UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

June 30, 2025

Dr. Arnulfo Franco, Executive Director
Inter-American Tropical Tuna Commission (IATTC)
8901 La Jolla Shores Drive
La Jolla, California 92037-1509

Subject: Data Submissions under IATTC Resolutions Related to Elasmobranchs

Dear Dr. Franco,

The United States is submitting this letter and enclosed report on information for calendar year 2024, pursuant to the following IATTC resolutions:

- Resolution C-11-10: *Resolution on the Conservation of Oceanic Whitetip Sharks Caught in Association with Fisheries in the Antigua Convention Area*
- Resolution C-15-04: *Resolution on the Conservation of Mobulid Rays Caught in Association with Fisheries in the IATTC Convention Area*
- Resolution C-23-08: *Conservation Measures for Shark Species, with Special Emphasis on the Silky Shark, for the Years 2024 and 2025*
- Resolution C-24-05: *Conservation measures for the Protection and Sustainable Management of Sharks*

Please contact Lucille Bulkeley at (858) 546-5620 or *lucille.bulkeley@noaa.gov* with any questions. Thank you for your attention to this matter.

Sincerely,

Rachael Wadsworth

Rachael Wadsworth
Highly Migratory Species Branch Chief

cc: Andrew Lawler, U.S. Commissioner to the IATTC
C. Colin Brinkman, U.S. Department of State
Ryan J. Wulff, Assistant Regional
Administrator for Sustainable Fisheries Division
Administrative File:151418WCR2021SF00217:LB

2024 ALL RESOLUTIONS PERTAINING TO SHARK CONSERVATION

This report contains information for U.S. deep-set and shallow-set longline fisheries in the IATTC Convention Area relevant to the respective Inter-American Tropical Tuna Commission (IATTC) elasmobranch resolutions (C-05-03, C-11-10, C-15-04, C-16-05, C-21-06). The IATTC maintains all observer information for U.S. purse seine vessels and as such already has access to reports of observed interactions with mobulids, oceanic whitetip shark (*Carcharhinus longimanus*), silky shark (*Carcharhinus falciformis*), and hammerhead shark (*Sphryna spp.*) caught in that fishery.

C-11-10

In 2024, National Marine Fisheries Service (NMFS) observers recorded no interactions with oceanic whitetip sharks in the U.S. deep-set longline vessel fishery in the eastern Pacific Ocean (EPO).

C-15-04

In 2024, no interactions with mobulid rays were recorded by observers on U.S. deep-set longline vessels in the EPO.

C-16-05

There were no interactions recorded by observers with silky sharks in shallow-set or deep-set longline trips in 2024.

C-21-06

As mentioned above under C-16-05, in 2024, there were no interactions with silky sharks observed in shallow-set or deep-set longline trips in the EPO.

2024 U.S. SHARK REPORT TO THE INTER-AMERICAN TROPICAL TUNA COMMISSION: AS REQUIRED PER RESOLUTION C-05-03

The IATTC adopted Resolution C-05-03 (*Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean)* in 2005. Under paragraph 11, the Resolution requires that members and cooperating non-members (CPCs) provide the IATTC Secretariat with a comprehensive annual report that includes data on sharks caught in association with fisheries managed by the IATTC. These data include "catches, effort by gear type, landing, and trade of sharks by species, where possible, in accordance with IATTC reporting procedures, including available historical data." In addition, the Resolution encourages CPCs to conduct research on sharks to identify ways to increase the selectivity of fishing gears, identify shark nursery areas, and provide assistance to developing countries to increase the collection of shark catch data in those countries. This report is being submitted to the IATTC Secretariat to provide updates on relevant shark research conducted by the United States in 2024, to fulfill the U.S. reporting obligations for 2025, and to provide updates on any domestic U.S. regulations that could impact sharks and shark fisheries in the IATTC Convention Area.

DATA SUBMITTED SEPARATELY

The United States submits catch, effort, and landings data on sharks caught by U.S.-flagged vessels in fisheries for tuna and tuna-like species in the IATTC Convention Area as part of its annual report to the IATTC as required under Resolution C-03-05 (*Resolution on Data Provision*). The United States provides catch and effort data by fishing gear at Level 3, the international standard for such data.

U.S. REGULATORY CHANGES IN 2024

U.S. National Level Updates

There were no new rules pertaining to shark conservation implemented in 2024 in the United States.

U.S. West Coast States Updates

There were no new rules pertaining to shark conservation implemented in 2024 in California, Oregon or Washington.

UPDATES ON SHARK RESEARCH IN 2024

The SWFSC's shark research program focuses on shark species that occur along the U.S. Pacific coast, including Shortfin Mako (*Isurus oxyrinchus*), Blue Shark (*Prionace glauca*), Basking Shark (*Cetorhinus maximus*), and three species of thresher sharks: Common Thresher (*Alopias vulpinus*), Bigeye Thresher (*Alopias superciliosus*), Pelagic Thresher (*Alopias pelagicus*), California Horn Sharks (*Heterodontus francisci*), and Leopard Shark (*Triakis semifasciata*). Center scientists have studied the sharks' life history, foraging ecology, distribution, movements, stock structure, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks.

Unseen overlap between fishing vessels and top predators in the northeast Pacific

Accurate assessments of human-wildlife risk associated with industrial fishing are critical for the conservation of marine top predators. Automatic Identification System (AIS) data provide a means of mapping fishing and estimating human-wildlife risk; however, risk can be obscured by gaps in the AIS record due to technical issues and intentional disabling. We assessed the extent to which unseen fishing vessel activity due to AIS gaps obscured estimates of overlap between fishing vessel activity and 14 marine predators including sharks, tunas, mammals, seabirds, and critically endangered leatherback turtles. Among vessels equipped with AIS in the northeast Pacific, up to 24% of total predator overlap with fishing vessel activity was unseen, and up to 36% was unseen for some individual species (Figure 1).

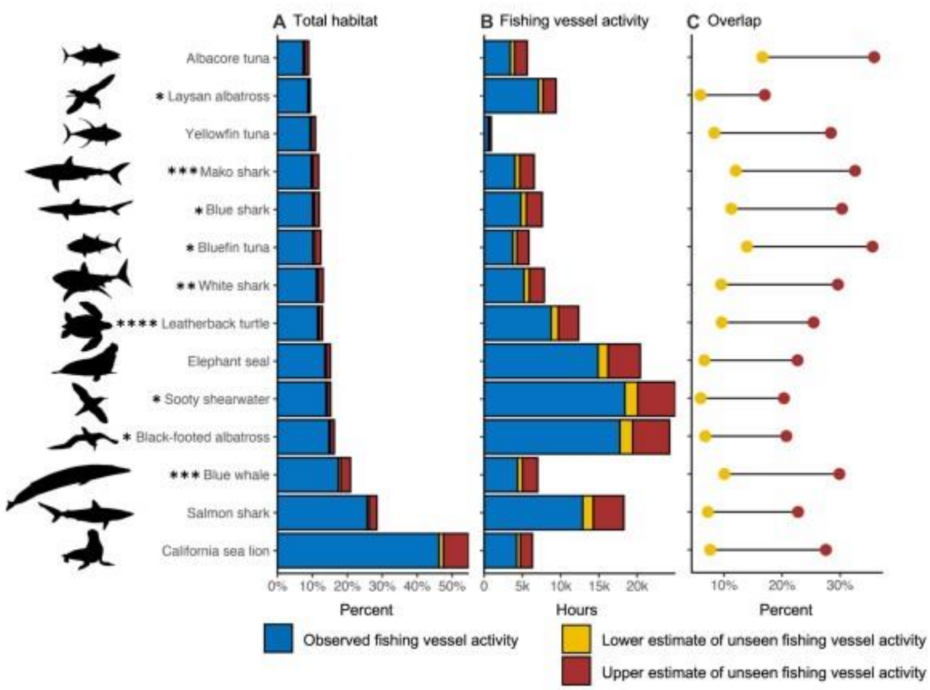

Figure 1. Relationship between species habitats, fishing vessel activity, and overlap. Overlap is a function of the amount of species habitat and the intensity (hours) of fishing vessel activity that coincide in space and time. Because overlap is unitless and difficult to interpret in absolute terms, the base components of overlap are also presented: (A) the percent of each species' total habitat coinciding with fishing vessel activity (ignoring the intensity of fishing vessel activity) and (B) the intensity of fishing vessel activity coinciding with each species' habitat (ignoring the amount of species habitat). (C) Percent of overlap between species and fishing vessel activity obscured by unseen

fishing vessel activity. Lower and upper estimation bounds of unseen fishing vessel activity in (A) to (C) represent gaps longer than 2 weeks excluded and included, respectively. Population status is represented as: *, for near threatened; **, for vulnerable; ***, for endangered; ****, for critically endangered; all other species are of least concern.

Nations are required to self-report fleet-wide and spatially resolved catch and effort information. However, self-reported data provided to RFMOs are typically biased toward nations with higher transparency, and underreporting or nonreporting is common. The only fleet that reports its total catches of sharks to the IATTC is the U.S. longline fleet. We assessed the ability of unseen overlap due to intentional disabling to identify data gaps in self-reported blue and mako shark catch provided to the IATTC by non-U.S. fleets (Fig. 2). Several areas located near 10°N and within the Mexican Exclusive Economic Zone (EEZ) had high unseen overlap and relatively low reported shark catch. On the basis of the magnitude of unseen overlap with intentional disabling in these anomalous areas, our results suggest that between 30,000 and 48,000 more sharks (above 35,332 sharks reported) are potentially being caught.

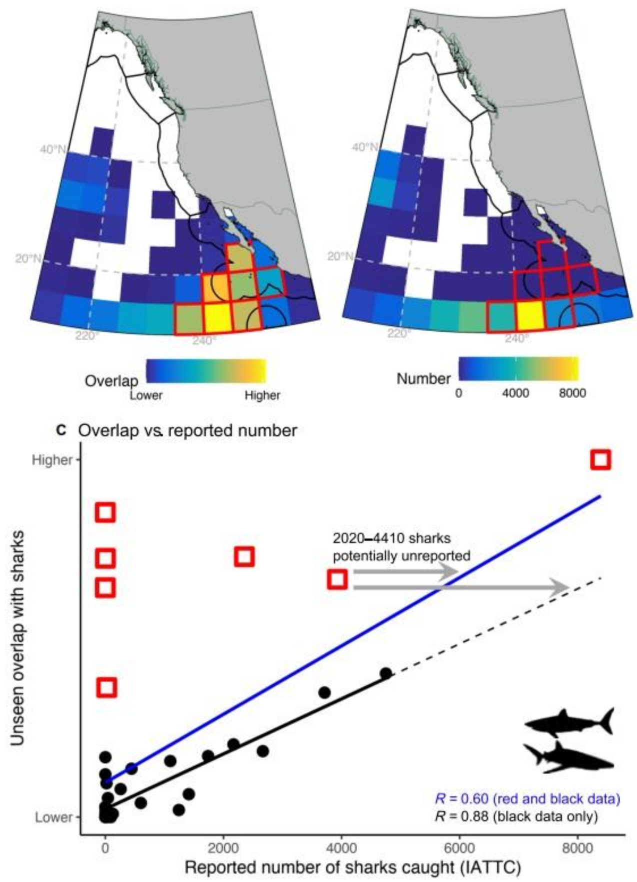

Figure 2. Potential shark reporting discrepancies. (A) Unseen overlap between sharks and vessels with intentionally disabled AIS devices. (B) Shark catch reported to the IATTC. (C) Relationship between unseen overlap (A) and reported shark catch (B). Line of best fit to full dataset in blue; black line shows the line of best fit to a partial dataset excluding seven anomalous areas with high unseen overlap and low reported shark catch [red squares in (A) to (C)]. Gray arrows indicate the range of potentially unreported shark catch based on lines of best fit; Pearson's

correlation coefficients (R) in blue and black text are reported for full and partial datasets, respectively. All panels use data on blue and mako sharks from 2017 to 2021 for non-U.S.–flagged fishing vessels fishing with tuna purse seines and longlines.

Estimates of catch based on the relationship between unseen overlap with intentional disabling and reported catch likely have high uncertainty. There is high uncertainty in RFMO data, which suffer from underreporting, nonreporting, lack of resolution on gear type and taxa, and noncomprehensive requirements for reporting catch fate (e.g., retained or discarded). Despite requirements to report spatially resolved catch data, catch is often reported as nonspatial fleetwide summaries. Furthermore, there is perceived ambiguity regarding reporting requirements for sharks among IATTC member countries. Intentional disabling can not only occur to obscure fishing activity but also occurs to obscure other behaviors such as transiting and transshipping. Thus, our estimates of potential reporting discrepancies are likely precautionary overestimates. Furthermore, while overlap provides insights as to where and when species and fisheries coincide in space and time, overlap does not necessarily result in interaction. Our overlap metric does not consider the vertical dimension of overlap, nor does it consider fishing effort (e.g., number of hooks) or animal abundance. Last, our study is limited to fishing vessels equipped with AIS, which is estimated as 52 to 85% of fishing vessels over 24 m in length but likely includes the majority of longline vessels within RFMOs. While accounting for unseen activity may improve assessments of AIS-based overlap, it does not capture overlap with vessels not equipped with AIS and thus our assessments are likely underestimated. Recent advances in satellite mapping provide a promising avenue for tracking fishing vessels not equipped with AIS and refining estimates of human-wildlife risk.

Welch, H., Clavelle, T., White, T.D., Cimino, M.A., Kroodsma, D. and Hazen, E.L., 2024. Unseen overlap between fishing vessels and top predators in the northeast Pacific. Science Advances, 10(10), p.eadl5528.

