852	+930
Guam	19,096	14,368	5,689	39,153	48.8	36.7	14.5	+13	+1	+1	+6.9	41,836	+2,683
New Caledonia	18,682	49,159	21,226	89,067	21.0	55.2	23.8	-4	-3	-5	-3.7	85,784	-3,283
Niue	2,989	9,692	5,579	18,260	16.4	53.1	30.6	-8	+4	0	+0.8	18,409	+149
Northern Mariana Is	61,047	37,202	19,499	117,748	51.8	31.6	16.6	+6	+5	-2	+4.4	122,881	+5,133
Pitcairn Islands	2,055	7,428	9,425	18,908	10.9	39.3	49.8	-18	+3	+6	_2.2	19,326	+418
Samoa	1,038	2,433	1,000	4,471	23.2	54.4	22.4	-14	+2	-3	-2.8	4,344	-127
Tonga	8,420	24,704	13,283	46,407	18.1	53.2	28.6	-2	+4	-2	+1.2	46,961	+554
Vanuatu	16,478	34,920	13,418	64,816	25.4	53.9	20.7	-2	-1	-4	-1.9	63,601	-1,215
Wallis Futuna	6,581	13,742	5,206	25,529	25.8	53.8	20.4	-13	+1	-4	-3.6	24,603	-926
Total	**278,329**	**392,801**	**211,090**	**882,220**	**31.5**	**44.5**	**23.9**					**885,281**	**+3,061 (+0.3%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 10c. ***Minimum*** (i.e., minimum negative/maximum positive) projected percentage changes in biomass (relative to 2011–2020) of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna, and total biomass, in the exclusive economic zones of other Pacific Small Island Developing States (Other Pacific SIDS) under RCP4.5 by 2050. Change in tonnes is also shown.

Other Pacific SIDS	**Reference biomass (tonnes)**				**Relative abundance (%)**			**% change in reference biomass under RCP4.5 in 2050**				**Biomass in 2050 (tonnes)**	**Change in biomass (tonnes)**
	SKJ	**YFT**	**BET**	**TOTAL**	**SKJ***	**YFT***	**BET***	**SKJ**	**YFT**	**BET**	**TOTAL****		
American Samoa	10,291	21,262	9,239	40,792	25.2	52.1	22.6	+11	+18	+6	+13.5	46,306	+5,514
Fiji	22,430	50,460	22,257	95,147	23.6	53.0	23.4	+43	+13	+5	+18.2	112,465	+17,318
French Polynesia	109,222	127,431	85,269	321,922	33.9	39.6	26.5	+17	+27	+16	+20.7	388,539	+ 66,617
Guam	19,096	14,368	5,689	39,153	48.8	36.7	14.5	+45	+6	+8	+25.3	49,063	+ 9,910
New Caledonia	18,682	49,159	21,226	89,067	21.0	55.2	23.8	+29	+3	0	+7.7	95,960	+6,893
Niue	2,989	9,692	5,579	18,260	16.4	53.1	30.6	+16	+19	+8	+15.1	21,026	+2,766
Northern Mariana Is	61,047	37,202	19,499	117,748	51.8	31.6	16.6	+39	+11	+5	+24.5	146,624	+28,876
Pitcairn Islands	2,055	7,428	9,425	18,908	10.9	39.3	49.8	0	+30	+20	+21.8	23,021	+4,113
Samoa	1,038	2,433	1,000	4,471	23.2	54.4	22.4	+12	+17	+5	+13.2	5,059	+588
Tonga	8,420	24,704	13,283	46,407	18.1	53.2	28.6	+29	+17	+6	+16.0	53,845	+7,438
Vanuatu	16,478	34,920	13,418	64,816	25.4	53.9	20.7	+41	+7	+3	+14.8	74,419	+9,603
Wallis Futuna	6,581	13,742	5,206	25,529	25.8	53.8	20.4	+14	+15	+4	+12.5	28,720	+3,191
Total	**278,329**	**392,801**	**211,090**	**882,220**	**31.5**	**44.5**	**23.9**					**1,045,047**	**+162,827 (+18.5%)**

* Rounded to one decimal place; ** weighted average of projected changes in reference biomass for SKJ, YFT and BET

Supplementary Table 11a. Projected ***average*** changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the exclusive economic zones (EEZs) of 10 Pacific Island Small Developing States by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 17a. Changes in the total catch from all EEZs for each species, and for all species from all EEZs, are also shown. All values except 'Change (%)' for totals for EEZs and for all species combined are rounded to nearest whole number.

Species	**Catch**	**EEZ**												**Total**
		Cook Islands	**FSM**	**Kiribati**			**Marshall Islands**	**Nauru**	**Palau**	**PNG**	**Solomon Islands**	**Tokelau**	**Tuvalu**	
				Gilbert	**Phoenix**	**Line**								
SKJ	Average catch	9,513	144,272	203,548	79,976	32,089	29,990	86,174	1,681	318,229	84,637	19,037	63,863	**1,073,008**
	2050 catch	8,942	124,074	175,051	78,376	36,581	30,289	65,492	1,681	184,573	57,553	15,610	47,259	**825,482**
	Change (t)	-571	-20,198	-28,497	-1,600	+4,492	+ 300	-20,682	0	-133,656	-27,084	-3,427	-16,604	**-247,526**
	Change (%)	-6	-14	-14	-2	+14	+1	-24	0	-42	-32	-18	-26	**-23.1**
YFT	Average catch	1,107	29,317	45,981	11,051	5,667	5,435	19,952	942	130,049	29,178	1,661	6,944	**287,285**
	2050 catch	1,229	26,386	40,003	10,277	6,064	4,891	16,959	932	111,842	25,969	1,678	6,597	**252,827**
	Change (t)	+122	-2,932	-5,978	-774	+397	-543	-2,993	-9	-18,207	-3,210	+17	-347	**-34,457**
	Change (%)	+11	-10	-13	-7	+7	-10	-15	-1	-14	-11	1	-5	**-12.0**
BET	Average catch	460	4,998	10,544	3,670	3,523	1,578	4,667	33	12,754	3,061	693	2,273	**48,256**
	2050 catch	469	4,948	10,123	3,486	3,558	1,547	4,434	33	11,989	2,877	666	2,137	**46,267**
	Change (t)	+9	-50	-422	-183	+35	-32	-233	0	-765	-184	-28	-136	**-1,988**
	Change (%)	+2	-1	-4	-5	+1	-2	-5	+1	-6	-6	-4	-6	**-4.1**
All species combined	**Average catch**	**11,080**	**178,587**	**260,073**	**94,696**	**41,279**	**37,003**	**110,794**	**2,655**	**461,032**	**116,877**	**21,392**	**73,080**	**1,408,548**
	2050 catch	**10,640**	**155,407**	**225,177**	**92,140**	**46,203**	**36,728**	**86,886**	**2,646**	**308,404**	**86,399**	**17,954**	**55,992**	**1,124,577**
	Change (t)	**-440**	**-23,180**	**-34,896**	**-2,557**	**+4,924**	**-275**	**-23,908**	**-9**	**-152,628**	**-30,477**	**-3,438**	**-17,088**	**-283,971**
	Change (%)	**-4.0**	**-13.0**	**-13.4**	**-2.7**	**+11.9**	**-0.7**	**-21.6**	**-0.3**	**-33.1**	**-26.1**	**-16.1**	**-23.4**	**-20.2**

Supplementary Table 11b. Projected ***maximum*** (i.e., maximum negative/minimum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the exclusive economic zones (EEZs) of 10 Pacific Island Small Developing States by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 17b. Changes in the total catch from all EEZs for each species, and for all species from all EEZs, are also shown. All values except 'Change (%)' for totals for EEZs and for all species combined are rounded to nearest whole number.

Species	Catch	EEZ												Total
		Cook Islands	FSM	Kiribati			Marshall Islands	Nauru	Palau	PNG	Solomon Islands	Tokelau	Tuvalu	
				Gilbert	Phoenix	Line								
SKJ	Average catch	9,513	144,272	203,548	79,976	32,089	29,990	86,174	1,681	318,229	84,637	19,037	63,863	**1,073,008**
	2050 catch	8,562	109,647	144,519	69,579	34,977	27,590	49,119	1,479	146,385	45,704	14,849	41,511	**693,921**
	Change (t)	-951	-34,625	-59,029	-10,397	+2,888	-2,399	-37,055	-202	-171,844	-38,933	-4,188	-22,352	**-379,087**
	Change (%)	-10	-24	-29	-13	+9	-8	-43	-12	-54	-46	-22	-35	**-35.3**
YFT	Average catch	1,107	29,317	45,981	11,051	5,667	5,435	19,952	942	130,049	29,178	1,661	6,944	**287,285**
	2050 catch	1,140	25,506	39,084	10,056	5,781	4,728	16,161	894	104,039	25,385	1,578	6,319	**240,673**
	Change (t)	+33	-3,811	-6,897	-995	+113	-707	-3,791	-47	-26,010	-3,793	-83	-625	**-46,612**
	Change (%)	+3	-13	-15	-9	+2	-13	-19	-5	-20	-13	-5	-9	**-16.2**
BET	Average catch	460	4,998	10,544	3,670	3,523	1,578	4,667	33	12,754	3,061	693	2,273	**48,256**
	2050 catch	455	4,798	10,017	3,450	3,488	1,484	4,434	33	11,861	2,816	645	2,091	**45,572**
	Change (t)	-5	-200	-527	-220	-35	-95	-233	0	-893	-245	-49	-182	**-2,684**
	Change (%)	-1	-4	-5	-6	-1	-6	-5	-1	-7	-8	-7	-8	**-5.6**
All species combined	**Average catch**	**11,080**	**178,587**	**260,073**	**94,696**	**41,279**	**37,003**	**110,794**	**2,655**	**461,032**	**116,877**	**21,392**	**73,080**	**1,408,548**
	2050 catch	**10,157**	**139,951**	**193,620**	**83,085**	**44,245**	**33,802**	**69,714**	**2,406**	**262,286**	**73,905**	**17,072**	**49,922**	**980,165**
	Change (t)	**-923**	**-38,636**	**-66,453**	**-11,612**	**+2,966**	**-3,200**	**-41,079**	**-249**	**-198,746**	**-42,971**	**-4,320**	**-23,159**	**-428,383**
	Change (%)	**-8.3**	**-21.6**	**-25.6**	**-12.3**	**+7.2**	**-8.6**	**-37.1**	**-9.4**	**-43.1**	**-36.8**	**-20.2**	**-31.7**	**-30.4**

Supplementary Table 11c. Projected ***minimum*** (i.e., minimum negative/maximum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the exclusive economic zones (EEZs) of 10 Pacific Island Small Developing States by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 17c. Changes in the total catch from all EEZs for each species, and for all species from all EEZs, are also shown. All values except 'Change (%)' for totals for EEZs and for all species combined are rounded to nearest whole number.