Beyond boundaries: governance considerations for climate-driven habitat shifts of highly migratory marine species across jurisdictions

The mobile nature of migratory marine animals across jurisdictional boundaries can challenge the management of biodiversity, particularly under global environmental change. While projections of climate-driven habitat change can reveal whether marine species are predicted to gain or lose habitat in the future, geopolitical boundaries and differing governance regimes may influence animals' abilities to thrive in new areas. Broad geographic movements and diverse governance approaches elicit the need for strong international collaboration to holistically manage and conserve these shared migratory species. In this study, we use data from the Tagging of Pacific Predators program to demonstrate the feasibility of using climate-driven habitat projections to assess species' jurisdictional redistribution. Focusing on four species (shortfin mako shark, California sea lion, northern elephant seal, and sooty shearwater), we calculate the projected change in core habitat across jurisdictional boundaries throughout the century and highlight associated management implications. Using climate-driven habitat projections from the period of 2001 to 2010, and an RCP 8.5 climate scenario, we found that all four species are projected to face up to a 2.5-10% change in core habitat across jurisdictions in the Northeast Pacific, with the greatest gains of core habitat redistribution within the United States exclusive economic zone and in areas beyond national jurisdiction (Figure 3). Overall, our study demonstrates how efforts to understand the impacts of climate change on species' habitat use should be expanded to consider how resulting shifts may provoke new management challenges in a legally bounded, yet physically borderless ocean. We discuss governance implications for transboundary habitat redistribution as highly migratory marine species potentially shift across legal jurisdictions, including new ocean areas beyond national judications, considerations which are applicable within and beyond this Pacific case study. Our study also highlights data needs and management strategies to inform high-level conservation strategies, as well as recommendations for using updated tagging data and climate models to build upon this approach in future work.

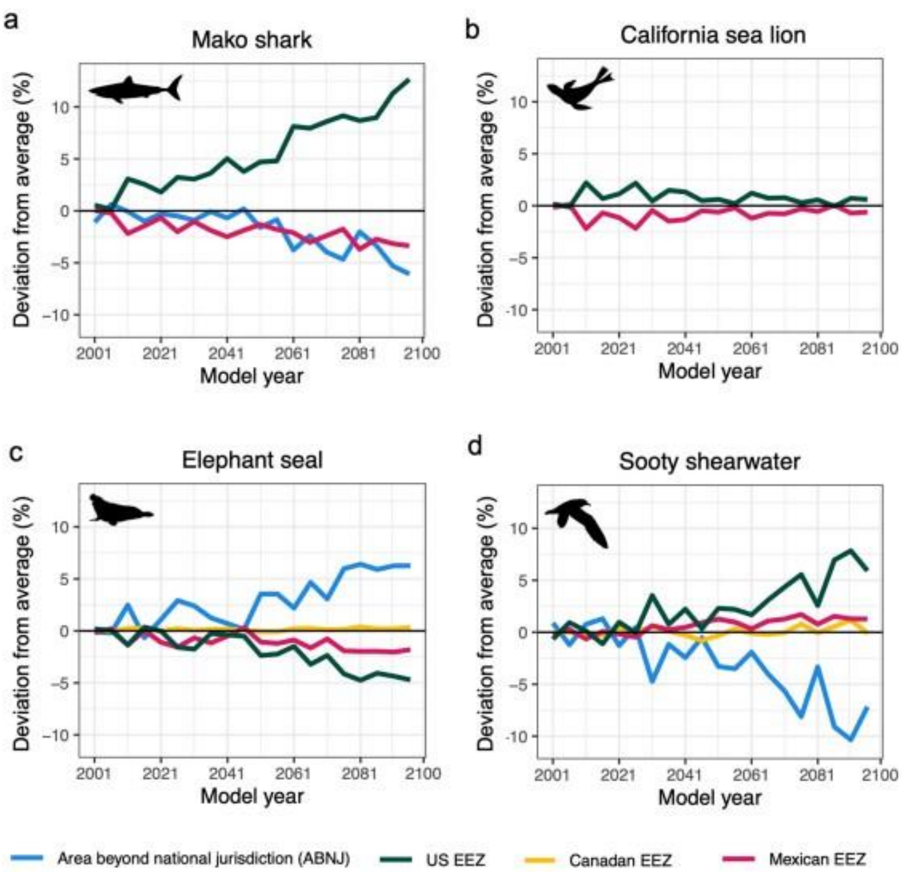

Figure 3. Predicted changes in the deviation from the average proportion of core habitat (%) within each jurisdictional area from 2001 to 2100, represented as a 5-year time series for each species. a Shortfin mako shark; b California sea lion; c northern elephant seal; d sooty shearwater. Colors represent jurisdictional waters that include areas beyond national jurisdiction (ABNJ) and the exclusive economic zones (EEZs) of Mexico, Canada, and the United States (US). The United States EEZ includes the Pacific coast of the continental states, Hawaii, Alaska, and the Johnston Atoll.

Santos, B.S., Hazen, E.L., Welch, H., Lezama-Ochoa, N., Block, B.A., Costa, D.P., Shaffer, S.A. and Crowder, L.B., 2024. Beyond boundaries: governance considerations for climate-driven habitat shifts of highly migratory marine species across jurisdictions. npj Ocean Sustainability, 3(1), p.22.

Observations of skin color aberrations in four shark species of the coast of southern California, USA

Skin color aberrations are naturally occurring abnormal pigment patterns that are generally rare among chondrichthyans. In this study, we highlight diferent skin color aberrations from observations of four shark species native to southern California, USA. We report the first recorded instance of apparent leucism (regional pigmentation loss), in a California horn shark *Heterodontus francisci* (Girard 1855) and tope shark *Galeorhinus galeus (*Linnaeus 1758) (Figure 4). We also report the apparent second documented occurrence of albinism in the swell shark *Cephaloscyllium ventriosum* (Garman 1880) from a newly hatched captive individual with parents of normal pigmentation (Figure 5). Lastly, we redescribe a rare secondary color morph in the leopard shark *Triakis semifasciata* Girard 1855 using previous literature and new sightings/images from sharks in the wild (Figure 6). Color aberrations may lead to different advantages (e.g., certain color morphs may offer additional camouflage) or disadvantages (e.g., reduced pigmentation may limit camouflage and protection from ultraviolet light). Documenting these rare color aberrations augments our understanding of how color patterns can vary between individuals and taxa, and ultimately how these conditions potentially impact shark biology.

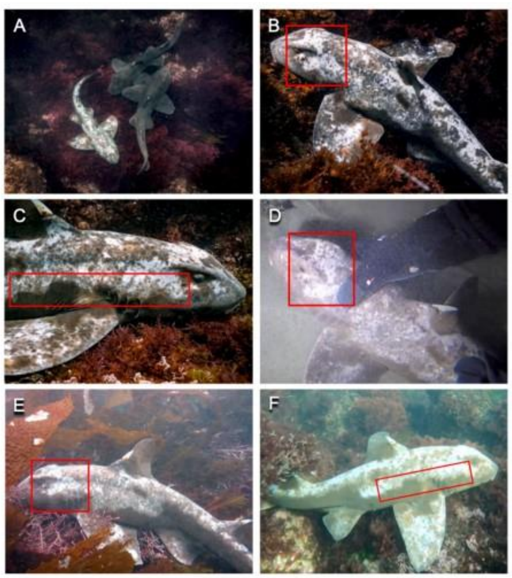

Figure 4. Underwater images of a mature male California horn shark (*Heterodontus francisci*) with apparent leucism encountered in La Jolla, CA, USA, over a 4-year period: A–C May 5, 2019 (La Jolla Cove, photos by Zoey Vagner), D June 24, 2019 (Scripps Institution of Oceanography Pier, screenshots from video by Tanya Prinzing), E July 18, 2020 (La Jolla Cove, screenshots from video by “Diver Jackie”), F April 6, 2023 (La Jolla Cove, screenshots from videos by Kevin Smith). Note the partial lack of skin pigmentation in comparison to conspecifics

with normal pigmentation (A) and normal-colored eyes (C) which is indicative of leucism. Red rectangles indicate similar pigmentation between B, D, and E, as well as C and F showing this is the same individual across sightings. In the most recent encounter (F), the white (pigment-lacking) areas of the shark appeared to be brighter than previous encounters, but these differences appear to be associated with reduced image quality rather than real pigmentation change that are occasionally observed with ontogeny, UV exposure, or other environmental stimuli in elasmobranchs.

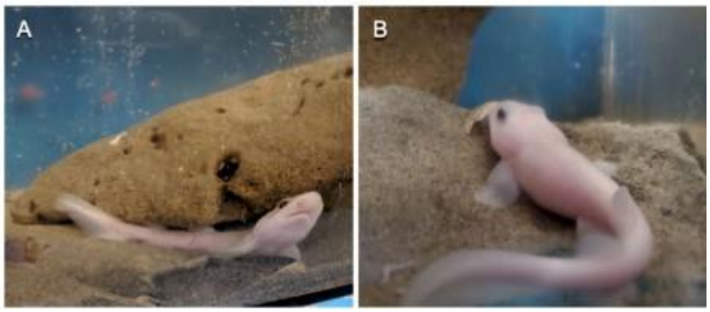

Figure 5. A newly hatched albino swell shark (*Cephaloscyllium ventriosum*) from parents of normal pigmentation on A November 7, 2019 (photo by Alma Trinidad Javier) and B December 13, 2019 (photo by Zachary Skelton).

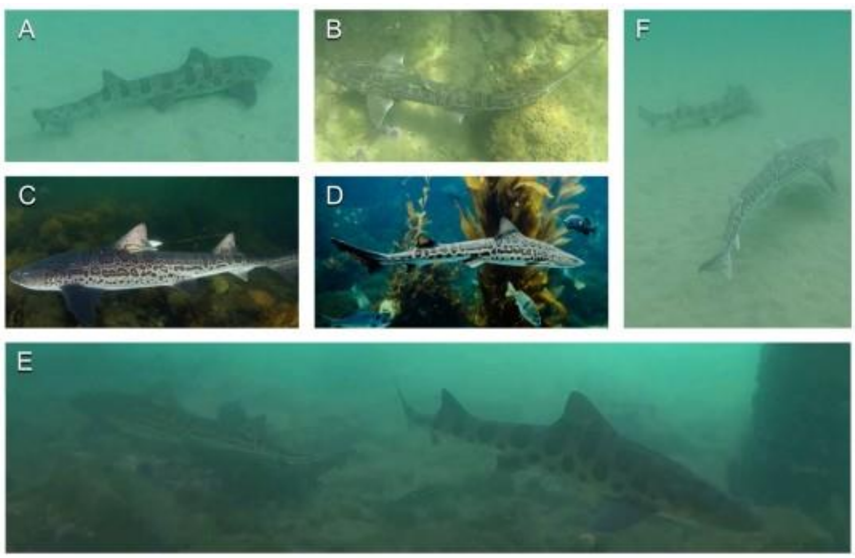

Figure 6. Comparison of the primary color morph with traditional saddle pattern (A, E [right] and F [top]), and the unusual secondary color morph (B–D, E [left], F [bottom]) in the leopard shark (*Triakis semifasciata*). These sharks were spotted in La Jolla, CA on August 10, 2015 (C by Ralph Pace Photography) and on September 8, 2020 (A, F by Zachary Skelton), under the Santa Cruz Island pier on August 16, 2020 (E, by Zachary Skelton), and from a captive individual at the Birch Aquarium (D, by Jordann Tomasek). The individuals with the secondary color morph reported here from La Jolla and Santa Cruz Island were encountered among aggregations of dozens of individuals with the primary color morph. The leopard shark pictured in C was equipped with a satellite tag; unfortunately, shark movement data was not recovered from the tag due to tag malfunction

Skelton, Z.R., Prinzing, T.S., Nosal, A.P., Vagner, Z., Demman, P., Zerofski, P.J. and Wegner, N.C., 2024. Observations of skin color aberrations in four shark species off the coast of southern California, USA. Environmental Biology of Fishes, 107(3), pp.391-400.

You Shall Not Pass: The Pacific Oxygen Minimum Zone Creates a Boundary to Shortfin Mako Shark Distribution in the Eastern North Pacific Ocean

Shoaling of large oxygen minimum zones (OMZs) that form along eastern margins of the world's oceans can reduce habitat availability for some pelagic fishes. Our aim was to test the hypothesis that habitat compression caused by shoaling of the Pacific OMZ in tropical regions creates a boundary to the southern distribution of shortfin mako sharks (*Isurus oxyrinchus*) in the Eastern North Pacific Ocean.

We compared environmental conditions between areas used by satellite-tagged mako sharks in the Eastern North Pacific, encompassing the world's largest OMZ, to those used in the Western North Atlantic where no OMZ is present. In the Pacific we quantified the effects of temperature and dissolved oxygen (DO) on depth use and tested if sharks spent less time in areas with strong habitat compression over the OMZ than expected by chance.

The southern distribution of sharks in the Pacific corresponded with the apex of OMZ shoaling in the North Equatorial Current. Sharks in the Atlantic occupied areas with warm surface temperatures (≥26°C) more often than the Pacific, and waters with these temperatures in the Atlantic had greater DO at depth. Sharks in the Pacific reduced time near the surface in warm temperatures and consistently avoided depths with low DO and spent less time in areas with strong habitat compression than expected by chance.

The combination of warm surface temperatures and shoaling of the OMZ creates a soft boundary to mako shark movements in the Eastern North Pacific Ocean. The expected expansion of OMZs due to climate change could have considerable impact on future distribution of mako sharks and other pelagic fish. As such, development of species distribution models to predict the effects of climate change on pelagic fish distributions should incorporate oxygen availability.

Byrne, M.E., Dewar, H., Vaudo, J.J., Wetherbee, B.M. and Shivji, M.S., 2024. You Shall Not Pass: The Pacific Oxygen Minimum Zone Creates a Boundary to Shortfin Mako Shark Distribution in the Eastern North Pacific Ocean. Diversity and Distributions, 30(12), p.e13924.

Spatial analysis of shortfin mako shark size compositions in the North Pacific Ocean

The ISC SHARKWG last assessed the North Pacific stock of shortfin mako shark (NP-SFM) in 2018. In preparation for the next assessment in 2024, the ISC SHARKWG is developing a conceptual model of the NP-SFM stock and using it to improve the 2024 assessment model. Discussions on the NP-SFM conceptual model showed that NP-SFM life history is complex and still highly uncertain in many aspects. These discussions indicated that the stock exhibit ontogenetic (and seasonal) shifts in spatial distribution.