Species	Catch	EEZ												Total
		Cook Islands	FSM	Kiribati			Marshall Islands	Nauru	Palau	PNG	Solomon Islands	Tokelau	Tuvalu	
				Gilbert	Phoenix	Line								
SKJ	Average catch	9,513	144,272	203,548	79,976	32,089	29,990	86,174	1,681	318,229	84,637	19,037	63,863	**1,073,008**
	2050 catch	9,418	137,058	201,513	83,974	38,506	32,389	81,865	2,000	229,125	66,863	17,895	53,645	**954,252**
	Change (t)	-95	-7,214	-2,035	+3,999	+6,418	+ 2,399	-4,309	+319	-89,104	-17,774	-1,142	-10,218	**-118,756**
	Change (%)	-1	-5	-1	+5	+20	+8	-5	19	-28	-21	-6	-16	**-11.1**
YFT	Average catch	1,107	29,317	45,981	11,051	5,667	5,435	19,952	942	130,049	29,178	1,661	6,944	**287,285**
	2050 catch	1,306	27,265	41,383	10,498	6,404	5,000	17,757	951	118,344	26,844	1,761	6,805	**264,320**
	Change (t)	+199	-2,052	-4,598	-553	+737	-435	-2,195	+9	-11,704	-2,334	+100	-139	**-22,965**
	Change (%)	+18	-7	-10	-5	+13	-8	-11	+1	-9	-8	6	-2	**-8.0**
BET	Average catch	460	4,998	10,544	3,670	3,523	1,578	4,667	33	12,754	3,061	693	2,273	**48,256**
	2050 catch	492	5,148	10,228	3,523	3,629	1,594	4,481	35	12,116	2,908	686	2,182	**47,022**
	Change (t)	+32	+150	-316	-147	+106	+16	-187	+2	-638	-153	-7	-91	**-1,233**
	Change (%)	+7	+3	-3	-4	+3	+1	-4	+5	-5	-5	-1	-4	**-2.6**
All species combined	**Average catch**	**11,080**	**178,587**	**260,073**	**94,696**	**41,279**	**37,003**	**110,794**	**2,655**	**461,032**	**116,877**	**21,392**	**73,080**	**1,408,548**
	2050 catch	**11,216**	**169,471**	**253,123**	**97,996**	**48,539**	**38,983**	**104,103**	**2,986**	**359,586**	**96,615**	**20,342**	**62,633**	**1,265,594**
	Change (t)	**+136**	**-9,116**	**-6,950**	**+3,299**	**+7,260**	**+1,980**	**-6,690**	**+330**	**-101,446**	**-20,261**	**-1,049**	**-10,448**	**-142,954**
	Change (%)	**+1.2**	**-5.1**	**-2.7**	**+3.5**	**+17.6**	**+5.4**	**-6.0**	**+12.4**	**-22.0**	**-17.3**	**-4.9**	**-14.3**	**-10.1**

Supplementary Table 12a. Projected ***average*** changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the high-seas areas (Supplementary Figure 1) by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 17a. Changes in the total catch from all high-seas areas for each species, and for all species from all high-seas areas, are also shown.

Species	**Catch**	**High-seas area**														**Total**
		I1	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**H4**	**H5**	**EPO-N**	**EPO-C**	**EPO-S**	
SKJ	Average catch	10,528	18,630	45	16,516	16,994	15,459	13	2	24	18,431	39,150	7,072	254,602	2,031	**399,495**
	2050 catch	6,948	12,482	58	17,011	21,412	16,078	14	2	31	15,482	42,281	7,921	336,075	2,763	**478,558**
	Change (t)	-3,580	-6,148	+ 13	+ 495	+4,418	+618	+1	0	+7	-2,949	+3,132	+849	+ 81,473	+731	**+79,062**
	Change (%)	-34	-33	+29	+3	+26	+4	+10	+23	+29	-16	+8	+12	+32	+36	**+19.8**
YFT	Average catch	4,215	3,647	1	3,199	3,530	507	3	1	6	1,936	5,542	77,092	147,743	540	**247,960**
	2050 catch	3,878	3,172	1	3,103	3,848	552	3	1	7	1,820	5,431	92,510	186,156	761	**301,243**
	Change (t)	-337	-474	0	-96	+318	+46	0	0	+ 1	-116	-111	+15,418	+38,413	+221	**+53,283**
	Change (%)	-8	-13	+3	-3	+9	+9	+9	0	+18	-6	-2	+20	+26	+41	**+ 21.5**
BET	Average catch	588	807	1	1,728	2,707	245	1	0	3	526	1,826	11	55,319	722	**64,483**
	2050 catch	570	758	1	1,659	2,761	238	1	0	3	494	1,789	13	60,851	816	**69,954**
	Change (t)	-18	-48	0	-69	+54	-7	0	0	0	-32	-37	+1	+ 5,532	+ 94	**+5,471**
	Change (%)	-3	-6	+2	-4	+2	-3	-2	-2	+4	-6	-2	+11	+10	+13	**+8.5**
All species combined	**Average catch**	**15,330**	**23,083**	**47**	**21,443**	**23,231**	**16,211**	**17**	**2.2**	**33**	**20,893**	**46,517**	**84,175**	**457,664**	**3,293**	**711,939**
	2050 catch	**11,396**	**16,413**	**60**	**21,773**	**28,021**	**16,868**	**18**	**2.5**	**41**	**17,796**	**49,502**	**100,443**	**583,082**	**4,339**	**849,755**
	Change (t)	**-3,934**	**-6,670**	**+13**	**+ 330**	**+4,790**	**+657**	**+ 1**	**+ 0.3**	**+8**	**-3,097**	**+2,985**	**+16,268**	**+125,418**	**+1,046**	**+137,816**
	Change (%)	**-25.7**	**-28.9**	**+27.8**	**+1.5**	**+20.6**	**+4.1**	**+9.0**	**15.5**	**+24.7**	**-14.8**	**+6.4**	**+19.3**	**+27.4**	**+31.8**	**+19.4**

All values except 'Change (%)' for totals for high-seas areas and for all species combined are rounded to nearest whole number.

Supplementary Table 12b. Projected ***maximum*** (i.e., maximum negative, minimum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the high-seas areas (Supplementary Figure 1) by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 17b. Changes in the total catch from all high-seas areas for each species, and for all species from all high-seas areas, are also shown. All values except 'Change (%)' for totals for high-seas areas and for all species combined are rounded to nearest whole number.

Species	**Catch**	**High-seas area**														**Total**
		I1	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**H4**	**H5**	**EPO-N**	**EPO-C**	**EPO-S**	
SKJ	Average catch	10,528	18,630	45	16,516	16,994	15,459	13	2	24	18,431	39,150	7,072	254,602	2,031	**399,495**
	2050 catch	5,264	9,129	49	15,360	19,203	13,913	13	1	29	13,639	39,150	7,213	295,338	2,499	**420,799**
	Change (t)	-5,264	-9,501	+4	-1,156	+2,209	-1,546	0	0	+5	-4,792	0	+141	+40,736	+467	**+21,304**
	Change (%)	-50	-51	+9	-7	+13	-10	+1	-7	+19	-26	0	+2	+16	+23	**+5.3**
YFT	Average catch	4,215	3,647	1	3,199	3,530	507	3	1	6	1,936	5,542	77,092	147,743	540	**247,960**
	2050 catch	3,709	3,063	1	2,975	3,636	522	3	0	7	1,742	5,210	87,885	172,859	674	**282,286**
	Change (t)	-506	-583	0	-224	+106	+15	0	0	+1	-194	-333	+10,793	+25,116	+135	**+34,326**
	Change (%)	-12	-16	-1	-7	+3	+3	+2	-5	+7	-10	-6	+14	+17	+25	**+13.8**
BET	Average catch	588	807	1	1,728	2,707	245	1	0	3	526	1,826	11	55,319	722	**64,483**
	2050 catch	552	742	1	1,624	2,653	230	1	0	3	489	1,753	12	58,085	765	**66,911**
	Change (t)	-35	-65	0	-104	-54	-15	0	0	0	-37	-73	+1	+2,766	+43	**+2,428**
	Change (%)	-6	-8	0	-6	-2	-6	-6	-4	+1	-7	-4	+6	+5	+6	**+3.8**
All species combined	**Average catch**	**15,330**	**23,083**	**47**	**21,443**	**23,231**	**16,211**	**17**	**2.2**	**33**	**20,893**	**46,517**	**84,175**	**457,664**	**3,293**	**711,939**
	2050 catch	**9,525**	**12,934**	**51**	**19,959**	**25,492**	**14,666**	**17**	**2.1**	**38**	**15,870**	**46,112**	**95,110**	**526,283**	**3,938**	**769,996**
	Change (t)	**-5,805**	**10,149**	**+4**	**-1,484**	**+ 2,261**	**-1,545**	**0**	**-0.1**	**+ 5**	**-5,022**	**-406**	**+10,935**	**+68,619**	**+645**	**+58,058**
	Change (%)	**-37.9**	**-44.0**	**+ 8.6**	**-6.9**	**+ 9.7**	**-9.5**	**0**	**-6.3**	**+15.1**	**-24.0**	**-0.9**	**+13.0**	**+15.0**	**+19.6**	**+8.2**

Supplementary Table 12c. Projected ***minimum*** (i.e., minimum negative/maximum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the high-seas areas (Supplementary Figure 1) by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 17c. Changes in the total catch from all high-seas areas for each species, and for all species from all high-seas areas, are also shown. All values except 'Change (%)' for totals for high-seas areas and for all species combined are rounded to nearest whole number.

Species	Catch	High-seas area														Total
		I1	I2	I3	I4	I5	I6	I7	I8	I9	H4	H5	EPO-N	EPO-C	EPO-S	
SKJ	Average catch	10,528	18,630	45	16,516	16,994	15,459	13	2	24	18,431	39,150	7,072	254,602	2,031	**399,495**
	2050 catch	8,949	15,463	66	18,002	23,961	17,933	17	2	36	16,772	43,847	8,416	364,081	3,006	**520,551**
	Change (t)	-1,579	-3,167	+21	+1,486	+ 6,967	+2,473	+ 4	0	+12	-1,659	+4,698	+1,344	+109,479	+975	**+121,055**
	Change (%)	-15	-17	+47	+9	+41	+16	+30	+48	+48	-9	+12	+19	+43	+48	**+30.3**
YFT	Average catch	4,215	3,647	1	3,199	3,530	507	3	1	6	1,936	5,542	77,092	147,743	540	**247,960**
	2050 catch	4,088	3,282	1	3,295	4,236	593	3	1	8	1,859	5,598	96,365	199,453	879	**319,660**
	Change (t)	-126	-365	0	+ 96	+706	+86	0	0	+2	-77	+55	+19,273	+51,710	+340	**+71,700**
	Change (%)	-3	-10	+7	+3	+20	+17	+18	+4	+27	-4	+1	+25	+35	+63	**+28.9**
BET	Average catch	588	807	1	1,728	2,707	245	1	0	3	526	1,826	11	55,319	722	**64,483**
	2050 catch	582	766	1	1,711	2,815	248	1	0	3	505	1,807	13	63,064	895	**72,411**
	Change (t)	-6	-40	0	-17	+108	+2	0	0	0	-21	-18	+2	+7,745	+173	**+7,928**
	Change (%)	-1	-5	+5	-1	+4	+1	+6	0	+9	-4	-1	+18	+14	+24	**+12.3**
All species combined	**Average catch**	**15,330**	**23,083**	**47**	**21,443**	**23,231**	**16,211**	**17**	**2**	**33**	**20,893**	**46,517**	**84,175**	**457,664**	**3,293**	**711,939**
	2050 catch	**13,619**	**19,511**	**69**	**23,008**	**31,012**	**18,773**	**21**	**3**	**47**	**19,135**	**51,252**	**104,794**	**626,598**	**4,781**	**912,622**
	Change (t)	**-1,712**	**-3,572**	**+21**	**+1,565**	**+7,782**	**+2,562**	**+ 4**	**+ 1**	**+13**	**-1,757**	**+4,735**	**+20,619**	**+168,934**	**+1,488**	**+200,684**
	Change (%)	**-11.2**	**-15.5**	**+45.2**	**+7.3**	**+33.5**	**+15.8**	**+26.3**	**+33.6**	**+40.6**	**-8.4**	**+10.2**	**+24.5**	**+36.9**	**+45.2**	**+28.2**

Supplementary Table 13a. Projected ***average*** changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the exclusive economic zones (EEZs) of 10 Pacific Island Small Developing States by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18a. Changes in the total catch from all EEZs for each species, and for all species from all EEZs, are also shown. All values except 'Change (%)' for totals for EEZs and for all species combined are rounded to nearest whole number.

Species	**Catch**	**EEZ**												**Total**
		Cook Islands	**FSM**	**Kiribati**			**Marshall Islands**	**Nauru**	**Palau**	**PNG**	**Solomon Islands**	**Tokelau**	**Tuvalu**	
				Gilbert	**Phoenix**	**Line**								
SKJ	Average catch	9,513	144,272	203,548	79,976	32,089	29,990	86,174	1,681	318,229	84,637	19,037	63,863	**1,073,009**
	2050 catch	10,369	139,944	223,903	86,374	34,014	30,889	93,930	1,714	257,766	76,174	20,179	66,418	**1,041,673**
	Change (t)	+856	-4,328	+20,355	+6,398	+ 1,925	+ 900	+7,756	+34	-60,464	-8,464	+1,142	+2,555	**-31,335**
	Change (%)	+9	-3	+10	+8	+6	+3	+9	+2	-19	-10	+6	+4	**-2.9**
YFT	Average catch	1,107	29,317	45,981	11,051	5,667	5,435	19,952	942	130,049	29,178	1,661	6,944	**287,284**
	2050 catch	1,218	28,731	43,682	11,051	6,347	5,326	18,555	989	119,645	27,719	1,745	6,944	**271,952**
	Change (t)	+ 111	-586	-2,299	0	+680	-109	-1,397	+ 47	-10,404	-1,459	+83	0	**-15,333**
	Change (%)	+10	-2	-5	0	+12	-2	-7	+5	-8	-5	+5	0	**-5.3**
BET	Average catch	460	4,998	10,544	3,670	3,523	1,578	4,667	33	12,754	3,061	693	2,273	**48,256**
	2050 catch	478	5,098	10,439	3,707	3,734	1,563	4,574	35	12,244	2,847	686	2,228	**47,632**
	Change (t)	+18	+100	-105	+37	+211	-16	-93	+2	-510	-214	-7	-45	**-623**
	Change (%)	+4	+2	-1	+1	+6	-1	-2	+5	-4	-7	-1	-2	**-4.0**
All species combined	**Average catch**	**11,080**	**178,587**	**260,073**	**94,697**	**41,279**	**37,003**	**110,794**	**2,655**	**461,032**	**116,877**	**21,392**	**73,080**	**1,408,549**
	2050 catch	**12,065**	**173,773**	**278,023**	**101,132**	**44,096**	**37,778**	**117,059**	**2,738**	**389,654**	**106,740**	**22,610**	**75,589**	**1,361,257**
	Change (t)	**+985**	**-4,815**	**+17,950**	**+ 6,435**	**+2,817**	**+775**	**+ 6,266**	**+ 82**	**-71,378**	**-10,137**	**+1,218**	**+2,509**	**-47,291**
	Change (%)	**+8.9**	**-2.7**	**+6.9**	**+ 6.8**	**+ 6.8**	**+2.1**	**+ 5.7**	**+3.1**	**-15.5**	**-8.7**	**+5.7**	**+ 3.4**	**-3.4**

Supplementary Table 13b. Projected ***maximum*** (i.e., maximum negative, minimum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the exclusive economic zones (EEZs) of 10 Pacific Island Small Developing States by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18b. Changes in the total catch from all EEZs for each species, and for all species from all EEZs, are also shown. All values except 'Change (%)' for totals for EEZs and for all species combined are rounded to nearest whole number.

Species	Catch	EEZ												Total
		Cook Islands	FSM	Kiribati			Marshall Islands	Nauru	Palau	PNG	Solomon Islands	Tokelau	Tuvalu	
				Gilbert	Phoenix	Line								
SKJ	Average catch	9,513	144,272	203,548	79,976	32,089	29,990	86,174	1,681	318,229	84,637	19,037	63,863	**1,073,009**
	2050 catch	8,657	128,402	201,513	81,576	30,164	28,190	83,589	1,529	225,943	63,478	16,943	60,670	**930,652**
	Change (t)	-856	-15,870	-2,035	+1,600	-1,925	-1,799	-2,585	-151	-92,286	-21,159	-2,094	-3,193	**-142,356**
	Change (%)	-9	-11	-1	+2	-6	-6	-3	-9	-29	-25	-11	-5	**-13.3**
YFT	Average catch	1,107	29,317	45,981	11,051	5,667	5,435	19,952	942	130,049	29,178	1,661	6,944	**287,284**
	2050 catch	1,140	27,558	42,303	10,830	6,064	5,054	17,957	970	117,044	26,844	1,661	6,666	**264,091**
	Change (t)	+33	-1,759	-3,678	-221	+397	-380	-1,995	+28	-13,005	-2,334	0	-278	**-23,193**
	Change (%)	+3	-6	-8	-2	+7	-7	-10	+3	-10	-8	0	-4	**-8.1**
BET	Average catch	460	4,998	10,544	3,670	3,523	1,578	4,667	33	12,754	3,061	693	2,273	**48,256**
	2050 catch	465	4,848	10,017	3,560	3,629	1,484	4,387	33	11,734	2,755	673	2,160	**45,743**
	Change (t)	+5	-150	-527	-110	+106	-95	-280	0	-1,020	-306	-21	-114	**-2,512**
	Change (%)	+1	-3	-5	-3	+3	-6	-6	+1	-8	-10	-3	-5	**-5.2**
All species combined	**Average catch**	**11,080**	**178,587**	**260,073**	**94,697**	**41,279**	**37,003**	**110,794**	**2,655**	**461,032**	**116,877**	**21,392**	**73,080**	**1,408,549**
	2050 catch	**10,262**	**160,808**	**253,832**	**95,965**	**39,856**	**34,728**	**105,933**	**2,533**	**354,720**	**93,077**	**19,277**	**69,496**	**1,240,487**
	Change (t)	**-818**	**-17,779**	**-6,241**	**1,268**	**-1,423**	**-2,275**	**-4,860**	**-123**	**-106,312**	**-23,800**	**-2,115**	**-3,585**	**-168,061**
	Change (%)	**-7.4**	**-10.0**	**-2.4**	**1.3**	**-3.4**	**-6.1**	**-4.4**	**-4.6**	**-23.1**	**-20.4**	**-9.9**	**-4.9**	**-11.9**

Supplementary Table 13c. Projected ***minimum*** (i.e., minimum negative, maximum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the exclusive economic zones (EEZs) of 10 Pacific Island Small Developing States by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18c. Changes in the total catch from all EEZs for each species, and for all species from all EEZs, are also shown. All values except 'Change (%)' for totals for EEZs and for all species combined are rounded to nearest whole number.

Species	Catch	EEZ											Total
		Cook Islands	FSM	Kiribati			Marshall Islands	Nauru	Palau	PNG	Solomon Islands	Tokelau	Tuvalu	
				Gilbert	Phoenix	Line								
SKJ	Average catch	9,513	144,272	203,548	79,976	32,089	29,990	86,174	1,681	318,229	84,637	19,037	63,863	**1,073,009**
	2050 catch	12,082	151,485	246,293	91,173	35,619	34,188	105,133	2,017	324,594	92,255	25,319	77,913	**1,198,069**
	Change (t)	+2,569	+7,214	+42,745	+11,197	+3,530	+4,199	+18,958	+336	+6,365	+ 7,617	+6,282	+14,050	**125,061**
	Change (%)	+27	+5	+21	+14	+11	+14	+22	+20	+2	+9	+33	+22	**+11.7**
YFT	Average catch	1,107	29,317	45,981	11,051	5,667	5,435	19,952	942	130,049	29,178	1,661	6,944	**287,284**
	2050 catch	1,317	29,904	44,602	11,383	6,574	5,435	19,553	1,017	127,448	28,595	1,877	7,361	**285,064**
	Change (t)	+210	+586	-1,379	+332	+ 907	0	-399	+75	-2,601	-584	+216	+417	**-2,220**
	Change (%)	+19	+2	-3	+3	+16	0	-2	+8	-2	-2	+13	+6	**-0.8**
BET	Average catch	460	4,998	10,544	3,670	3,523	1,578	4,667	33	12,754	3,061	693	2,273	**48,256**
	2050 catch	501	5,248	10,755	3,817	3,875	1,610	4,667	36	12,627	2,908	721	2,319	**49,084**
	Change (t)	+41	+ 250	+ 211	+147	+352	+32	0	+3	-128	-153	+28	+45	**+ 828**
	Change (%)	+9	+5	+2	+4	+10	+2	0	+9	-1	-5	+4	+2	**+9.0**
All species combined	**Average catch**	**11,080**	**178,587**	**260,073**	**94,697**	**41,279**	**37,003**	**110,794**	**2,655**	**461,032**	**116,877**	**21,392**	**73,080**	**1,408,549**
	2050 catch	**13,900**	**186,637**	**301,650**	**106,372**	**46,068**	**41,233**	**129,353**	**3,070**	**464,668**	**123,757**	**27,918**	**87,592**	**1,532,218**
	Change (t)	**+2,820**	**+8,050**	**+41,577**	**+11,675**	**+4,789**	**+4,230**	**+18,559**	**+414**	**+3,636**	**+6,881**	**+6,526**	**+14,512**	**+123,669**
	Change (%)	**+25.5**	**+4.5**	**+16.0**	**+12.3**	**+11.6**	**+11.4**	**+16.8**	**+15.6**	**+0.8**	**+5.9**	**+30.5**	**+19.9**	**+8.8**

Supplementary Table 14a. Projected ***average*** changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the high-seas areas (Supplementary Figure 1) by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18a. Changes in the total catch from all high-seas areas for each species, and for all species from all high-seas areas, are also shown. All values except 'Change (%)' for totals for high-seas areas and for all species combined are rounded to nearest whole number.