In preparation for the next assessment in 2024, the ISC SHARKWG is developing a conceptual model of the NP-SFM stock and using it to improve the 2024 assessment model (SHARKWG 2023). Discussions on the NP-SFM conceptual model showed that NP-SFM life history is complex and still highly uncertain in many aspects. These discussions indicated that the stock exhibit ontogenetic (and seasonal) shifts in spatial distribution.

This study follows up on the conceptual model work and used a series of regression tree analyses, using the R package 'FishFreqTree', to examine the size compositions used in the 2018 assessment (1981 through 2016), as well as updated data through 2022 for some fisheries. These data were from 10 fisheries: 1) Japan Kinkai Shallow Longline (JPLL_KK); 2) Japan Coastal Longline (JPLL_C); 3) Japan Deep Longline (JPLL_D); 4) US Shallow Longline (USLL_S); 5) US Deep Longline (USLL_D); 6) Mexico Longline North (MXLL_N); 7) Mexico Longline South (MXLL_S); 8) Japan Drift Gill Net (JPDGN); 9) US Drift Gill Net (USDGN), and 10) Taiwan Large-scale Longline (TWLL). The aim is to identify areas with more consistent size compositions for each fishery and these areas with consistent size compositions could be used as candidate fishery definitions. The analyses were focused on three groups of fisheries in three regions.

We found that the three fisheries (JPLL_KK, USLL_S, and USDGN) have bimodal size compositions (Fig. 7). These bimodal size compositions likely indicate that these fisheries are composite fisheries fishing on different groups of fish. It may be useful to try separating these into their constituent fisheries to improve the consistency of the size compositions. Several of the fisheries (JPLL_KK, MXLL_N, USDGN, and USLL_S) also have relatively large proportions of fish <100 cm PCL, which indicate that at least part of the distributions of these fisheries overlap with the habitat of age-0 and age-1 fish.

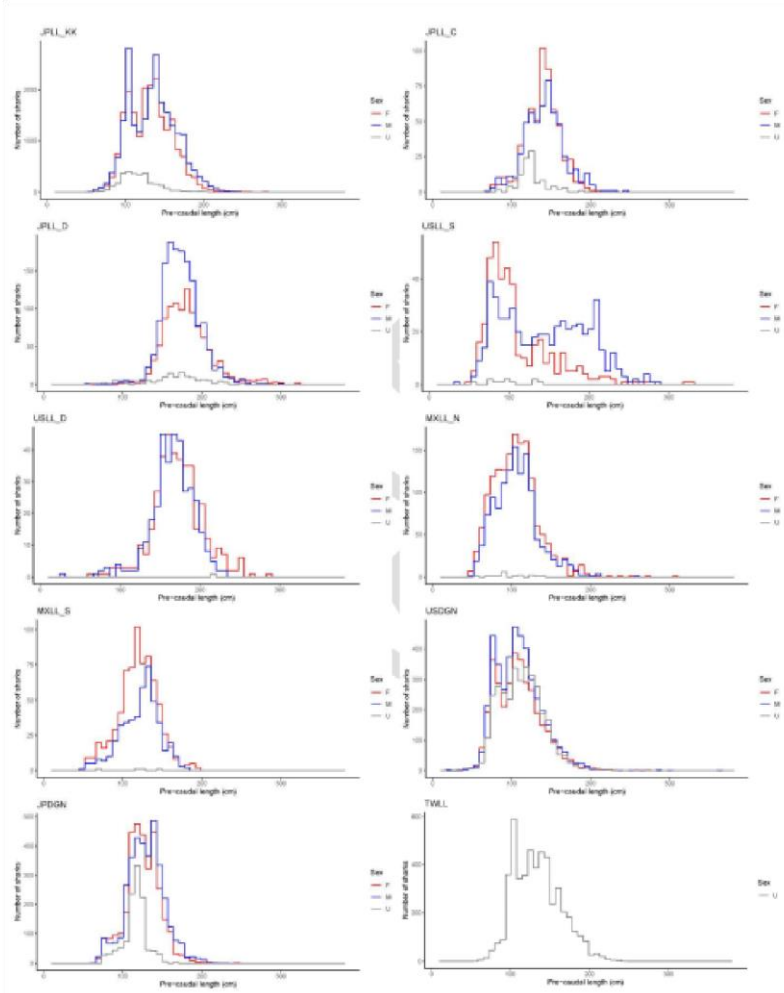

Figure 7. Sex- and fishery-specific size compositions using 7 cm bins. Only data with spatial resolutions of 5°x5° or finer are shown. Upper left corner of each panel indicate the fishery. See text for description of each fishery.

Teo, S.L., Carvalho, F., Castillo-Geniz, J.L., Ducharme-Barth, N.D., Kinney, M.J., Lui, K.M. and Semba, Y., Spatial analysis of shortfin mako shark size compositions in the North Pacific Ocean. ISC/23/SHARKWG-1/6.

Insights into vertebral band pair deposition rate in the juvenile common thresher shark (*Alopias vulpinus*) in the northeastern Pacific Ocean

Sustainable management of fishing activity on exploited shark populations requires accurate life-history information. Stock assessment models that incorporate age, growth, reproduction, and movement are essential for understanding populations. Quantitative assessments commonly rely on length or weight data of individuals caught. A common technique for estimating age in elasmobranchs is counting band pairs formed in vertebral centra. These band pairs are formed by cartilage matrices of contrasting calcification densities. A band pair consists of a more calcified (hypermineralized) band and a less calcified (hypomineralized) band, in either order, deposited adjacent to one another, with deposition occurring distal to the centrum focus. The rate at which band pairs are deposited within the vertebrae (band pair deposition rate) in sharks can vary within and across species, geographic locations, and throughout ontogeny.

We present a validation study of the vertebral band pair deposition rate for juvenile common thresher sharks *Alopias vulpinus* in the northeastern Pacific Ocean (NEPO) using tag and recapture with oxytetracycline (OTC) injection. A total of 14 juvenile *A. vulpinus* marked with OTC from 1998 through 2013 were recaptured with times at liberty ranging from 1.08 to 3.81 years with an average of 2.14 years (±0.97 years standard deviation, SD) (Figure 8). Shark size ranged from 80 to 128 cm fork length (LF) at the time of OTC injection and from 112 to 168 cm LF for those measured at recapture. The slopes of the relationships between band pairs post OTC and years at liberty for each reader ranged from 0.84 to 0.95, slightly lower than the 1.0 slope expected from annual band pair formation.

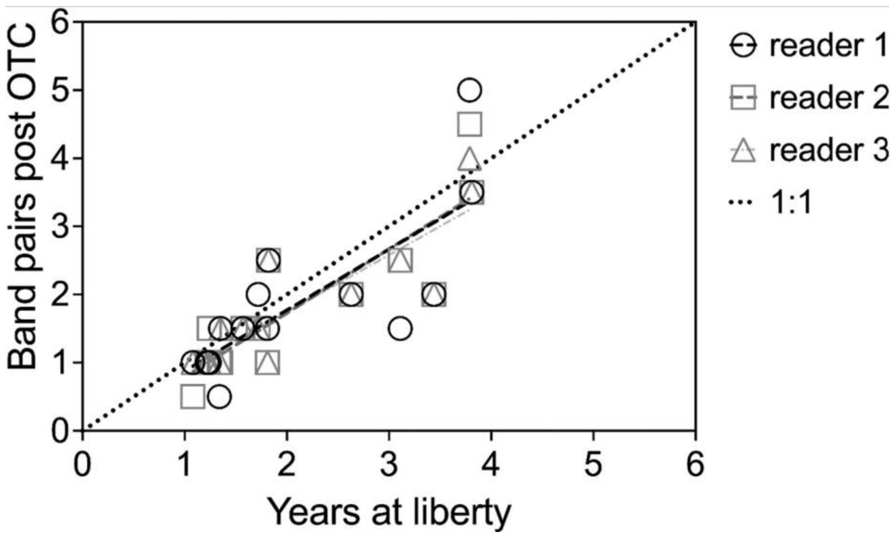

Figure 8. Number of vertebral band pairs after the oxytetracycline mark compared to days at liberty for *Alopias vulpinus* at liberty ≥1 year, tagged and recaptured in the northeastern Pacific Ocean (1998–2013) n = 14. The dashed lines represent the relationship of band pairs to days at liberty; the dotted line represents a 1:1 deposition rate of one band pair per year.

These findings preliminarily support previous age and growth assumptions based on a one band pair per year deposition rate. However, high variation in band pair deposition rates between samples, coupled with regression slopes falling just under one band pair per year, indicates that further investigation is needed to refine band pair deposition rate estimates.

Spear, L.N., Kohin, S., Mohan, J.A. and Wells, R.D., 2024. Insights into vertebral band pair deposition rate in the juvenile common thresher shark (Alopias vulpinus) in the northeastern Pacific Ocean. Journal of Fish Biology, 104(1), pp.104-112.

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Please contact Amanda Munro at (619) 407-9284 or amanda.munro@noaa.gov with any questions.

Sincerely,

Rachael Wadsworth

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Highly Migratory Species Branch Chief

cc: C. Colin Brinkman, Department of State
Ryan J. Wulff, U.S. Commissioner to the IATTC
Mike Thompson, Alternate U.S. Commissioner to the IATTC
John Zuanich, Alternate U.S. Commissioner to the IATTC
Shana Miller, Alternate U.S. Commissioner to the IATTC

Administrative File: 150413SWR2013SF00273:ALM

Enclosure

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C-11-10

In 2023, National Marine Fisheries Service (NMFS) observers recorded one oceanic whitetip shark caught by a U.S. deep-set longline vessel fishing in the eastern Pacific Ocean (EPO). It was released alive.

C-15-04

In 2023, two mobulid rays were caught by U.S. deep-set longline vessels in the EPO. They were released alive.

C-16-05

There were no interactions with silky sharks observed in shallow-set or deep-set longline trips in 2023.

One smooth hammerhead shark was caught by a deep-set longline vessel in the EPO. It was returned dead.

C-21-06

As mentioned above under C-16-05, in 2023, there were no interactions with silky sharks observed in shallow-set or deep-set longline trips in the EPO.

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U.S. REGULATORY CHANGES IN 2023

U.S. National Level Updates

On April 6th, 2023 NMFS received a petition to list the whitespotted eagle ray (*Aetobatus narinari*) as threatened or endangered and designate critical habitat. It is currently awaiting a 90-day finding.

On May 23rd, 2023 NMFS issued a positive 90-day finding for the smalltail shark (*Carcharhinus porosus*) under the Endangered Species Act. NMFS has commenced a review of the status of the smalltail shark to determine whether listing under the ESA is warranted.

U.S. West Coast States Updates

There were no new rules pertaining to shark conservation implemented in 2023 in California, Oregon or Washington.

UPDATES ON SHARK RESEARCH IN 2023

The SWFSC's shark research program focuses on shark species that occur along the U.S. Pacific coast, including Shortfin Mako (*Isurus oxyrinchus*), Blue Shark (*Prionace glauca*), Basking Shark (*Cetorhinus maximus*), and three species of thresher sharks: Common Thresher (*Alopias vulpinus*), Bigeye Thresher (*Alopias superciliosus*), Pelagic Thresher (*Alopias pelagicus*), California Horn Sharks (*Heterodontus francisci*), and Leopard Shark (*Triakis semifasciata*). Center scientists have studied the sharks' life history, foraging ecology, distribution, movements, stock structure, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks.

Impacts of Marine Heatwaves on top Predator Distributions are Variable but Predictable

Marine heatwaves cause widespread environmental, biological, and socio-economic impacts, placing them at the forefront of 21st-century management challenges. Faced with a changing climate, mobile species' first responses are often to shift their geographic ranges to remain within suitable environmental conditions. However, heatwaves vary in intensity and evolution, and a paucity of information on how this variability impacts marine species limits our ability to proactively manage for these extreme events.

Statistical models provide a means of interpolating across space, time, and taxa, providing information on MHW-driven redistribution by offering inferences on unobserved locations, MHWs, and individuals. Furthermore, statistical models can relate species distributions to multiple environmental drivers, thereby accounting for the complex physical and biogeochemical changes beyond the increased temperature that occurs during MHWs. We modeled the effects of four major North Pacific MHWs (2014, 2015, 2019, 2020) on the spatial distributions of 14 marine top predators, spanning several major guilds: sharks, tunas, seabirds, mammals, and turtles (Figure 1) of ecological, cultural, and commercial importance.