Species	**Catch**	**High-seas area**														**Total**
		I1	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**H4**	**H5**	**EPO-N**	**EPO-C**	**EPO-S**	
SKJ	Average catch	10,528	18,630	45	16,516	16,994	15,459	13	2	24	18,431	39,150	7,072	254,602	2,031	**399,495**
	2050 catch	8,738	16,580	59	17,672	19,203	17,005	13	2	26	20,827	40,715	7,921	297,884	2,316	**448,961**
	Change (t)	-1,790	-2,049	+14	+1,156	+2,209	+1,546	0	0	+2	+2,396	+1,566	+ 849	+43,282	+ 284	**+49,466**
	Change (%)	-17	-11	+31	+7	+13	+10	0	+28	+8	+13	+4	+12	+17	+14	**+ 12.4**
YFT	Average catch	4,215	3,647	1	3,199	3,530	507	3	1	6	1,936	5,542	77,092	147,743	540	**247,960**
	2050 catch	4,215	3,391	1	3,327	4,095	552	3	1	7	1,955	5,764	90,197	180,246	637	**294,392**
	Change (t)	0	-255	0	+128	+ 565	+46	0	0	+ 1	+19	+ 222	+13,106	+32,503	+ 97	**+46,431**
	Change (%)	0	-7	+6	+4	+16	+9	+8	+5	+14	+1	+4	+17	+22	+18	**+18.7**
BET	Average catch	588	807	1	1,728	2,707	245	1	0	3	526	1,826	11	55,319	722	**64,483**
	2050 catch	588	766	1	1,728	2,896	243	1	0	3	526	1,880	12	63,064	794	**72,503**
	Change (t)	0	-40	0	0	+189	-2	0	0	0	0	+55	+ 1	+7,745	+72	**+ 8,020**
	Change (%)	0	-7	+6	+4	+16	+9	+8	+5	+14	+1	+4	+17	+22	+18	**+12.4**
All species combined	**Average catch**	**15,330**	**23,083**	**47**	**21,443**	**23,231**	**16,211**	**17**	**2**	**33**	**20,893**	**46,517**	**84,175**	**457,664**	**3,293**	**711,939**
	2050 catch	**13,541**	**20,738**	**61**	**22,727**	**26,194**	**17,800**	**17**	**3**	**36**	**23,308**	**48,360**	**98,130**	**541,194**	**3,747**	**815,856**
	Change (t)	**-1,790**	**-2,345**	**+14**	**+1,284**	**+2,963**	**+1,589**	**0**	**+1**	**+3**	**+2,415**	**+1,842**	**+13,955**	**+83,530**	**+454**	**+103,917**
	Change (%)	**-11.7**	**-10.2**	**+29.8**	**+6.0**	**+12.8**	**+9.8**	**0**	**+20.2**	**+8.9**	**+ 11.6**	**+4.0**	**+16.6**	**+18.3**	**+13.8**	**+14.6**

Supplementary Table 14b. Projected ***maximum*** (i.e., maximum negative, minimum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the high-seas areas (Supplementary Figure 1) by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18b. Changes in the total catch from all high-seas areas for each species, and for all species from all high-seas areas, are also shown. All values except 'Change (%)' for totals for high-seas areas and for all species combined are rounded to nearest whole number.

Species	Catch	High-seas area														Total
		I1	I2	I3	I4	I5	I6	I7	I8	I9	H4	H5	EPO-N	EPO-C	EPO-S	
SKJ	Average catch	10,528	18,630	45	16,516	16,994	15,459	13	2	24	18,431	39,150	7,072	254,602	2,031	**399,495**
	2050 catch	7,580	14,531	54	16,516	16,654	14,995	12	2	22	19,168	38,758	7,567	262,240	2,113	**400,211**
	Change (t)	-2,948	-4,099	+ 9	0	-340	-464	-1	0	-2	+737	-391	+ 495	+ 7,638	+81	**+716**
	Change (%)	-28	-22	+19	0	-2	-3	-9	+2	-7	+4	-1	+7	+3	+4	**0.2**
YFT	Average catch	4,215	3,647	1	3,199	3,530	507	3	1	6	1,936	5,542	77,092	147,743	540	**247,960**
	2050 catch	4,131	3,282	1	3,167	3,918	527	3	1	6	1,897	5,653	84,801	168,427	567	**276,380**
	Change (t)	-84	-365	0	-32	+388	+20	0	0	0	-39	+111	+7,709	+20,684	+27	**+28,420**
	Change (%)	-2	-10	+4	-1	+11	+4	+3	+1	+4	-2	+2	+10	+14	+5	**+11.5**
BET	Average catch	588	807	1	1,728	2,707	245	1	0	3	526	1,826	11	55,319	722	**64,483**
	2050 catch	558	734	1	1,642	2,734	230	1	0	3	505	1,826	12	59,192	758	**68,195**
	Change (t)	-29	-73	0	-86	+ 27	-15	0	0	0	-21	0	+1	+ 3,872	+36	**3,712**
	Change (%)	-5	-9	-1	-5	+1	-6	-6	-4	+2	-4	0	+5	+7	+5	**5.8**
All species combined	**Average catch**	**15,330**	**23,083**	**47**	**21,443**	**23,231**	**16,211**	**17**	**2**	**33**	**20,893**	**46,517**	**84,175**	**457,664**	**3,293**	**711,939**
	2050 catch	**12,269**	**18,547**	**56**	**21,324**	**23,306**	**15,753**	**16**	**2**	**32**	**21,570**	**46,237**	**92,380**	**489,858**	**3,437**	**744,787**
	Change (t)	**-3,062**	**-4,536**	**+9**	**-118**	**+75**	**-458**	**-1**	**0**	**-1**	**+677**	**-281**	**+8,205**	**+32,194**	**+144**	**+32,848**
	Change (%)	**-20.0**	**-19.6**	**+18.3**	**-0.6**	**+0.3**	**-2.8**	**-6.8**	**0**	**-4.1**	**_3.2**	**-0.6**	**+9.7**	**+7.0**	**+4.4**	**+ 4.6**

Supplementary Table 14c. Projected ***minimum*** (i.e., minimum negative/maximum positive) changes in catches of skipjack (SKJ), yellowfin (YFT) and bigeye (BET) tuna in tonnes (t) caught by purse-seine fishing in the high-seas areas (Supplementary Figure 1) by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18c. Changes in the total catch from all high-seas areas for each species, and for all species from all high-seas areas, are also shown. All values except 'Change (%)' for totals for high-seas areas and for all species combined are rounded to nearest whole number.

Species	Catch	High-seas area														Total
		I1	I2	I3	I4	I5	I6	I7	I8	I9	H4	H5	EPO-N	EPO-C	EPO-S	
SKJ	Average catch	10,528	18,630	45	16,516	16,994	15,459	13	2	24	18,431	39,150	7,072	254,602	2,031	**399,495**
	2050 catch	10,528	18,630	68	18,663	21,242	18,242	15	2	30	21,749	42,281	8,203	343,713	2,580	**505,946**
	Change (t)	0	0	+ 23	+2,147	+ 4,248	+2,783	+ 2	0	+6	+3,318	+3,132	+1,132	+89,111	+548	**+106,450**
	Change (%)	0	0	+51	+13	+25	+18	+15	+56	+25	+18	+8	+16	+35	+27	**+26.6**
YFT	Average catch	4,215	3,647	1	3,199	3,530	507	3	1	6	1,936	5,542	77,092	147,743	540	**247,960**
	2050 catch	4,341	3,501	2	3,519	4,306	578	3	1	8	2,072	5,985	97,136	200,930	739	**323,120**
	Change (t)	+126	-146	1	+320	+777	+71	0	0	2	+136	+ 443	+20,044	+53,187	+199	**+75,160**
	Change (%)	+3	-4	+10	+10	+22	+14	+18	+10	+22	+7	+8	+26	+36	+37	**+30.3**
BET	Average catch	588	807	1	1,728	2,707	245	1	0	3	526	1,826	11	55,319	722	**64,483**
	2050 catch	599	791	1	1,780	2,977	248	1	0	3	547	1,953	13	67,489	859	**77,262**
	Change (t)	+12	-16	0	+52	+271	+2	0	0	0	+21	+128	+2	+12,170	+137	**+12,779**
	Change (%)	+2	-2	+7	+3	+10	+1	*8	+3	+11	+4	+7	+16	+22	+19	**+19.8**
All species combined	**Average catch**	**15,330**	**23,083**	**47**	**21,443**	**23,231**	**16,211**	**17**	**2**	**33**	**20,893**	**46,517**	**84,175**	**457,664**	**3,293**	**711,939**
	2050 catch	**15,468**	**22,921**	**70**	**23,961**	**28,526**	**19,067**	**19**	**3**	**41**	**24,367**	**50,220**	**105,352**	**612,132**	**4,178**	**906,328**
	Change (t)	**+138**	**-162**	**+23**	**+ 2,519**	**+5,296**	**+2,856**	**+2**	**1**	**+8**	**+3,474**	**+3,703**	**+21,177**	**+154,468**	**+885**	**+194,389**
	Change (%)	**+0.9**	**-0.7**	**+49.1**	**+11.7**	**+22.8**	**+17.6**	**+12.0**	**+50.0**	**+24.2**	**+16.6**	**+8.0**	**+ 25.2**	**+33.8**	**+26.9**	**+27.3**

Supplementary Table 15a. Estimated ***average*** changes in tuna-fishing access fees, and total government revenue (excluding grants) in percentage terms, for 10 Pacific Small Island Developing States (Pacific SIDS) under the RCP8.5 emissions scenario by 2050. Numbers have been rounded to one decimal place, see spreadsheets at https://osf.io/qa8w4/ for details of calculations. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Pacific SIDS	**Average 2015–2018**			**Change in tuna catch by 2050 (RCP8.5) (%)***	**2050 (RCP8.5)**			**Change by 2050**	
	Gov't revenue (USD) million	**Access fees (USD) million**	**Access fees as % Gov't revenue**		**Gov't revenue (USD) million**	**Access fees (USD) million**	**Access fees as % Gov't revenue**	**Access fees (USD) million**	**Gov't revenue (%)**
Cook Is	126.1	13.5	10.6	-4.0	125.6	13.0	10.3	-0.5	-0.4
FSM	150.6	68.4	47.6	-13.0	141.8	59.5	42.0	-8.9	-5.9
Kiribati	181.7	128.3	70.6	-8.2	171.2	117.8	68.8	-10.5	-5.8
Marshall Is	66.1	31.0	47.8	-0.7	65.8	30.8	46.8	-0.2	-0.3
Nauru	98.6	29.5	31.1	-21.6	92.2	23.2	25.1	-6.4	-6.5
Palau	75.2	7.1	9.4	-0.3	75.2	7.1	9.4	-0.02	-0.03
PNG	3360.8	134.3	4.0	-33.1	3316.4	89.8	2.7	-44.4	-1.3
Solomon Is	429.0	41.3	9.6	-26.1	418.2	30.5	7.3	-10.8	-2.5
Tokelau	16.0	13.4	84.2	-16.1	13.9	11.2	80.9	-2.1	-13.4
Tuvalu	47.4	25.6	53.9	-23.4	41.4	19.6	47.4	-6.0	-12.6
Total		**492.4**				**402.5**		**-89.9**	

* Based on the weighted average change in biomass of skipjack, yellowfin and bigeye tuna (see Supplementary Table 17a, and Supplementary Table 19a for Kiribati)

Supplementary Table 15b. Estimated ***maximum*** changes in tuna-fishing access fees, and total government revenue (excluding grants) in percentage terms, for 10 Pacific Small Island Developing States (Pacific SIDS) under the RCP8.5 emissions scenario by 2050. Numbers have been rounded to one decimal place, see spreadsheets at https://osf.io/qa8w4/ for details of calculations. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Pacific SIDS	Average 2015–2018			Change in tuna catch by 2050 (RCP8.5) (%)*	2050 (RCP8.5)			Change by 2050	
	Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue		Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue	Access fees (USD) million	Gov't revenue (%)
Cook Is	126.1	13.5	10.6	-8.3	125.0	12.4	9.9	-1.1	-0.9
FSM	150.6	68.4	47.6	-21.6	135.9	53.6	39.4	-14.8	-9.8
Kiribati	181.7	128.3	70.6	-19.0	157.3	103.9	66.1	-24.4	-13.4
Marshall Is	66.1	31.0	47.8	-8.6	63.4	28.4	44.7	-2.7	-4.0
Nauru	98.6	29.5	31.1	-37.1	87.6	18.6	21.2	-10.9	-11.1
Palau	75.2	7.1	9.4	-9.5	74.5	6.4	8.6	-0.7	-0.9
PNG	3360.8	134.3	4.0	-43.1	3302.9	76.4	2.3	-57.9	-1.7
Solomon Is	429.0	41.3	9.6	-36.8	413.8	26.1	6.3	-15.2	-3.5
Tokelau	16.0	13.4	84.2	-20.2	13.3	10.7	80.1	-2.7	-16.9
Tuvalu	47.4	25.6	53.9	-31.7	39.3	17.5	44.6	-8.1	-17.1
Total		**492.4**				**354.0**		**-138.5**	

*Based on the weighted average change in biomass of skipjack, yellowfin and bigeye tuna (see Supplementary Table 17b, and Supplementary Table 19b for Kiribati)

Supplementary Table 15c. Estimated ***minimum*** changes in tuna-fishing access fees, and total government revenue (excluding grants) in percentage terms, for 10 Pacific Small Island Developing States (Pacific SIDS) under the RCP8.5 emissions scenario by 2050. Numbers have been rounded to one decimal place, see spreadsheets at https://osf.io/qa8w4/ for details of calculations. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Pacific SIDS	Average 2015–2018			Change in tuna catch by 2050 (RCP8.5) (%)*	2050 (RCP8.5)			Change by 2050	
	Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue		Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue	Access fees (USD) million	Gov't revenue (%)
Cook Is	126.1	13.5	10.6	+1.2	126.3	13.7	10.8	+0.2	+0.1
FSM	150.6	68.4	47.6	-5.1	147.2	64.9	44.1	-3.5	-2.3
Kiribati	181.7	128.3	70.6	+0.9	182.9	129.5	70.8	+1.2	+0.6
Marshall Is	66.1	31.0	47.8	+5.4	67.7	32.7	48.3	+1.7	+2.5
Nauru	98.6	29.5	31.1	-6.0	96.8	27.7	28.7	-1.8	-1.8
Palau	75.2	7.1	9.4	+12.6	76.1	8.0	10.5	+0.9	+1.2
PNG	3360.8	134.3	4.0	-22.0	3331.3	104.7	3.1	-29.5	-0.9
Solomon Is	429.0	41.3	9.6	-17.3	421.8	34.2	8.1	-7.2	-1.7
Tokelau	16.0	13.4	84.2	-4.9	15.4	12.7	82.7	-0.7	-4.1
Tuvalu	47.4	25.6	53.9	-14.3	43.7	22.0	50.2	-3.7	-7.7
Total		**492.4**				**450.0**		**-42.4**	

* Based on the weighted average change in biomass of skipjack, yellowfin and bigeye tuna (see Supplementary Table 17c, and Supplementary Table 19c for Kiribati)

Supplementary Table 16a. Estimated ***average*** changes in tuna-fishing access fees, and total government revenue (excluding grants) in percentage terms, for 10 Pacific Small Island Developing States (Pacific SIDS) under the RCP8.5 emissions scenario by 2050. Numbers have been rounded to one decimal place, see spreadsheets at https://osf.io/qa8w4/ for details of calculations. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Pacific SIDS	Average 2015–2018			Change in tuna catch by 2050 (RCP4.5) (%)*	2050 (RCP4.5)			Change by 2050	
	Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue		Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue	Access fees (USD) million	Gov't revenue (%)
Cook Is	126.1	13.5	10.6	+8.9	127.3	14.7	11.6	+1.2	+1.0
FSM	150.6	68.4	47.6	-2.7	148.8	66.5	44.7	-1.8	-1.2
Kiribati	181.7	128.3	70.6	+6.9	190.6	137.2	72.0	+8.9	+4.9
Marshall Is	66.1	31.0	47.8	+2.1	66.7	31.7	47.5	+0.7	+1.0
Nauru	98.6	29.5	31.1	+5.7	100.2	31.2	31.1	+1.7	+1.7
Palau	75.2	7.1	9.4	+3.1	75.4	7.3	9.7	+0.2	+0.3
PNG	3360.8	134.3	4.0	-15.5	3340.0	113.5	3.4	-20.8	-0.6
Solomon Is	429.0	41.3	9.6	-8.7	425.4	37.7	8.9	-3.6	-0.8
Tokelau	16.0	13.4	84.2	+5.7	16.8	14.1	84.2	+0.8	+4.8
Tuvalu	47.4	25.6	53.9	+3.4	48.3	26.5	54.9	+0.9	+1.9
Total		**492.4**				**480.5**		**-12.0**	

*Based on the weighted average change in biomass of skipjack, yellowfin and bigeye tuna (see Supplementary Table 18a, and Supplementary Table 20a for Kiribati)

Supplementary Table 16b. Estimated ***maximum*** changes in tuna-fishing access fees, and total government revenue (excluding grants) in percentage terms, for 10 Pacific Small Island Developing States (Pacific SIDS) under the RCP8.5 emissions scenario by 2050. Numbers have been rounded to one decimal place, see spreadsheets at https://osf.io/qa8w4/ for details of calculations. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Pacific SIDS	Average 2015–2018			Change in tuna catch by 2050 (RCP4.5) (%)*	2050 (RCP4.5)			Change by 2050	
	Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue		Gov't revenue (USD) million	Access fees (USD) million	Access fees as % Gov't revenue	Access fees (USD) million	Gov't revenue (%)
Cook Is	126.1	13.5	10.6	-7.4	125.1	12.5	10.0	-1.0	-0.8
FSM	150.6	68.4	47.6	-10.0	143.8	61.5	42.8	-6.8	-4.5
Kiribati	181.7	128.3	70.6	-1.6	179.7	126.3	70.3	-2.1	-1.1
Marshall Is	66.1	31.0	47.8	-6.1	64.2	29.1	45.4	-1.9	-2.9
Nauru	98.6	29.5	31.1	-4.4	97.3	28.2	29.0	-1.3	-1.3
Palau	75.2	7.1	9.4	-4.7	74.9	6.8	9.1	-0.3	-0.4
PNG	3360.8	134.3	4.0	-23.1	3329.8	103.3	3.1	-31.0	-0.9
Solomon Is	429.0	41.3	9.6	-20.4	420.6	32.9	7.8	-8.4	-2.0
Tokelau	16.0	13.4	84.2	-9.9	14.7	12.1	82.0	-1.3	-8.3
Tuvalu	47.4	25.6	53.9	-4.9	46.1	24.4	52.8	-1.3	-2.7
Total		**492.4**				**437.1**		**-55.3**	

*Based on the weighted average change in biomass of skipjack, yellowfin and bigeye tuna (see Supplementary Table 18b, and Supplementary Table 20b for Kiribati)