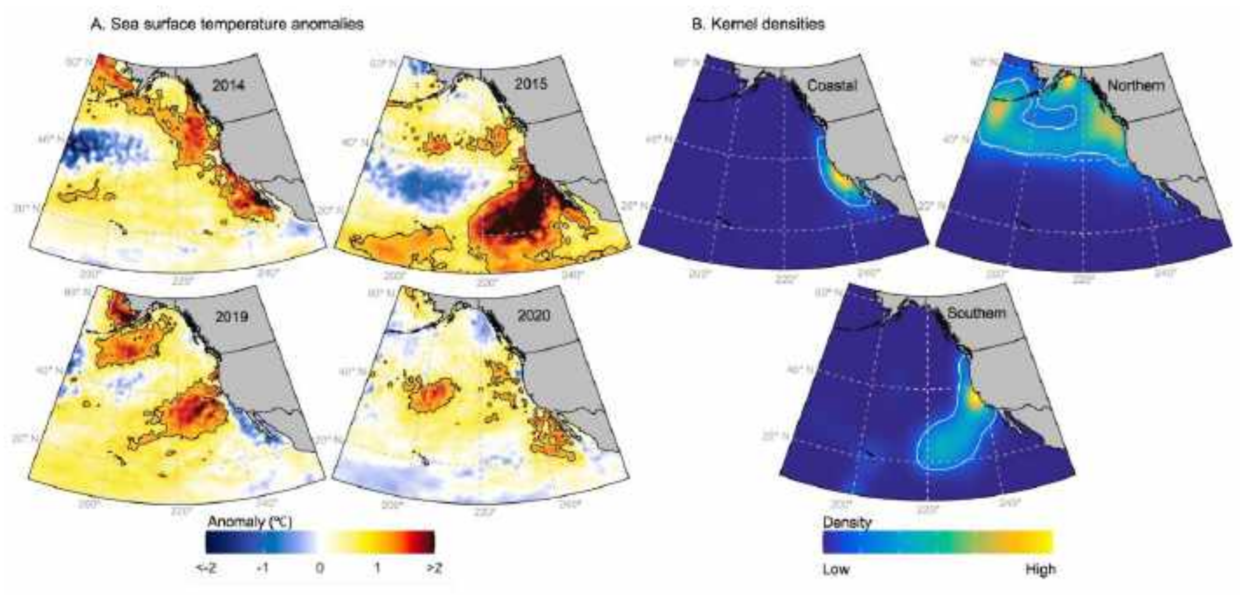

Figure 1. A. Mean sea surface temperature anomaly in August–October (the months in which the highest temperature anomalies were observed across the Pacific), calculated relative to a 2000–2020 baseline for each of the four MHW events explored, with 1.5°C contour in black. B. Species kernel densities while foraging and transiting in the Northeastern Pacific, grouped by the location of animal tracking data (2000–2010). The 75th percentile kernel for each species group is shown by the white contour. Coastal species include blue and mako sharks, yellowfin, albacore, and bluefin tuna, California sea lions, sooty shearwaters, and blue whales; Northern species include elephant seals, salmon sharks, black-footed and Laysan albatross; Southern species include white sharks and leatherback turtles.

Our models accurately predicted distribution shifts during MHW years captured by an extensive (>one million records) independent top predator dataset collated from public, private, and government tagging programs, shipboard surveys, opportunistic sightings, and fisheries observer programs.

Predicted responses were highly variable across species and heatwaves, ranging from near total loss of habitat to a two-fold increase. Heatwaves rapidly altered political bio-geographies, with up to 10% of predicted habitat across all species shifting jurisdictions during individual heatwaves. For example, while all Coastal species were displaced to the northwest during the 2014 and 2015 events, the 2019 and/or 2020 events drove southeastward displacement for bluefin and albacore tuna, and blue and mako shark.

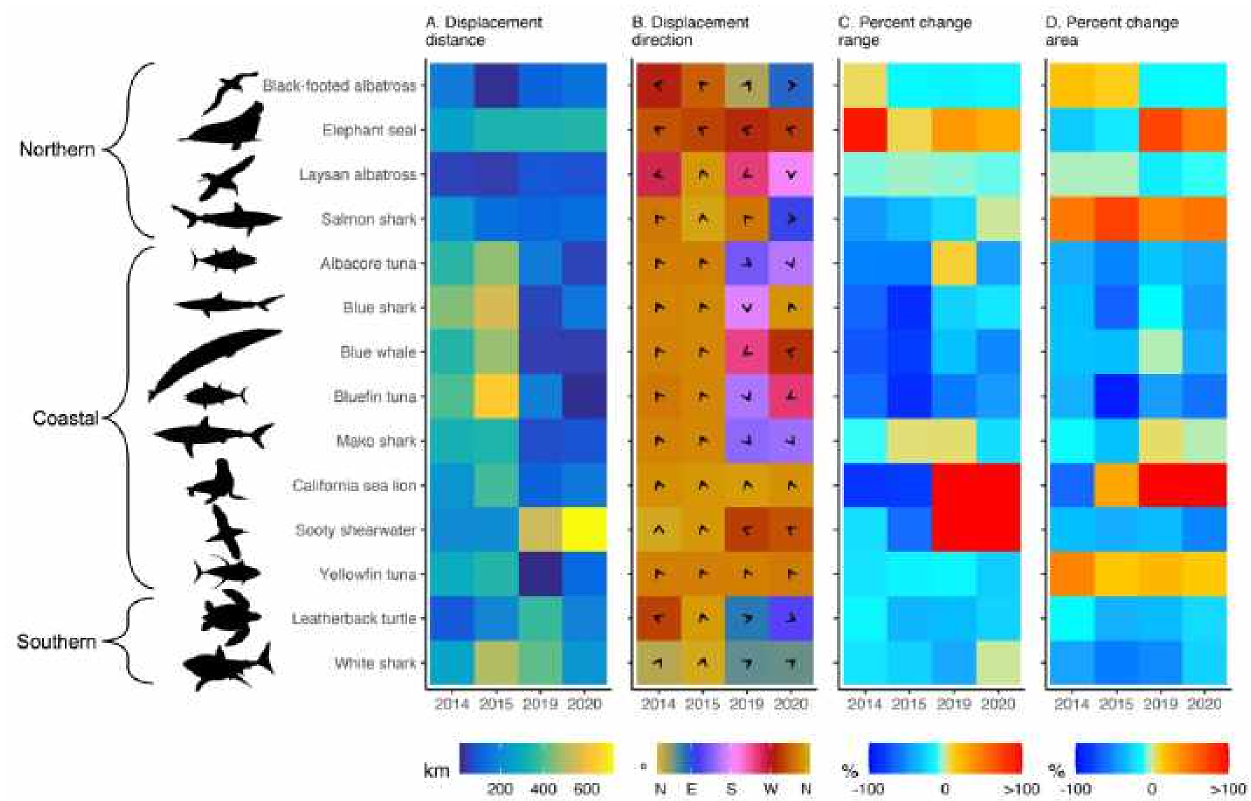

Figure 2. A. Displacement distance (kilometers), B. displacement direction (degrees, where 0/360 is north (N), 90 is east (E), 180 is south (S), and 270 is west (W)), C. range compression or expansion (percent change relative to baseline conditions), D. habitat area gain or loss (percent change relative to baseline conditions). All metrics were calculated from August–October in each MHW year relative to baseline conditions (August–October 2000–2020). Northern, Coastal, and Southern regional groupings indicate the geographies where the majority of the species telemetry data occurs.

The variability in predicted responses across species and heatwaves portends the need for novel management solutions that can rapidly respond to extreme climate events. Between 10 and 31% of the predicted habitat of commercially valuable albacore, bluefin, and yellowfin tuna shifted from Mexico to the US; indeed, an unusual abundance of yellowfin and bluefin tuna was reported by California commercial and recreational fishers during the 2014 and 2015 event. Up to 39% of threatened white shark habitat shifted into the US waters from the high seas—the largest redistribution of any species. Although redistributed white sharks may benefit from low bycatch rates in US waters, higher white shark prevalence may lead to increasing predation rates of protected pinnipeds and associated ecosystem effects such as reduced kelp cover.

Dynamic ocean management tools are designed to translate changing environmental and biological information into real-time management recommendations, and have shown promise at keeping pace with anomalous ecological conditions during MHW events. As proof-of-concept, we developed an operational dynamic ocean management tool (https://oceanview.pfeg.noaa.gov/top-predator-watch/) that predicts predator distributions and responses to extreme conditions in near real-time. These early warning systems would allow for proactive—as opposed to reactive—responses to new human-wildlife conflicts, changing marine resource availability, and emergent refugia caused by MHWs, allowing us to plan ahead for our fundamentally dynamic world.

Welch, H., Savoca, M.S., Brodie, S., Jacox, M.G., Muhling, B.A., Clay, T.A., Cimino, M.A., Benson, S.R., Block, B.A., Conners, M.G., Costa, D.P., Jordan, F.D., Leisong, A.W., Mikles, C.S., Palacios, D.M., Shaffer, S.A., Thorne, L.H., Watson, J.T., Holser, R.R., Dewitt, L., Bograd, S.J., Hazen, E.L. 2023. Impacts of marine heatwaves on top predator distributions are variable but predictable. Nat Commun 14, 5188. https://doi.org/10.1038/s41467-023-40849-y

Divergent Responses of Highly Migratory Species to Climate Change in the California Current

Climate change is predicted to trigger significant changes in ocean circulation and environmental conditions, making it a pressing threat to marine species. In response to ongoing climate change, species may shift their range in search of more favorable habitats, disappearing locally or in some cases, globally from their current ranges. Changing distributions of vulnerable species are expected to affect the efficacy of management strategies, such as marine protected areas, if the distribution or timing of species' migrations shift in response to changing ocean conditions. At the same time, changes in the location of target species or in the timing of fishing seasons may have important economic implications for local coastal communities and conservation concerns for future bycatch mitigation.

Species distribution models (SDMs) are commonly used as tools to explore relationships between species occurrences, abundance or behavior and environmental variables (Elith & Leathwick, 2009). We project suitable habitat for 10 highly migratory species [blue shark (*Prionace glauca*), swordfish (*Xiphias gladius),* thresher shark (*Alopias vulpinus*), shortfin mako shark (*Isurus oxyrinchus*), leatherback sea turtle (*Dermochelys coriacea*), California sea lion (*Zalophus californianus*), humpback whale (*Megaptera novaeangliae*), fin whale (*Balaenoptera physalus*), northern right-dolphin whale (*Lissodelphis borealis*) and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)] in the California Current System using an ensemble of three high-resolution (~10km) downscaled ocean projections under the Representative Concentration Pathway 8.5 (RCP8.5). Spanning the period from 1980 to 2100, our analysis focuses on assessing the direction and distance of distributional shifts, as well as changes in core habitat area for each species. This work represents a substantial advance from previous studies for the most economically and ecologically important HMS in the CCS.

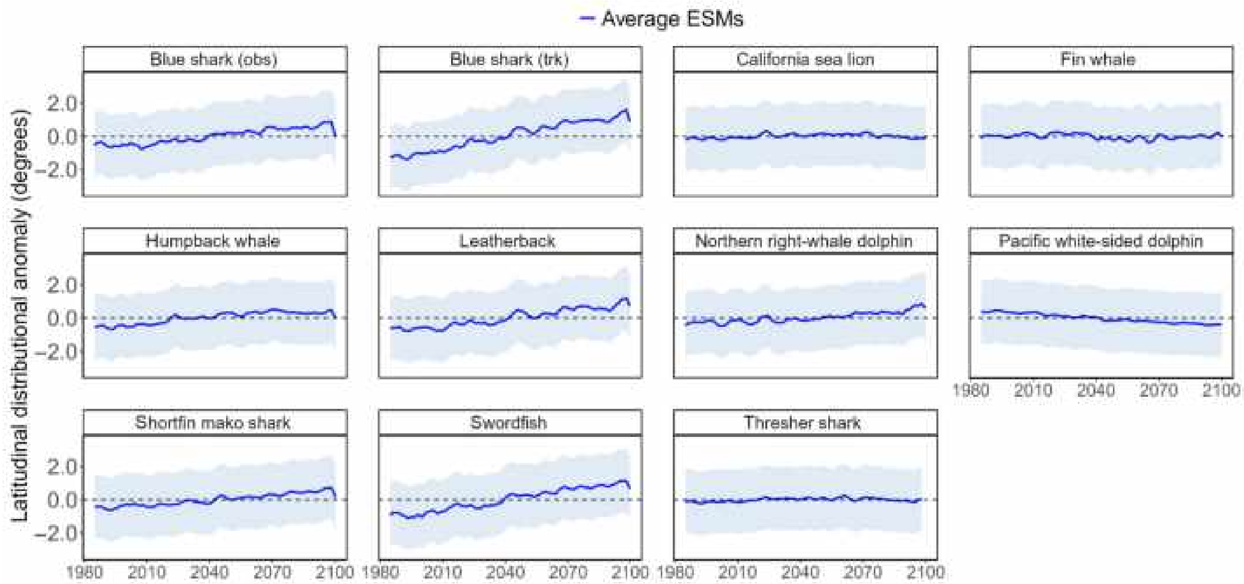

Figure 3. Time series of the projected change in the latitudinal distributional anomaly (in degrees). Results are shown for the average of the 3 ESMs (dark blue line) and their corresponding spread (standard deviation shaded in light blue). The latitudinal distributional anomaly was calculated by subtracting the average centre of gravity given by north–south dimension across species (1980–2100) from each day in the projected period. Species ordered alphabetically. obs, observer data; trk, tracking data.

Our findings reveal a divergent response among species to climate impacts. Specifically, four species (blue shark, swordfish, leatherback turtle, shortfin mako shark) were projected to undergo significant poleward shifts exceeding 100km, and gain habitat (~7%–60%) in response to climate change. Conversely, six species (Northern right whale dolphin, California sea lion, humpback whale, common thresher shark, Pacific white-sided dolphin, fin whale) were projected to shift towards the coast, resulting in a loss of habitat ranging from 10% to 66% by the end of the century. These divergent responses could typically be characterized by the mode of thermoregulation (i.e., ectotherm vs. endotherm) and species' affiliations with cool and productive upwelled waters that are characteristic of the region. Furthermore, our study highlights an increase in niche overlap between protected species and those targeted by fisheries, which may lead to increased human interaction events under climate change.

By providing valuable species distribution projections, our research contributes to the understanding of climate change effects on marine biodiversity and offers critical insight and support for developing climate-ready management of protected and fished species.

Lezama-Ochoa, N., Brodie, S., Welch, H., Jacox, M.G., Pozo Buil, M., Fiechter, J., Cimino, M., Muhling, B., Dewar, H., Becker, E.A., Forney, K.A., Costa, D., Benson, S.R., Farchadi, N., Braun, C., Lewison, R., Bograd, S., and Hazen, E.L. 2023. Divergent responses of Highly Migratory Species to climate change in the California Current. ***https://doi.org/10.1111/ddi.13800***

The Allometric Scaling of Oxygen Supply and Demand in the California Horn Shark, *Heterodontus Francisci*

The gill surface area of aquatic ectotherms is thought to be closely linked to the ontogenetic scaling of metabolic rate, a relationship that is often used to explain and predict ecological patterns across species. However, there are surprisingly few within-species tests of whether metabolic rate and gill area scale similarly.

We examined the allometric scaling between oxygen supply (gill surface area) and demand (metabolic rate) using paired estimates of gill surface area with resting and maximum metabolic rates in 20 California horn shark (*Heterodontus francisci*) individuals over a wide body-size range representing nearly the full ontogeny of the species. To determine how California horn sharks increase their gill surface area as they grow in size, we also examined the allometric scaling of each gill surface area component (filament length, lamellar frequency and lamellar surface area) and compared each estimate with the values expected under surface-area-to-volume relationships.

We found that the allometric slope of resting metabolic rate was 0.966±0.058 (±95% CI), whereas that of maximum metabolic rate was somewhat steeper (1.073±0.040) (see Figure 4 below). We also discovered that the scaling of gill area shifted with ontogeny: the allometric slope of gill area was shallower in individuals <0.203kg in body mass (0.564±0.261), but increased to 1.012±0.113 later in life (see Figure 4 below). This appears to reflect changes in demand for gill-oxygen uptake during egg case development and immediately post hatch, whereas for most of ontogeny, gill area scales in between that of resting and maximum metabolic rate. These relationships differ from predictions of the gill oxygen limitation theory, which argues that the allometric scaling of gill area constrains metabolic processes.

The relationship between metabolic rate and gill surface area show that for some species, such as the relatively inactive California horn shark, the allometric slope of metabolic rate and gill surface area can approach or even exceed b=1.0. Thus, for the California horn shark, metabolic rate does not appear limited by theoretical surface-area-to-volume ratio constraints of gill area. The unusually steep allometric slopes found here emphasize the need for more work examining these traits in species of varying activity levels and across ecological lifestyles. Finally, the inflection point found in the allometric scaling of gill surface area in the California horn shark highlights the importance of examining a species' complete body-size range in allometric studies and the potential importance of life-stage-dependent influences on allometric slopes.

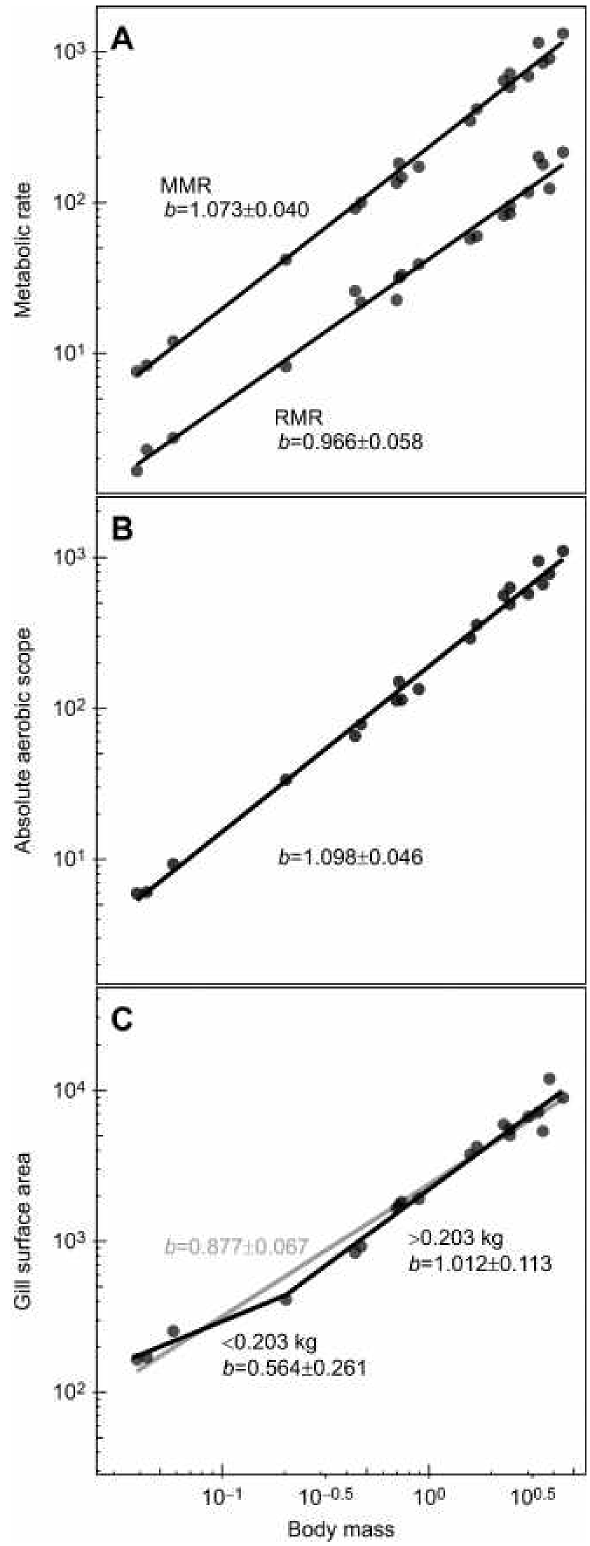

Figure 4. Allometric scaling of resting metabolic rate (RMR), maximum metabolic rate (MMR), absolute aerobic scope and gill surface area (GSA) in the California horn shark, *Heterodontus*

francisci, as a function of body mass on a log10–log10 scale. (A) RMR and MMR (both mg O2 h−1), (B) absolute aerobic scope (mg O2 h−1) and (C) GSA (cm2). Metabolic data were determined at 18.2±0.2°C (mean±s.d.). The relationship of GSA with body mass (C) is shown using both the better-fit broken stick regression (solid black line) compared with the ordinary least squares regression (gray line). Allometric slopes are shown for each regression segment.

Prinzing, T.S, Bigman, J.S., Skelton, Z.R., Dulvy, N.K., and Wegner, N.C . 2023. The allometric scaling of oxygen supply and demand in the California horn shark, Heterodontus francisci. J. Exp. Biol. 226: jeb246054. https://doi.org/10.1242/jeb.246054

Laboratory-based measures of temperature preference and metabolic thermal sensitivity provide insight into the habitat utilisation of juvenile California Horn Shark (*Heterodontus francisci*) and Leopard Shark (*Triakis semifasciata*).

Understanding species-specific behavioural and physiological responses to temperature is important for understanding fish habitat utilisation in the face of changing temperatures, whether it be in response to broader scale changes, such as anthropogenic-induced climate change, or more local changes, such as habitat alteration associated with human encroachment (e.g., changing bay or estuary circulation patterns through development and dredging or thermal effluents). Insights into elasmobranch behavioural thermoregulation are often derived from in situ movement data from tagging and tracking studies used to examine habitat utilisation. Nonetheless, isolating the direct effect of temperature on fish movements and behaviour can be difficult as various environmental and biological drivers of habitat utilisation can act simultaneously and may co-vary with temperature. Laboratory-based studies examining fish physiological and behavioural responses to temperature can provide important insight into species-specific habitat preferences and utilisation, and are especially useful in examining vulnerable life stages that are difficult to study in the wild. This study couples shuttle box behavioural experiments with respirometry trials to determine the temperature preferences and metabolic thermal sensitivity of juvenile California horn shark (*Heterodontus francisci*) and leopard shark (*Triakis semifasciata*).

As juveniles, California horn shark and leopard shark often occupy similar estuarine habitats but display contrasting behaviours and activity levels – *H. francisci* are relatively sedentary, whereas *T. semifasciata* are more active and mobile. As co-occurring species with contrasting behaviours and activity levels, *H. francisci* and *T. semifasciata* serve as good model organisms to understand how temperature may drive habitat utilisation.

The preferred temperature and occupied temperature range of *H. francisci* and *T. semifasciata* determined through shuttle box experimentation did not differ significantly between species, acclimation treatment or sex, though *H. francisci* metabolism is more sensitive to acute changes in temperature as expressed through a higher Q10 (*H. francisci* = 2.58; *T. semifasciata* = 1.97; temperature range: 12–24°C). Likewise, both species generally showed similar lower and upper bound temperatures around their preferred mean temperature, although the effect of acclimation on the upper bound temperature was near the significance threshold ($P = 0.05524$), likely due to warm-acclimated horn sharks which exhibited a trend of exploring warmer upper bound temperatures. Underlying chronic temperature acclimation to both warm (21°C) and cool (15°C) representative seasonal temperatures did not appear to significantly affect these parameters.

These results are discussed in the context of field studies examining known distributions, habitat and movement patterns of *H. francisci* and *T. semifasciata* to better understand the role of temperature in species-specific behaviour. This work indicates that Juvenile *H. francisci* likely target thermally stable environments, such as estuaries that are close to their preferred temperature, whereas juvenile *T. semifasciata* metabolism and behaviour appear less dependent on temperature. Baseline assessments linking physiology and behaviour, such as presented in our study, are critical for understanding species-specific and life-stage-specific drivers of habitat selection, particularly in the face of changing environmental conditions.

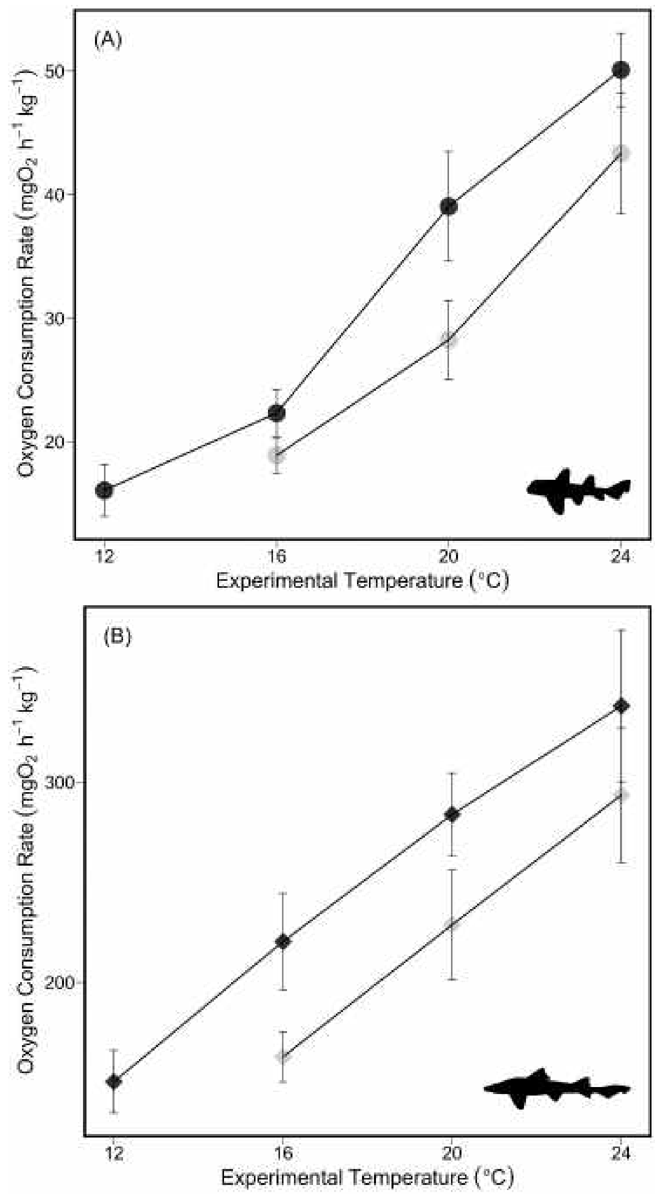

Figure 5. Mean (± S.E.) resting oxygen consumption rates (MO2) at each experimental temperature during each acclimation treatment for (a) *Heterodontus francisci* and (b) *Triakis semifasciata*. (a) For warm-acclimated *H. francisci*, n = 10 at 12, 16 and 20°C and n = 9 at 24°C; for cold-acclimated *H. francisci*, n = 5 at all experimental temperatures. Acclimation temperature: 15°C (black diamonds) and 21°C (grey circles). (b) For warm-acclimated *T. semifasciata*, n = 8 at all experimental temperatures; for cold-acclimated *T. semifasciata*, n = 7 at 12, 16 and 20°C and n = 5 at 24°C. Acclimation temperature: 15°C (black diamonds) and 21°C (grey circles).

Skelton, Z.R., Prinzing, T.S., Hastings, P.A. and Wegner, N.C. 2023. Laboratory-based measures of temperature preference and metabolic thermal sensitivity provide insight into the

habitat utilisation of juvenile California Horn Shark (Heterodontus francisci) and Leopard Shark (Triakis semifasciata). Journal of Fish Biology. ***https://doi.org/10.1111/jfb.15307***

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

March 31, 2023

Dr. Arnulfo Franco, Executive Director
Inter-American Tropical Tuna Commission (IATTC)
8901 La Jolla Shores Drive
La Jolla, California 92037-1509

Subject: Data Submissions under IATTC Resolutions Related to Elasmobranchs

Dear Dr. Franco,

The United States is submitting this letter, enclosed report, and Excel workbook on information for calendar year 2022, pursuant to the IATTC Resolutions listed below.

- Resolution C-05-03: *Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean*.
- Resolution C-11-10: *Resolution on the Conservation of Oceanic Whitetip Sharks Caught in Association with Fisheries in the Antigua Convention Area*.
- Resolution C-15-04: *Resolution on the Conservation of Mobulid Rays Caught in Association with Fisheries in the IATTC Convention Area*.
- Resolution C-16-05: *Resolution on the Management of Shark Species*.
- Resolution C-21-06: *Conservation Measures for Shark Species, with Special Emphasis on the Silky Shark, for the Years 2022 and 2023*.

Please contact Amanda Munro at (619) 407-9284 or *amanda.munro@noaa.gov* with any questions.

Sincerely,

Rachael Wadsworth

Rachael Wadsworth
Acting Highly Migratory Species Branch Chief

cc: Carolyn Gruber, Department of State
William Fox, Jr., U.S. Commissioner to the IATTC
Ryan J. Wulff, Alternate U.S. Commissioner to the IATTC
Mike Thompson, Alternate U.S. Commissioner to the IATTC
John Zuanich, Alternate U.S. Commissioner to the IATTC
Administrative File: 150413SWR2013SF00273:ALM

Enclosure

2022 ALL RESOLUTIONS PERTAINING TO SHARK CONSERVATION

This report contains information for U.S. deep-set and shallow-set longline fisheries in the IATTC Convention Area relevant to the respective Inter-American Tropical Tuna Commission (IATTC) elasmobranch resolutions (C-05-03, C-11-10, C-15-04, C-16-05, C-21-06). The IATTC maintains all observer information for U.S. purse seine vessels and as such already has access to reports of observed interactions with mobulids, oceanic whitetip shark (*Carcharhinus longimanus*), silky shark (*Carcharhinus falciformis*), and hammerhead shark (*Sphryna spp.*) caught in that fishery.