Supplementary Table 16c. Estimated ***minimum*** changes in tuna-fishing access fees, and total government revenue (excluding grants) in percentage terms, for 10 Pacific Small Island Developing States (Pacific SIDS) under the RCP8.5 emissions scenario by 2050. Numbers have been rounded to one decimal place, see spreadsheets at https://osf.io/qa8w4/ for details of calculations. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Pacific SIDS	**Average 2015–2018**			**Change in tuna catch by 2050 (RCP4.5) (%)***	**2050 (RCP4.5)**			**Change by 2050**	
	Gov't revenue (USD) million	**Access fees (USD) million**	**Access fees as % Gov't revenue**		**Gov't revenue (USD) million**	**Access fees (USD) million**	**Access fees as % Gov't revenue**	**Access fees (USD) million**	**Gov't revenue (%)**
Cook Is	126.1	13.5	10.6	+25.5	129.6	16.9	13.1	+3.4	+2.7
FSM	150.6	68.4	47.6	+4.5	153.7	71.4	46.5	+3.1	+2.0
Kiribati	181.7	128.3	70.6	+14.7	200.6	147.2	73.4	+18.9	+10.4
Marshall Is	66.1	31.0	47.8	+11.4	69.6	34.6	49.7	+3.5	+5.4
Nauru	98.6	29.5	31.1	+16.8	103.5	34.5	33.3	+4.9	+5.0
Palau	75.2	7.1	9.4	+15.7	76.3	8.2	10.8	+1.1	+1.5
PNG	3360.8	134.3	4.0	+0.8	3361.9	135.3	4.0	+1.1	<0.001
Solomon Is	429.0	41.3	9.6	+5.9	431.4	43.7	10.1	+2.4	+0.6
Tokelau	16.0	13.4	84.2	+30.5	20.1	17.5	86.8	+4.1	+25.5
Tuvalu	47.4	25.6	53.9	+19.9	52.5	30.7	58.5	+5.1	+10.7
Total		**492.4**				**540.1**		**+47.7**	

* Based on weighted average change in biomass of skipjack, yellowfin and bigeye tuna (see Supplementary Table 18c, and Supplementary Table 20c for Kiribati).

Supplementary Table 17a. Projected ***average*** percentage changes in purse-seine catch in the exclusive economic zones (EEZs) of 10 Pacific Small Island Developing States (Pacific SIDS), and high-seas areas (Supplementary Figure 1), based on SEAPODYM simulations for the IPCC RCP8.5 emissions scenario by 2050. Projections for the percentage changes in purse-seine catch are based on average percentage changes in combined biomass of skipjack, yellowfin and bigeye tuna, weighted by their average relative abundance in purse-seine catches for the 10-year period (2009–2018) (Supplementary Tables 3 and 4). FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Area	**Relative abundance of tuna species (%)***			**Projected changes in biomass (%)**			**Change in purse-seine catch by 2050 (%)****
	Skipjack	**Yellowfin**	**Bigeye**	**Skipjack**	**Yellowfin**	**Bigeye**	
	a	***b***	***c***	***d***	***e***	***f***	
EEZs of Pacific SIDS							
Cook Islands	85.9	10.0	4.1	-6	+11	+2	-4.0
FSM	80.8	16.4	2.8	-14	-10	-1	-13.0
Kiribati - Gilbert Is	78.3	17.7	4.1	-14	-13	-4	-13.4
Kiribati - Phoenix Is	84.5	11.7	3.9	-2	-7	-5	-2.7
Kiribati - Line Is	77.7	13.7	8.5	+14	+7	+1	+11.9
Marshall Islands	81.0	14.7	4.3	+1	-10	-2	-0.7
Nauru	77.8	18.0	4.2	-24	-15	-5	-21.6
Palau	64.0	35.5	1.2	0	-1	+1	-0.3
PNG	69.0	28.2	2.8	-42	-14	-6	-33.1
Solomon Islands	72.4	25.0	2.6	-32	-11	-6	-26.1
Tokelau	89.0	7.8	3.2	-18	+1	-4	-16.1
Tuvalu	87.4	9.5	3.1	-26	-5	-6	-23.4
High-seas areas							
I1	68.7	27.5	3.8	-34	-8	-3	-25.7
I2	80.7	15.8	3.5	-33	-13	-6	-28.9
I3	95.6	3.0	1.5	+29	+3	+2	+27.8
I4	77.0	14.9	8.1	+3	-3	-4	+1.5
I5	73.2	15.2	11.7	+26	+9	+2	+20.6
I6	95.4	3.1	1.5	+4	+9	-3	+4.1
I7	76.6	16.2	7.2	+10	+9	-2	+9.0
I8	68.2	22.7	9.1	+23	0	-2	+15.5
I9	72.3	18.7	9.0	+29	+18	+4	+24.7
H4	88.2	9.3	2.5	-16	-6	-6	-14.8
H5	84.2	11.9	3.9	+8	-2	-2	+6.4
EPO-N	8.4	91.6	0.0	+12	+20	+11	+19.3
EPO-C	55.6	32.3	12.1	+32	+26	+10	+27.4
EPO-S	61.7	16.4	21.9	+36	+41	+13	+31.8

*Rounded to one decimal place; **Calculated as ((*a* x *d*) + (*b* x *e*) + (*c* x *f*))/100

Supplementary Table 17b. Projected ***maximum*** (i.e., maximum negative/minimum positive) percentage changes in purse-seine catch in the exclusive economic zones (EEZs) of 10 Pacific Small Island Developing States (Pacific SIDS), and high-seas areas (Supplementary Figure 1), based on SEAPODYM simulations for the IPCC RCP8.5 emissions scenario by 2050. Projections for the percentage changes in purse-seine catch are based on average percentage changes in combined biomass of skipjack, yellowfin and bigeye tuna, weighted by their average relative abundance in purse-seine catches for the 10-year period (2009–2018) (Supplementary Tables 3 and 4). FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Area	Relative abundance of tuna species (%)*			Projected changes in biomass (%)			Change in purse-seine catch by 2050 (%)**
	Skipjack	Yellowfin	Bigeye	Skipjack	Yellowfin	Bigeye	
	a	*b*	*c*	*d*	*e*	*f*	
EEZs of Pacific SIDS							
Cook Islands	85.9	10.0	4.1	-10	+3	-1	-8.3
FSM	80.8	16.4	2.8	-24	-13	-4	-21.6
Kiribati - Gilbert Is	78.3	17.7	4.1	-29	-15	-5	-25.6
Kiribati - Phoenix Is	84.5	11.7	3.9	-13	-9	-6	-12.3
Kiribati - Line Is	77.7	13.7	8.5	+9	+2	-1	+7.2
Marshall Islands	81.0	14.7	4.3	-8	-13	-6	-8.6
Nauru	77.8	18.0	4.2	-43	-19	-5	-37.1
Palau	64.0	35.5	1.2	-12	-5	-1	-9.5
PNG	69.0	28.2	2.8	-54	-20	-7	-43.1
Solomon Islands	72.4	25.0	2.6	-46	-13	-8	-36.8
Tokelau	89.0	7.8	3.2	-22	-5	-7	-20.2
Tuvalu	87.4	9.5	3.1	-35	-9	-8	-31.7
High-seas areas							
I1	68.7	27.5	3.8	-50	-12	-6	-37.9
I2	80.7	15.8	3.5	-51	-16	-8	-44.0
I3	95.6	3.0	1.5	+9	-1	0	+8.6
I4	77.0	14.9	8.1	-7	-7	-6	-6.9
I5	73.2	15.2	11.7	+13	+3	-2	+9.7
I6	95.4	3.1	1.5	-10	+3	-6	-9.5
I7	76.6	16.2	7.2	+1	+2	-6	+0.7
I8	68.2	22.7	9.1	-7	-5	-4	-6.3
I9	72.3	18.7	9.0	+19	+7	+1	+15.1
H4	88.2	9.3	2.5	-26	-10	-7	-24.0
H5	84.2	11.9	3.9	0	-6	-4	-0.9
EPO-N	8.4	91.6	0.0	+2	+14	+6	+13.0
EPO-C	55.6	32.3	12.1	+16	+17	+5	+15.0
EPO-S	61.7	16.4	21.9	+23	+25	+6	+19.6

*Rounded to one decimal place; **Calculated as ((*a* x *d*) + (*b* x *e*) + (*c* x *f*))/100

Supplementary Table 17c. Projected ***minimum*** (i.e., minimum negative/maximum positive)percentage changes in purse-seine catch in the exclusive economic zones (EEZs) of 10 Pacific Small Island Developing States (Pacific SIDS), and high-seas areas (Supplementary Figure 1), based on SEAPODYM simulations for the IPCC RCP8.5 emissions scenario by 2050. Projections for the percentage changes in purse-seine catch are based on average percentage changes in combined biomass of skipjack, yellowfin and bigeye tuna, weighted by their average relative abundance in purse-seine catches for the 10-year period (2009–2018) (Supplementary Tables 3 and 4). FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Area	**Relative abundance of tuna species (%)***			**Projected changes in biomass (%)**			**Change in purse-seine catch by 2050 (%)****
	Skipjack	**Yellowfin**	**Bigeye**	**Skipjack**	**Yellowfin**	**Bigeye**	
	a	***b***	***c***	***d***	***e***	***f***	
EEZs of Pacific SIDS							
Cook Islands	85.9	10.0	4.1	-1	+18	+7	+1.2
FSM	80.8	16.4	2.8	-5	-7	+3	-5.1
Kiribati - Gilbert Is	78.3	17.7	4.1	-1	-10	-3	-2.7
Kiribati - Phoenix Is	84.5	11.7	3.9	+5	-5	-4	+3.5
Kiribati - Line Is	77.7	13.7	8.5	+20	+13	+3	+17.6
Marshall Islands	81.0	14.7	4.3	+8	-8	+1	+5.4
Nauru	77.8	18.0	4.2	-5	-11	-4	-6.0
Palau	64.0	35.5	1.2	+19	+1	+5	+12.6
PNG	69.0	28.2	2.8	-28	-9	-5	-22.0
Solomon Islands	72.4	25.0	2.6	-21	-8	-5	-17.3
Tokelau	89.0	7.8	3.2	-6	+6	-1	-4.9
Tuvalu	87.4	9.5	3.1	-16	-2	-4	-14.3
High-seas areas							
I1	68.7	27.5	3.8	-15	-3	-1	-11.2
I2	80.7	15.8	3.5	-17	-10	-5	-15.5
I3	95.6	3.0	1.5	+47	+7	+5	+45.2
I4	77.0	14.9	8.1	+9	+3	-1	+7.3
I5	73.2	15.2	11.7	+41	+20	+4	+33.5
I6	95.4	3.1	1.5	+16	+17	+1	+15.8
I7	76.6	16.2	7.2	+30	+18	+6	+26.3
I8	68.2	22.7	9.1	+48	+4	0	+33.6
I9	72.3	18.7	9.0	+48	+27	+9	+40.6
H4	88.2	9.3	2.5	-9	-4	-4	-8.4
H5	84.2	11.9	3.9	+12	+1	-1	+10.2
EPO-N	8.4	91.6	0.0	+19	+25	+18	+24.5
EPO-C	55.6	32.3	12.1	+43	+35	+14	+36.9
EPO-S	61.7	16.4	21.9	+48	+63	+24	+45.2