C-11-10

In 2022, National Marine Fisheries Service (NMFS) observers recorded three oceanic whitetip shark caught by U.S. deep-set longline vessels fishing in the eastern Pacific Ocean (EPO). All were released alive.

C-15-04

In 2022, one mobulid ray was caught by a deep-set longline vessel in the EPO. It was released alive.

C-16-05

There were no interactions with silky sharks observed in shallow-set or deep-set longline trips in 2022.

One smooth hammerhead shark was caught by a deep-set longline vessel in the EPO. It was released alive.

C-21-06

As mentioned above under C-16-05, in 2022, there were no interactions with silky sharks observed in shallow-set or deep-set longline trips in the EPO.

2022 U.S. SHARK REPORT TO THE INTER-AMERICAN TROPICAL TUNA COMMISSION: AS REQUIRED PER RESOLUTION C-05-03

The IATTC adopted Resolution C-05-03 (*Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean)* in 2005. Under paragraph 11, the Resolution requires that members and cooperating non-members (CPCs) provide the IATTC Secretariat with a comprehensive annual report that includes data on sharks caught in association with fisheries managed by the IATTC. These data include "catches, effort by gear type, landing, and trade of sharks by species, where possible, in accordance with IATTC reporting procedures, including available historical data." In addition, the Resolution encourages CPCs to conduct research on sharks to identify ways to increase the selectivity of fishing gears, identify shark nursery areas, and provide assistance to developing countries to increase the collection of shark catch data in those countries. This report is being submitted to the IATTC Secretariat to provide updates on relevant shark research conducted by the United States in 2022, to fulfill the U.S. reporting obligations for 2023, and to provide updates on any domestic U.S. regulations that could impact sharks and shark fisheries in the IATTC Convention Area.

DATA SUBMITTED SEPARATELY

The United States submits catch, effort, and landings data on sharks caught by U.S.-flagged vessels in fisheries for tuna and tuna-like species in the IATTC Convention Area as part of its annual report to the IATTC as required under Resolution C-03-05 (*Resolution on Data Provision*). The United States provides catch and effort data by fishing gear at Level 3, the international standard for such data.

UPDATES ON SHARK RESEARCH IN 2022

NMFS' Southwest Fisheries Science Center (SWFSC) shark research program focuses on pelagic sharks that occur along the U.S. Pacific coast, including shortfin mako, blue shark, basking shark (*Cetorhinus maximus)*, and three species of thresher sharks: common thresher (*Alopias vulpinus*)*,* bigeye thresher (*Alopias superciliosus*)*,* and pelagic thresher (*Alopias pelagicus)*. SWFSC scientists have studied the sharks' life history, foraging ecology, distribution, movements, stock structure, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks.

Global-scale environmental niche and habitat of blue shark (*Prionace glauca*) by size and sex: a pivotal step to improving stock management.

Blue shark is amongst the most abundant shark species in international trade. Like many other shark species, they are segregated by size and sex throughout their range. Given that the impact of fisheries removals differs depending on both size and sex, it is important to better understand distributions and their overlap with fisheries both geographically and vertically. With the relatively high landings and the recent electronic tagging programs, a large volume of data is available on the occurrence and movements of blue sharks globally, although these datasets had not been combined. We combined 265,595 blue shark observations (capture or satellite tag) with environmental data to present the first global-scale analysis of blue shark habitat preferences for five size and sex classes (small juveniles, large juvenile males and females, adult males and females). We leveraged the understanding of blue shark biotic environmental associations to develop two indicators of foraging location: productivity fronts in mesotrophic areas and mesopelagic micronekton in oligotrophic environments.

To capture the horizontal and vertical extent of thermal habitat for the blue shark, we defined the temperature niche relative to both sea surface temperature (*SST*) and the temperature 100 m below the mixed layer depth ($T_{mld+100}$). An example of the modeled quarterly distribution of small juveniles is shown in Figure 1. We show that the lifetime foraging niche incorporates highly diverse biotic and abiotic conditions: the Blue shark tends to shift from mesotrophic and temperate surface waters during juvenile stages to more oligotrophic and warm surface waters for adults.

However, low productivity limits all classes of blue shark habitat in the tropical western North Atlantic, and both low productivity and warm temperatures limit habitat in most of the equatorial Indian Ocean (except for the adult males) and Tropical Eastern Pacific Ocean. Large females tend to have greater habitat overlap with small juveniles than large males, more defined by temperature than productivity preferences. In particular, large juvenile females tend to extend their range into higher latitudes than large males, likely due to greater tolerance to relatively cold waters. Large juvenile and adult females also seem to avoid areas with intermediate *SST* (~21.7-24.0°C), resulting in separation from large males mostly in the tropical and temperate latitudes in the cold and warm seasons, respectively. A greater understanding of sex- and size- specific habitat preferences of blue sharks will contribute to management and projections of shifts in distributions associated with climate variability over long- and short-time scales.

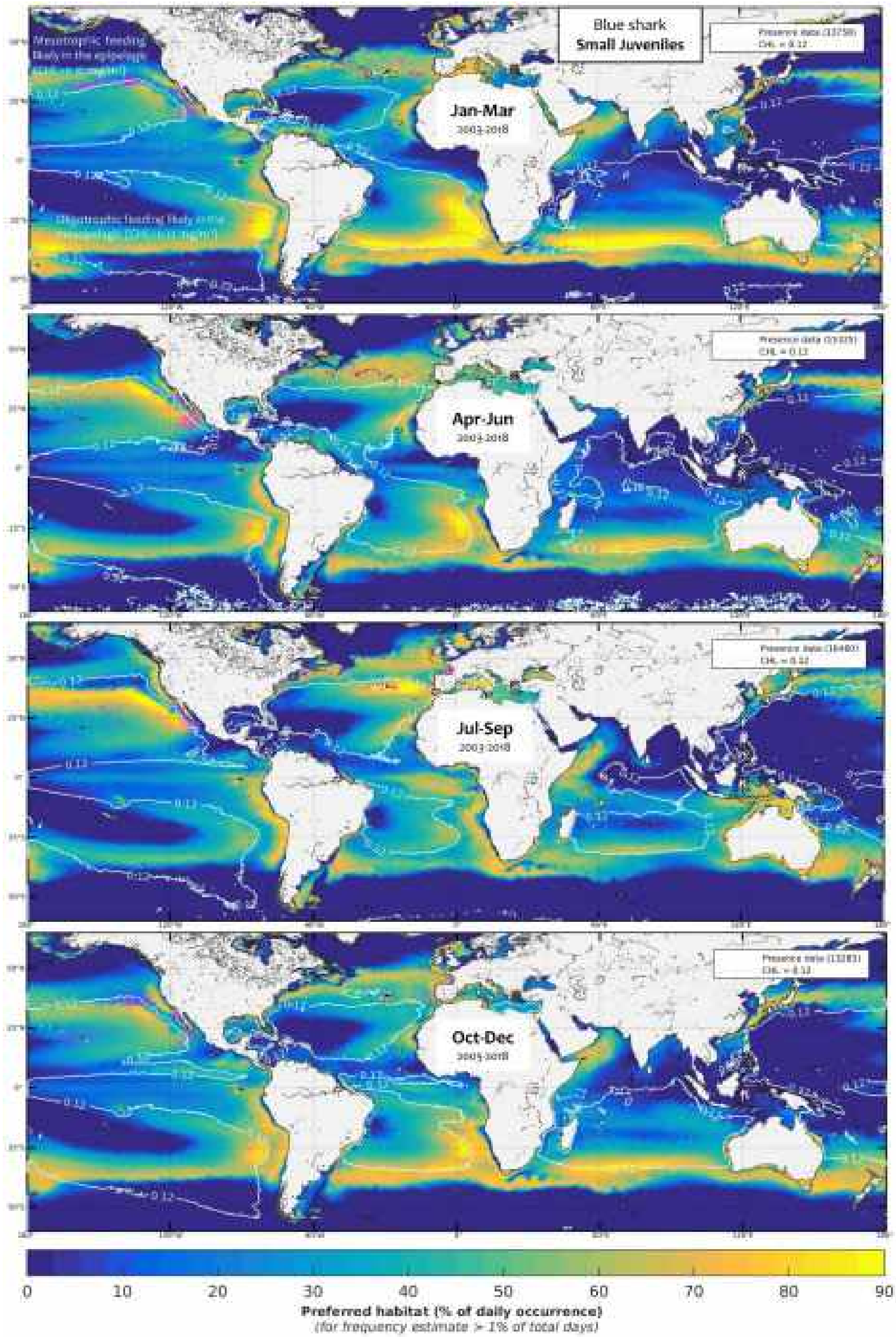

Figure 1: Mean seasonal distribution of blue shark foraging habitat for the small juveniles (SJ, 2003-2018, in frequency of suitable habitat occurrence, %). The chlorophyll-a isocontour of 0.12 mg.m^{-3} (CHL_{min}) separates the mean area of oligotrophic foraging (below this value using mesopelagic micronekton as foraging proxy) and mesotrophic foraging (above this value using productivity fronts). Presence data (calibration and validation) are represented as pink dots for observer data and colored line transects for electronic tagging data (start and end of months are shown by a black star).

Druon, J. N., Campana, S., Vandeperre, F., Hazin, F. H., Bowlby, H., Coelho, R., ... & Travassos, P. 2022. Global-scale environmental niche and habitat of Blue shark (Prionace glauca) by size and sex: a pivotal step to improving stock management. Front. Mar. Sci. 9:828412. https://doi.org/10.3389/fmars.2022.828412

Diving into the vertical dimension of elasmobranch movement ecology

Knowledge of the three-dimensional movement patterns of elasmobranchs is vital to understanding their ecological roles and exposure to anthropogenic pressures. To date, comparative studies among species at global scales have mostly focused on horizontal movements. This study addresses the knowledge gap of vertical movements by compiling the first global synthesis of vertical habitat use by elasmobranchs from data obtained by the deployment of 989 biotelemetry tags on 38 elasmobranch species (Figure 2).

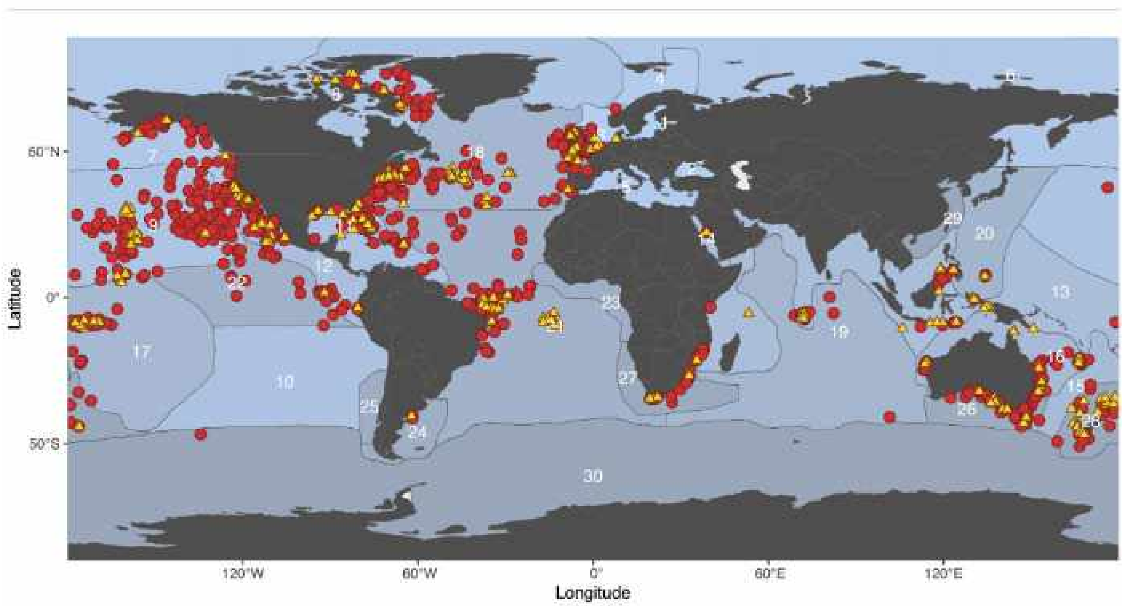

Figure 2. Yellow triangles indicate deployment and red circles indicate pop-up and/or recapture of the 989 elasmobranchs included within the analysis for this study. Numbers refer to the ocean biogeographic realms. Pop-up locations were not available for 144 tags.

For this study NOAA Southwest Fisheries Science Center provided data on common thresher, shortfin mako and blue sharks.

Elasmobranchs displayed a high intra- and inter-specific variability in vertical movement patterns (Figure 3). While almost all species exhibited diel vertical movements, patterns were variable with neutral and reverse diel movements also relatively common. Substantial vertical overlap was observed for many epipelagic species indicating an increased likelihood to interact and share similar risks to anthropogenic threats that vary on vertical gradients.

This large-scale modeling approach can inform management efforts, especially in regions where vertical behavioral data are absent. We highlight the critical next steps towards incorporating vertical movement info global management and monitoring strategies for elasmobranchs. We emphasize the need to address geographic and taxonomic biases in deployment and to concurrently consider both horizontal and vertical movements and overlay these with anthropogenic threats in three dimensions.