* Rounded to one decimal place; **Calculated as ((*a* x *d*) + (*b* x *e*) + (*c* x *f*))/100

Supplementary Table 18a. Projected ***average*** percentage changes in purse-seine catch in the exclusive economic zones (EEZs) of 10 Pacific Small Island Developing States (Pacific SIDS), and high-seas areas (Supplementary Figure 1), based on SEAPODYM simulations for the IPCC RCP4.5 emissions scenario by 2050. Projections for the percentage changes in purse-seine catch are based on average percentage changes in combined biomass of skipjack, yellowfin and bigeye tuna, weighted by their average relative abundance in purse-seine catches for the 10-year period (2009–2018) (Supplementary Tables 3 and 4). FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Area	**Relative abundance of tuna species (%)***			**Projected changes in biomass (%)**			**Change in purse-seine catch by 2050 (%)****
	Skipjack	**Yellowfin**	**Bigeye**	**Skipjack**	**Yellowfin**	**Bigeye**	
	a	***B***	***c***	***d***	***e***	***F***	
EEZs of Pacific SIDS							
Cook Is	85.9	10.0	4.1	+9	+10	+4	+8.9
FSM	80.8	16.4	2.8	-3	-2	+2	-2.7
Kiribati - Gilbert Is	78.3	17.7	4.1	+10	-5	-1	+6.9
Kiribati - Phoenix Is	84.5	11.7	3.9	+8	0	+1	+6.8
Kiribati - Line Is	77.7	13.7	8.5	+6	+12	+6	+6.8
Marshall Is	81.0	14.7	4.3	+3	-2	-1	+2.1
Nauru	77.8	18.0	4.2	+9	-7	-2	+5.7
Palau	64.0	35.5	1.2	+2	+5	+5	+3.1
PNG	69.0	28.2	2.8	-19	-8	-4	-15.5
Solomon Is	72.4	25.0	2.6	-10	-5	-7	-8.7
Tokelau	89.0	7.8	3.2	+6	+5	-1	+5.7
Tuvalu	87.4	9.5	3.1	+4	0	-2	+3.4
High-seas areas							
I1	68.7	27.5	3.8	-17	0	0	-11.7
I2	80.7	15.8	3.5	-11	-7	-5	-10.2
I3	95.6	3.0	1.5	+31	+6	+3	+29.8
I4	77.0	14.9	8.1	+7	+4	0	+6.0
I5	73.2	15.2	11.7	+13	+16	+7	+12.8
I6	95.4	3.1	1.5	+10	+9	-1	+9.8
I7	76.6	16.2	7.2	0	+8	0	+1.3
I8	68.2	22.7	9.1	+28	+5	0	+20.2
I9	72.3	18.7	9.0	+8	+14	+6	+8.9
H4	88.2	9.3	2.5	+13	+1	0	+11.6
H5	84.2	11.9	3.9	+4	+4	+3	+4.0
EPO-N	8.4	91.6	0.0	+12	+17	+10	+16.6
EPO-C	55.6	32.3	12.1	+17	+22	+14	+18.3
EPO-S	61.7	16.4	21.9	+14	+18	+10	+13.8

* Rounded to one decimal place; **Calculated as $((a \times d) + (b \times e) + (c \times f))/100$

Supplementary Table 18b. Projected ***maximum*** (i.e., maximum negative, minimum positive***)*** percentage changes in purse-seine catch in the exclusive economic zones (EEZs) of 10 Pacific Small Island Developing States (Pacific SIDS), and high-seas areas (Supplementary Figure 1), based on SEAPODYM simulations for the IPCC RCP4.5 emissions scenario by 2050. Projections for the percentage changes in purse-seine catch are based on average percentage changes in combined biomass of skipjack, yellowfin and bigeye tuna, weighted by their average relative abundance in purse-seine catches for the 10-year period (2009–2018) (Supplementary Tables 3 and 4). FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Area	Relative abundance of tuna species (%)*			Projected changes in biomass (%)			Change in purse-seine catch by 2050 (%)**
	Skipjack	Yellowfin	Bigeye	Skipjack	Yellowfin	Bigeye	
	a	***B***	***c***	***d***	***e***	***F***	
EEZs of Pacific SIDS							
Cook Is	85.9	10.0	4.1	-9	+3	1	-7.4
FSM	80.8	16.4	2.8	-11	-6	-3	-10.0
Kiribati - Gilbert Is	78.3	17.7	4.1	-1	-8	-5	-2.4
Kiribati - Phoenix Is	84.5	11.7	3.9	+2	-2	-3	1.3
Kiribati - Line Is	77.7	13.7	8.5	-6	+7	3	-3.4
Marshall Is	81.0	14.7	4.3	-6	-7	-6	-6.1
Nauru	77.8	18.0	4.2	-3	-10	-6	-4.4
Palau	64.0	35.5	1.2	-9	+3	1	-4.7
PNG	69.0	28.2	2.8	-29	-10	-8	-23.1
Solomon Is	72.4	25.0	2.6	-25	-8	-10	-20.4
Tokelau	89.0	7.8	3.2	-11	0	-3	-9.9
Tuvalu	87.4	9.5	3.1	-5	-4	-5	-4.9
High-seas areas							
I1	68.7	27.5	3.8	-28	-2	-5	-20.0
I2	80.7	15.8	3.5	-22	-10	-9	-19.6
I3	95.6	3.0	1.5	+19	+4	-1	+18.3
I4	77.0	14.9	8.1	0	-1	-5	-0.6
I5	73.2	15.2	11.7	-2	+11	+1	+0.3
I6	95.4	3.1	1.5	-3	+4	-6	-2.8
I7	76.6	16.2	7.2	-9	+3	-6	-6.8
I8	68.2	22.7	9.1	+2	+1	-4	+1.2
I9	72.3	18.7	9.0	-7	+4	+2	-4.1
H4	88.2	9.3	2.5	+4	-2	-4	+3.2
H5	84.2	11.9	3.9	-1	+2	0	-0.6
EPO-N	8.4	91.6	0.0	+7	+10	+5	+9.7
EPO-C	55.6	32.3	12.1	+3	+14	+7	+7.0
EPO-S	61.7	16.4	21.9	+4	+5	+5	+4.4

* Rounded to one decimal place; **Calculated as ((*a* x *d*) + (*b* x *e*) + (*c* x *f*))/100

Supplementary Table 18c. Projected ***minimum*** (i.e., minimum negative, maximum positive) percentage changes in purse-seine catch in the exclusive economic zones (EEZs) of 10 Pacific Small Island Developing States (Pacific SIDS), and high-seas areas (Supplementary Figure 1), based on SEAPODYM simulations for the IPCC RCP4.5 emissions scenario by 2050. Projections for the percentage changes in purse-seine catch are based on average percentage changes in combined biomass of skipjack, yellowfin and bigeye tuna, weighted by their average relative abundance in purse-seine catches for the 10-year period (2009–2018) (Supplementary Tables 3 and 4). FSM = Federated States of Micronesia; PNG = Papua New Guinea.

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Area	**Relative abundance of tuna species (%)***			**Projected changes in biomass (%)**			**Change in purse-seine catch by 2050 (%)****
	Skipjack	**Yellowfin**	**Bigeye**	**Skipjack**	**Yellowfin**	**Bigeye**	
	a	***B***	***c***	***D***	***e***	***F***	
EEZs of Pacific SIDS							
Cook Is	85.9	10.0	4.1	+27	+19	+9	+25.5
FSM	80.8	16.4	2.8	+5	+2	+5	+4.5
Kiribati - Gilbert Is	78.3	17.7	4.1	+21	-3	+2	+16.0
Kiribati - Phoenix Is	84.5	11.7	3.9	+14	+3	+4	+12.3
Kiribati - Line Is	77.7	13.7	8.5	+11	+16	+10	+11.6
Marshall Is	81.0	14.7	4.3	+14	0	+2	+11.4
Nauru	77.8	18.0	4.2	+22	-2	+0	+16.8
Palau	64.0	35.5	1.2	+20	+8	+9	+15.7
PNG	69.0	28.2	2.8	+2	-2	-1	+0.8
Solomon Is	72.4	25.0	2.6	+9	-2	-5	+5.9
Tokelau	89.0	7.8	3.2	+33	+13	+4	+30.5
Tuvalu	87.4	9.5	3.1	+22	+6	+2	+19.9
High-seas areas							
I1	68.7	27.5	3.8	0	+3	+2	+0.9
I2	80.7	15.8	3.5	0	-4	-2	-0.7
I3	95.6	3.0	1.5	+51	+10	+7	+49.1
I4	77.0	14.9	8.1	+13	+10	+3	+11.7
I5	73.2	15.2	11.7	+25	+22	+10	+22.8
I6	95.4	3.1	1.5	+18	+14	+1	+17.6
I7	76.6	16.2	7.2	+15	+18	+8	+15.0
I8	68.2	22.7	9.1	+56	+10	+3	+40.7
I9	72.3	18.7	9.0	+25	+22	+11	+23.2
H4	88.2	9.3	2.5	+18	+7	+4	+16.6
H5	84.2	11.9	3.9	+8	+8	+7	+8.0
EPO-N	8.4	91.6	0.0	+16	+26	+16	+25.2
EPO-C	55.6	32.3	12.1	+35	+36	+22	+33.8
EPO-S	61.7	16.4	21.9	+27	+37	+19	+26.9

* Rounded to one decimal place; **Calculated as ((*a* x *d*) + (*b* x *e*) + (*c* x *f*))/100

Supplementary Table 19a. Projected ***average*** changes in the catches of skipjack, yellowfin and bigeye tuna in tonnes (t) caught by purse-seine fishing in the three exclusive economic zone (EEZ) areas of Kiribati by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 17a. Changes in the total combined catch of all three tuna species in each EEZ area, and for the total EEZ of Kiribati, are shown. Values for '2050 catch' and 'Change (t)' are rounded to the nearest whole number.