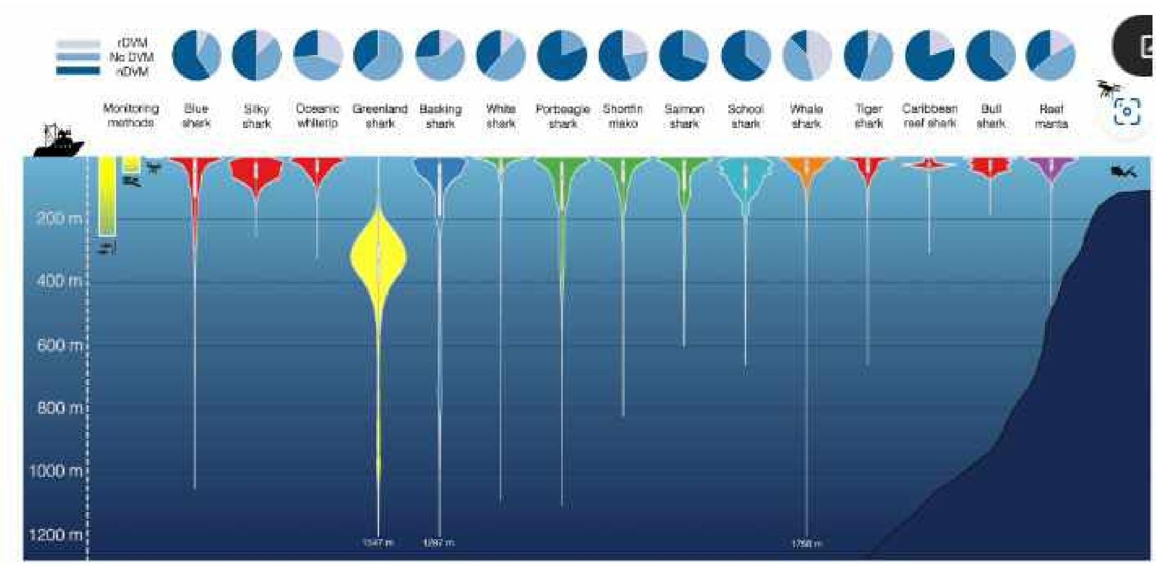

Figure 3: The hourly median depth distributions of 15 species determined from hourly median depths. Only species with >1000 days of depth time-series data were included. Violin plots represent the full distribution of the data, with colors relating to family. Boxplots depict the lower quartile, upper quartile, and median, with whiskers extending from the shallowest to the deepest depths. Whiskers are capped to 1200 m. Bars represent the estimated detection zones of aerial surveys (top 5 m), scuba-diving surveys (top 50 m), and longline fishing (top 250 m) used within this study. Pie charts represent the proportion of individuals within each species that primarily exhibited nDVM, rDVM, or no clear evidence of DVM (neutral). Species are ordered by habitat type, moving from oceanic to transient to coastal species from left to right.

Andrzejaczek, S., Lucas, T. C., Goodman, M. C., Hussey, N. E., Armstrong, A. J., Carlisle, A.,... Dewar, H, ... & Sulikowski, J. A. 2022. Diving into the vertical dimension of elasmobranch movement ecology. Science Advances, 8(33), eabo1754.
https://www.science.org/doi/full/10.1126/sciadv.abo1754

Vulnerability to climate change of managed stocks in the California Current large marine ecosystem.

Understanding how abundance, productivity and distribution of individual species may respond to climate change is a critical first step towards anticipating alterations in marine ecosystem structure and function, as well as developing strategies to adapt to the full range of potential changes. This study applies the NOAA Fisheries Climate Vulnerability Assessment method to 64 species in the California Current Large Marine Ecosystem (CCLME) to assess their vulnerability to climate change. Vulnerability is a function of two factors a 1) species' exposure to environmental change and 2) its biological sensitivity to a set of environmental conditions. "Exposure" includes factors such as changes in sea surface temperature, ocean acidification, and phenology. "Sensitivity" includes components of a species resiliency, population status, reproductive rate and adaptive capacity to respond to these new conditions. Species classified as Highly or Very Highly vulnerable share one or more characteristics including: 1) having complex life histories that utilize a wide range of freshwater and marine habitats; 2) having habitat specialization, particularly for areas that are likely to experience increased hypoxia; 3) having long lifespans and low population growth rates; and/or 4) being of high commercial value combined with impacts from non-climate stressors such as anthropogenic habitat degradation. Species with Low or Moderate vulnerability are typically habitat generalists, occupy deep-water habitats or are highly mobile and likely to shift their ranges.

The compilation of results across all species is shown in Figure 4. Here we focus specifically on shark considered to be HMS, (blue, shortfin mako, common thresher and white sharks). All HMS shark species had a high level of exposure, given the level of expected change in the CCLME. The two factors which had the highest ranking for negative impacts were sea surface temperature and ocean acidification. Sensitivity to this exposure varied across species. Only the common thresher shark was estimated to have a moderate vulnerability. The other three species were found to have low vulnerability. For common thresher sharks, increased sensitivity resulted from the fact that they have a more specialized diet than other HMS considered and have relatively low reproductive rates. The ability of HMS to undertake large-scale movements was a key factor reducing their overall vulnerability as a group.

This approach compiles a large amount of diverse biological and environmental information into a relatively simple metric. This metric can inform near-term advice for prioritizing species-level data collection and research on climate impacts and help fishers predict changes and shifts in available target and non-target species. In addition, the results can help managers to determine

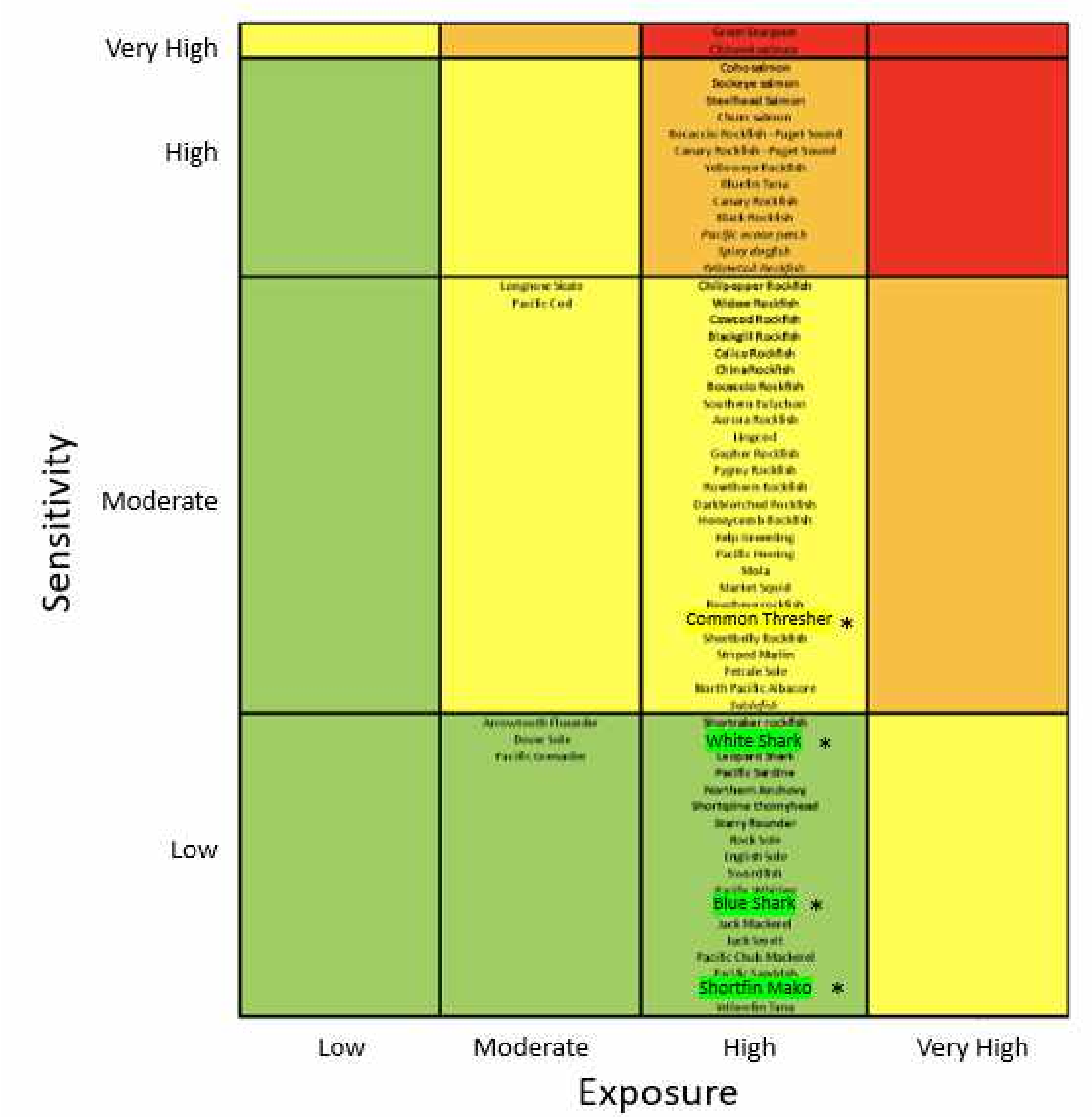

Figure 4: Overall vulnerability, a function of sensitivity and exposure, is indicated by color green = low, yellow = moderate, orange = High, and red = Very High. Note that all HMS shark species are indicated with an *.

when and where a precautionary approach might be warranted, in harvest or other management decisions and can help identify habitats or life history stages that might be especially effective to protect or restore.

McClure, M. M., Haltuch, M. A., Willis-Norton, E., Huff, D. D., Hazen, E. L., Crozier, L. G., ... & Bograd, S. J. (2023). Vulnerability to climate change of managed stocks in the California Current large marine ecosystem. Frontiers in Marine Science.

Vertebral Chemistry Distinguishes Nursery Habitats of Juvenile Shortfin Mako in the Eastern North Pacific Ocean

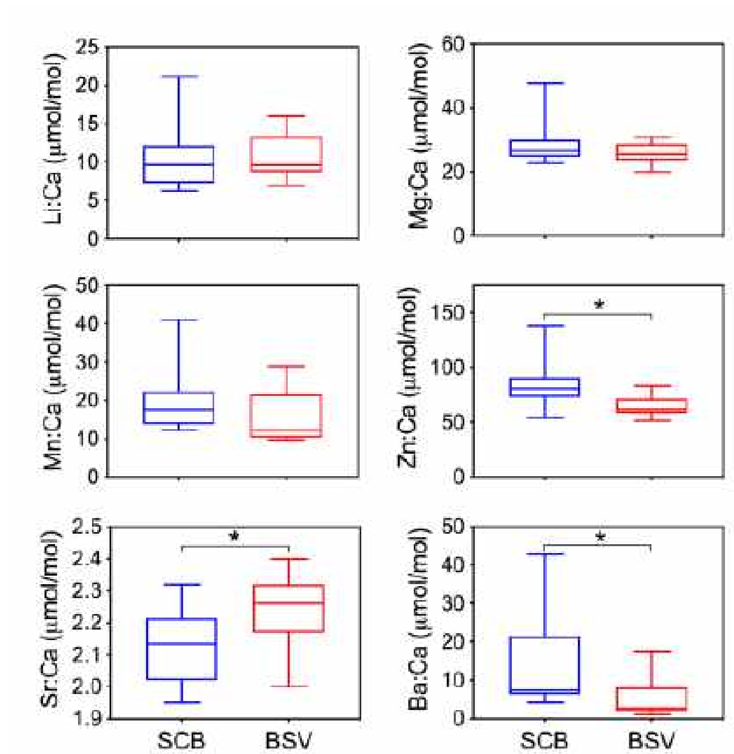

Figure 5. Box plots of vertebral element concentrations of the edge comparing shortfin mako sampled in the Southern California Bight (SCB: blue) and Bahia Sebastian Vizcaino (BSV: red); the line inside the box represents the median, box dimensions represent the 25th and 75th quartiles, whiskers represent minimum and maximum values, and asterisk brackets indicate significant differences between birth band and vertebral edge based on a Mann–Whitney rank-sum test.

Shortfin mako (*Isurus oxyrinchus)* are ecologically and economically important predators throughout the global oceans. The eastern North Pacific Ocean contains several coastal nurseries for this species, where juveniles can forage and grow until venturing into offshore pelagic habitats. Opportunistically sampled vertebrae from both male and female juvenile shortfin mako (65.5–134.4 cm total length, neonate to age 2) were sourced from two distinct nurseries in the eastern North Pacific: the Southern California Bight (n = 12), USA, and Bahía Sebastián Vizcaíno (n = 11), Mexico. Mineralized vertebral cartilage was analyzed to determine concentrations of selected elements (Li, Mg, Mn, Zn, Sr, Ba, standardized to Ca) using laser ablation inductively coupled plasma mass spectrometry, targeting growth bands at specific life stages, including postparturition at the birth band and the recent life history of the individual at the vertebral edge. Comparing the vertebral core revealed significant differences between the two nursery grounds in Zn:Ca, Sr:Ca, and Ba:Ca (Figure 5). These differences are likely associated with factors such as temperature and water chemistry. Comparing the core with the recent history edge revealed variability across ontogeny in Li:Ca, Mg:Ca, and Zn:Ca which could relate to regional differences and/or developmental shifts in mineralization. Understanding what drives element variations in vertebrae is likely complicated but will further efforts to use elements as a tool in species management. The ability to determine the origin of highly migratory species allows fishery managers to better understand essential habitat and how nursery habitats contribute to adult populations.

LaFreniere, B. R., Sosa-Nishizaki, O., Herzka, S. Z., Snodgrass, O., Dewar, H., Miller, N., ... & Mohan, J. A. (2023). Vertebral Chemistry Distinguishes Nursery Habitats of Juvenile Shortfin Mako in the Eastern North Pacific Ocean. Marine and Coastal Fisheries, 15(2), e10234.

TRADE INFORMATION FOR SHARKS

The Unites States engages in the export, import, and re-export of shark products. A summary of those activities including the country, product type, volume, and value, for calendar year 2022, can be found in a separate Excel workbook attached alongside this report. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database, which can be accessed from this website: https://www.fisheries.noaa.gov/foss/f?p=215:2:1264859450776

U.S. REGULATORY CHANGES IN 2022

U.S. National Level Updates

On November 1st, 2022, NMFS received a petition to list the smalltail shark (*Carcharhinus porosus*) as threatened or endangered and designate critical habitat. It is currently awaiting a 90-day finding.