Species	**Catch**	**EEZ area**			
		Gilbert Is	**Phoenix Is**	**Line Is**	**Total**
Skipjack	10-year average catch	203,548	79,976	32,089	**315,613**
	2050 catch	175,051	78,376	36,581	**290,008**
	Change (t)	-28,497	-1,600	+4,492	**-25,604**
	Change (%)	-14	-2	+14	**-8.1**
Yellowfin	10-year average catch	45,981	11,051	5,667	**62,699**
	2050 catch	40,003	10,277	6,064	**56,345**
	Change (t)	-5,978	-774	+397	**-6,354**
	Change (%)	-13	-7	+7	**-10.1**
Bigeye	10-year average catch	10,544	3,670	3,523	**17,737**
	2050 catch	10,123	3,486	3,558	**17,167**
	Change (t)	-422	-183	+35	**-570**
	Change (%)	-4	-5	+1	**-3.2**
All species combined	**10-year average catch**	**260,073**	**94,697**	**41,279**	**396,049**
	2050 catch	**225,177**	**92,140**	**46,203**	**363,520**
	Change (t)	**-34,896**	**-2,557**	**+4,924**	**-32,528**
	Change (%)	**-13.4**	**-2.7**	**+11.9**	**-8.2**

Supplementary Table 19b. Projected ***maximum*** (i.e., maximum negative, minimum positive) changes in the catches of skipjack, yellowfin and bigeye tuna in tonnes (t) caught by purse-seine fishing in the three exclusive economic zone (EEZ) areas of Kiribati by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table17b. Changes in the total combined catch of all three tuna species in each EEZ area, and for the total EEZ of Kiribati, are shown. Values for '2050 catch' and 'Change (t)' are rounded to the nearest whole number.

Species	**Catch**	**EEZ area**			
		Gilbert Is	**Phoenix Is**	**Line Is**	**Total**
Skipjack	10-year average catch	203,548	79,976	32,089	**315,613**
	2050 catch	144,519	69,579	34,977	**249,074**
	Change (t)	-59,029	-10,397	+2,888	**-66,538**
	Change (%)	-29	-13	+9	**-21.1**
Yellowfin	10-year average catch	45,981	11,051	5,667	**62,699**
	2050 catch	39,084	10,056	5,781	**54,921**
	Change (t)	-6,897	-995	+113	**-7,778**
	Change (%)	-15	-9	+2	**-12.4**
Bigeye	10-year average catch	10,544	3,670	3,523	**17,737**
	2050 catch	10,017	3,450	3,488	**16,954**
	Change (t)	-527	-220	-35	**-783**
	Change (%)	-5.0	-6.0	-1.0	**-4.4**
All species combined	**10-year average catch**	**260,073**	**94,697**	**41,279**	**396,049**
	2050 catch	**193,620**	**83,085**	**44,245**	**320,950**
	Change (t)	**-66,453**	**-11,612**	**+2,966**	**-75,099**
	Change (%)	**-25.6**	**-12.3**	**+7.2**	**-19.0**

Supplementary Table 19c. Projected ***minimum*** (i.e., minimum negative, maximum positive) changes in the catches of skipjack, yellowfin and bigeye tuna in tonnes (t) caught by purse-seine fishing in the three exclusive economic zone (EEZ) areas of Kiribati by 2050 under the IPCC RCP8.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table17c. Changes in the total combined catch of all three tuna species in each EEZ area, and for the total EEZ of Kiribati, are shown. Values for '2050 catch' and 'Change (t)' are rounded to the nearest whole number.

Species	Catch	EEZ area			
		Gilbert Is	Phoenix Is	Line Is	Total
Skipjack	10-year average catch	203,548	79,976	32,089	**315,613**
	2050 catch	201,513	83,974	38,506	**323,993**
	Change (t)	-2,035	+3,999	+6,418	**+8,381**
	Change (%)	-1	+5	+20	**+2.7**
Yellowfin	10-year average catch	45,981	11,051	5,667	**62,699**
	2050 catch	41,383	10,498	6,404	**58,285**
	Change (t)	-4,598	-553	+737	**-4,414**
	Change (%)	-10	-5	+13	**-7.0**
Bigeye	10-year average catch	10,544	3,670	3,523	**17,737**
	2050 catch	10,228	3,523	3,629	**17,380**
	Change (t)	-316	-147	+106	**-357**
	Change (%)	-3	-4	+3	**-2.0**
All species combined	**10-year average catch**	**260,073**	**94,697**	**41,279**	**396,049**
	2050 catch	**253,123**	**97,996**	**48,539**	**399,658**
	Change (t)	**-6,950**	**+3,299**	**+7,260**	**+3,610**
	Change (%)	**-2.7**	**+3.5**	**+17.6**	**+0.9**

Supplementary Table 20a. Projected ***average*** changes in the catches of skipjack, yellowfin and bigeye tuna in tonnes (t) caught by purse-seine fishing in the three exclusive economic zone (EEZ) areas of Kiribati by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18a. Changes in the total combined catch of all three tuna species in each EEZ area, and for the total EEZ of Kiribati, are shown. Values for '2050 catch' and 'Change (t)' are rounded to the nearest whole number.

Species	**Catch**	**EEZ area**			
		Gilbert Is	**Phoenix Is**	**Line Is**	**Total**
Skipjack	10-year average catch	203,548	79,976	32,089	**315,613**
	2050 catch	223,903	86,374	34,014	**344,291**
	Change (t)	+20,355	+6,398	+1,925	**+28,678**
	Change (%)	+10	+8	+6	**+9.1**
Yellowfin	10-year average catch	45,981	11,051	5,667	**62,699**
	2050 catch	43,682	11,051	6,347	**61,080**
	Change (t)	-2,299	0	+680	**-1,619**
	Change (%)	-5	0	+12	**-2.6**
Bigeye	10-year average catch	10,544	3,670	3,523	**17,737**
	2050 catch	10,439	3,707	3,734	**17,880**
	Change (t)	-105	+37	+211	**+143**
	Change (%)	-1	+1	+6	**+0.8**
All species combined	**10-year average catch**	**260,073**	**94,697**	**41,279**	**396,049**
	2050 catch	**278,023**	**101,132**	**44,096**	**423,251**
	Change (t)	**+17,950**	**+6,435**	**+2,817**	**+27,202**
	Change (%)	**+6.9**	**+6.8**	**+6.8**	**+6.9**

Supplementary Table 20b. Projected ***maximum*** (i.e., maximum negative, minimum positive) changes in the catches of skipjack, yellowfin and bigeye tuna in tonnes (t) caught by purse-seine fishing in the three exclusive economic zone (EEZ) areas of Kiribati by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18b. Changes in the total combined catch of all three tuna species in each EEZ area, and for the total EEZ of Kiribati, are shown. Values for '2050 catch' and 'Change (t)' are rounded to the nearest whole number.

Species	**Catch**	**EEZ area**			
		Gilbert Is	**Phoenix Is**	**Line Is**	**Total**
Skipjack	10-year average catch	203,548	79,976	32,089	**315,613**
	2050 catch	201,513	81,576	30,164	**313,252**
	Change (t)	-2,035	1,600	-1,925	**-2,361**
	Change (%)	-1	+2	-6	**-0.7**
Yellowfin	10-year average catch	45,981	11,051	5,667	**62,699**
	2050 catch	42,303	10,830	6,064	**59,196**
	Change (t)	-3,678	-221	+397	**-3,503**
	Change (%)	-8	-2	+7	**-5.6**
Bigeye	10-year average catch	10,544	3,670	3,523	**17,737**
	2050 catch	10,017	3,560	3,629	**17,205**
	Change (t)	-527	-110	+106	**-532**
	Change (%)	-5	-3	+3	**-3.0**
All species combined	**10-year average catch**	**260,073**	**94,697**	**41,279**	**396,049**
	2050 catch	**253,832**	**95,965**	**39,856**	**389,653**
	Change (t)	**-6,241**	**+1,268**	**-1,423**	**-6,396**
	Change (%)	**-2.4**	**+1.3**	**-3.4**	**-1.6**

Supplementary Table 20c. Projected ***minimum*** (i.e., minimum negative, maximum positive) changes in the catches of skipjack, yellowfin and bigeye tuna in tonnes (t) caught by purse-seine fishing in the three exclusive economic zone (EEZ) areas of Kiribati by 2050 under the IPCC RCP4.5 emissions scenario, relative to average catches for the 10-year period 2009–2018, based on the projected changes in biomass of each tuna species in Supplementary Table 18c. Changes in the total combined catch of all three tuna species in each EEZ area, and for the total EEZ of Kiribati, are shown. Values for '2050 catch' and 'Change (t)' are rounded to the nearest whole number.

Species	**Catch**	**EEZ area**			
		Gilbert Is	**Phoenix Is**	**Line Is**	**Total**
Skipjack	10-year average catch	203,548	79,976	32,089	**315,613**
	2050 catch	246,293	91,173	35,619	**373,085**
	Change (t)	+42,745	+11,197	+3,530	**+57,472**
	Change (%)	+21	+14	+11	**+18.2**
Yellowfin	10-year average catch	45,981	11,051	5,667	**62,699**
	2050 catch	44,602	11,383	6,574	**62,558**
	Change (t)	-1,379	+332	+907	**-141**
	Change (%)	-3	+3	+16	**-0.2**
Bigeye	10-year average catch	10,544	3,670	3,523	**17,737**
	2050 catch	10,755	3,817	3,875	**18,447**
	Change (t)	+211	+147	+352	**+710**
	Change (%)	+2	+4	+10	**+4**
All species combined	**10-year average catch**	**260,073**	**94,697**	**41,279**	**396,049**
	2050 catch	**301,650**	**106,372**	**46,068**	**454,089**
	Change (t)	**+41,577**	**+11,675**	**+4,789**	**+58,040**
	Change (%)	**+16.0**	**+12.3**	**+11.6**	**+14.7**

Supplementary Table 21. Uncertainties explored in the simulation ensembles for the three tropical tuna species.

Name	Model				Uncertainty
	GFDL	**IPSL**	**MIROC-**	**MPI**	
REF	DSF5+GFDL-ESM2G anomalies	DSF5+IPSL-CM5A-MR anomalies	DSF5+MIROC-ESM anomalies	DSF5+MPI-ESM-MR anomalies	Atmospheric forcing
SP	*Primary production:* Increase of PP by 10% in tropical waters (defined by SST >27°C)				Structural uncertainty in biogeochemical model
SO	*Dissolved Oxygen*: No change = Use of climatological fields				
ST	*Genetic adaptation:* Gradual increase in optimal spawning temperature to reach + 1°C by mid-century				Structural uncertainty in SEAPODYM
PH	*Ocean acidification*: Additional mortality of larvae based on laboratory experiments with low medium and high sensitivity to pH (available only for yellowfin tuna).				