On April 28th, 2022, NMFS issued a 90-day finding on a petition under the Endangered Species Act (ESA) to list the tope shark (*Galeorhinus galeus*) as a threatened or endangered species. NMFS determined that the petitioned action may be warranted.

After issuing a 90-day finding that listing may be warranted for the shortfin mako shark (*Isurus oxyrinchus*), NMFS completed a comprehensive review on November 14th, 2022 that determined listing is not warranted.

U.S. West Coast States Updates

California passed new legislation that prohibits "chumming" for or around white shark (*Carcharodon carcharias*). The relevant text of this legislation can be found here: https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=FGC&sectionNum=5517. There were no new rules or legislation pertaining to shark conservation implemented in 2022 in Oregon or Washington.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
Sustainable Fisheries Division
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802

April 18, 2022

Jean-François Pulvenis, Acting Executive Director
Inter-American Tropical Tuna Commission (IATTC)
8901 La Jolla Shores Drive
La Jolla, California 92037-1509

Subject: Data Submissions under IATTC Resolutions Related to Elasmobranchs

Dear Mr. Pulvenis:

The United States is submitting this letter and enclosed report on information for calendar year 2021, pursuant to the following IATTC resolutions:

- Resolution C-05-03: *Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean*
- Resolution C-11-10: *Resolution on the Conservation of Oceanic Whitetip Sharks Caught in Association with Fisheries in the Antigua Convention Area*
- Resolution C-15-04: *Resolution on the Conservation of Mobulid Rays Caught in Association with Fisheries in the IATTC Convention Area*
- Resolution C-16-05: *Resolution on the Management of Shark Species*
- Resolution C-21-06: *Conservation Measures for Shark Species, with Special Emphasis on the Silky Shark, for the Years 2022 and 2023*

Please contact William Stahnke at (562) 980-4088 or william.stahnke@noaa.gov with any questions.

Sincerely,

Lyle Enriquez
Highly Migratory Species Branch Chief

cc: David Hogan, Department of State
William Fox, Jr., U.S. Commissioner to the IATTC
Ryan J. Wulff, Alternate U.S. Commissioner to the IATTC
Mike Thompson, Alternate U.S. Commissioner to the IATTC
John Zuanich, Alternate U.S. Commissioner to the IATTC
Administrative File: 150413SWR2013SF00273:WJS

Enclosure

This report contains information for U.S. deep-set and shallow-set longline fisheries relevant to the respective Inter-American Tropical Tuna Commission (IATTC) elasmobranch resolutions (C-05-03, C-11-10, C-15-04, C-16-05, C-21-06). The IATTC maintains all observer information for U.S. purse seine vessels and as such already has access to reports of observed interactions with mobulids, oceanic white tip sharks (*Carcharhinus longimanus*), silky sharks (*Carcharhinus falciformis*), and hammerhead sharks (*Sphryna spp.*) caught in that fishery.

C-11-10

In 2021, National Marine Fisheries Service (NMFS) observers recorded thirteen oceanic whitetip sharks caught by U.S. deep-set longline vessels fishing in the eastern Pacific Ocean (EPO). One was returned dead and twelve were returned alive.

C-15-04

In 2021, NMFS observers recorded four mobulid rays caught by U.S. deep-set longline vessels in the EPO. All were returned alive.

C-16-05

In 2021, NMFS observers recorded twelve silky sharks caught by U.S. deep-set longline vessels in the EPO. Eleven were returned alive, and one was returned dead. During the same period, one silky shark was observed caught by a U.S. shallow-set longline vessel. This shark was returned dead.

In 2021, NMFS observers recorded one smooth hammerhead shark (*Sphyrna zygaena*) caught by U.S. deep-set longline vessels in the EPO. This shark was returned alive.

C-21-06

The U.S. observer program does not collect weight data and only opportunistically collects lengths of individual fish. As such, we cannot report on the percent by weight of silky sharks caught during trips with total lengths <100 cm. However, below are the percentages of silky sharks observed caught (regardless of size) by number of individual fish caught by trip.

As mentioned above under C-16-05, in 2021, thirteen silky sharks were observed caught in one shallow set and seven deep-set longline trips (Table 1).

Table 1. Total numbers of silky shark caught on each trip in 2021, expressed as a percentage of total catch by number of individuals.

Trip Number in 2021	Total EPO fish caught on trip	Total EPO silky sharks caught on trip	Percentage of silky shark catch for trip
1 (shallow set)	588	1	0.2%
2 (deep set)	307	5	1.6%
3 (deep set)	1103	2	0.2%
4 (deep set)	1077	1	0.1%
5 (deep set)	370	1	0.3%
6 (deep set)	1122	1	0.1%
7 (deep set)	479	1	0.2%
8 (deep set)	200	1	0.5%

2021 U.S. SHARK REPORT TO THE INTER-AMERICAN TROPICAL TUNA COMMISSION: AS REQUIRED PER RESOLUTION C-05-03

The IATTC adopted Resolution C-05-03 (*Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean)* in 2005. Under paragraph 11, the Resolution requires that members and cooperating non-members (CPCs) provide the IATTC Secretariat with a comprehensive annual report that includes data on sharks caught in association with fisheries managed by the IATTC. These data include "catches, effort by gear type, landing, and trade of sharks by species, where possible, in accordance with IATTC reporting procedures, including available historical data." In addition, the Resolution encourages CPCs to conduct research on sharks to identify ways to increase the selectivity of fishing gears, identify shark nursery areas, and provide assistance to developing countries to increase the collection of shark catch data in those countries. This report is being submitted to the IATTC Secretariat to provide updates on relevant shark research conducted by the United States in 2021, to fulfill the U.S. reporting obligations for 2022, and to provide updates on any domestic U.S. regulations that could impact sharks and shark fisheries in the IATTC Convention Area.

DATA SUBMITTED SEPARATELY

The United States submits catch, effort, and landings data on sharks caught by U.S.-flagged vessels in fisheries for tuna and tuna-like species in the IATTC Convention Area as part of its annual report to the IATTC as required under Resolution C-03-05 (Resolution on Data Provision). The United States provides catch and effort data by fishing gear at Level 3, the international standard for such data.

UPDATES ON SHARK RESEARCH IN 2021

The Southwest Fisheries Science Center (SWFSC)'s shark research program focuses on pelagic sharks along the U.S. Pacific coast, including Shortfin Mako Sharks (*Isurus oxyrinchus*), Blue Sharks (*Prionace glauca*), Basking Sharks (*Cetorhinus maximus*), and three species of thresher sharks: Common Thresher (*Alopias vulpinus*), Bigeye Thresher (*Alopias superciliosus*), and Pelagic Thresher (*Alopias pelagicus*). SWFSC scientists have studied the sharks' life history, foraging ecology, distribution, movements, stock structure, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks.

Isotopic Tracers Suggest Limited Trans-Oceanic Movements and Regional Residency in North Pacific Blue Sharks

Blue Sharks are globally distributed, large-bodied pelagic sharks known to migrate across entire ocean basins. In the North Pacific, mark-recapture studies have demonstrated trans-Pacific migrations, but knowledge gaps in migration frequency hinder understanding of regional demography and connectivity. We used gradients of stable isotope ratios (i.e., regional isoscapes) to determine exchange rates of Blue Sharks between the East and West North Pacific Ocean (Figure 1). Discriminant analysis suggested low trans-Pacific exchange (Figure 2), categorizing all western (100%) and most eastern (95.3%) Blue Sharks as resident to their sampling region. Isotopic niche overlap of Western Pacific Ocean (WPO) and Eastern Pacific Ocean (EPO) shows that these regions are highly distinct (0.01–5.6% overlap). Potential finer-scale movement structure was observed within both eastern and western Pacific sub-regions, with mixing models suggesting potential region-specific residency and localized foraging. Our results suggest that Blue Shark population dynamics may be effectively assessed on a regional basis (i.e., WPO and EPO), though further studies are required to assess size- and sex-specific movement patterns based on empirical isotopic values from regional studies with large sample sizes. Strategically applied stable isotope approaches can continue to elucidate migration dynamics of migratory marine predators, complementing traditional approaches to fisheries biology and ecology.

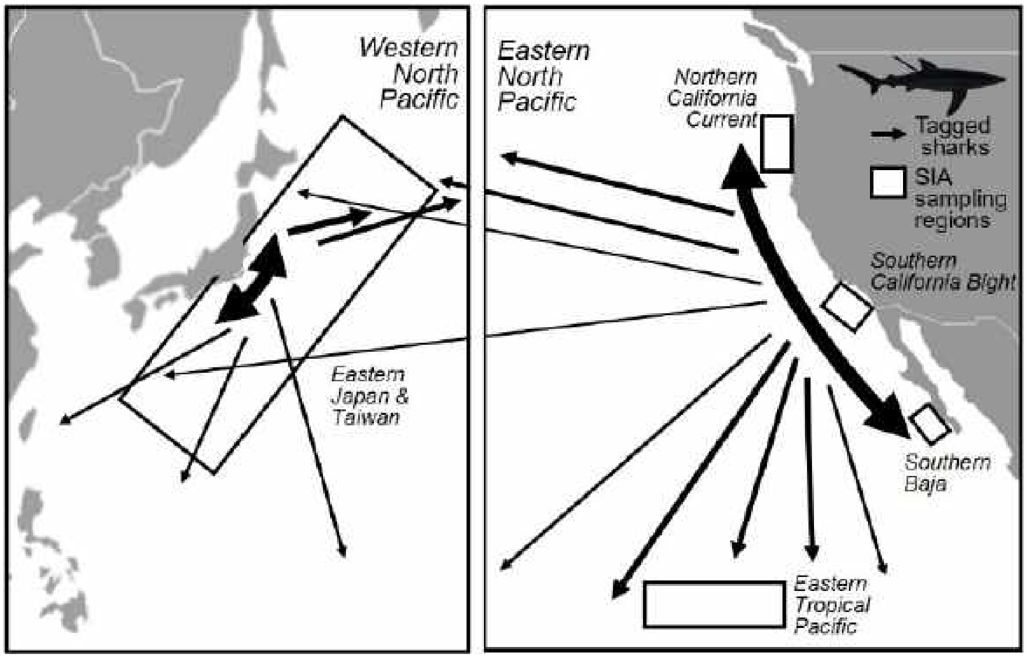

Figure 1. Map of summarized Blue Shark movements and sampling locations for isotopic studies in the North Pacific Ocean. Movements (black arrows) are based on conventional tagging data in the western and eastern Pacific Ocean (WPO and EPO), with arrow size scaled to relative proportion of observed movements. Boxes show regions of Blue Shark tissue sampling for stable isotope analysis (SIA; solid lines, EPO; dashed lines, WPO). Tagging data simplified from Sippel *et al*. 2011; SIA data from Miller *et al*. 2010, Madigan *et al*. 2012, Li *et al*. 2014, Hernández-Aguilar *et al*. 2015.

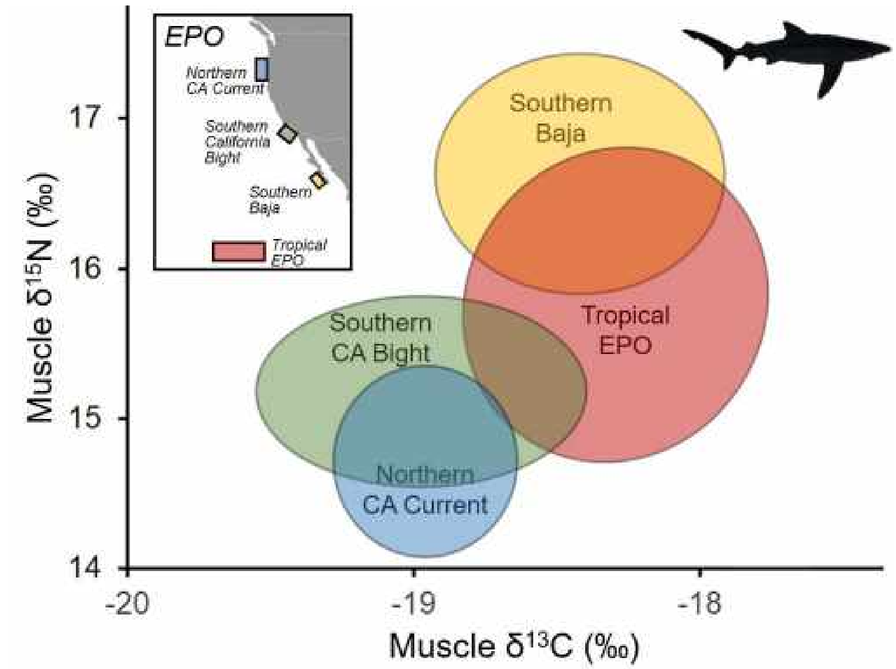

Figure 2. Differences in isotopic niches of Blue Shark across discrete regions within the eastern North Pacific Ocean. Map (upper left) shows regions where Blue Sharks were sampled and subsequently analyzed for $\delta^{13}C$ and $\delta^{15}N$ values. Ellipses represent 95% of Blue Shark $\delta^{13}C$ and $\delta^{15}N$ values following Swanson *et al*. (2015).

These results, drawing upon published $\delta^{13}C$ and $\delta^{15}N$ data for Blue Sharks and prey sampled at multiple locations in the EPO and WPO, provide a new and replicable means to assess Blue Shark residency and migration dynamics in the North Pacific. The analyzed data provide strong evidence for limited direct migrations between the WPO and EPO, and reiterated the utility of $\delta^{15}N$ isoscapes for the reconstruction of migratory predator movements in the North Pacific Ocean. Regional structure in $\delta^{13}C$ and $\delta^{15}N$ data have promise for further quantification of finer-scale Blue Shark movements, increasing the resolutions of movement patterns suggested here, but consideration of isotopic parameters (*e.g.*, accurate DTDFs), appropriate sample preparation of shark tissues, and length/sex metadata of sampled sharks are necessary. With emerging research showing varying residency and trans-regional movements in migratory predators, isoscapes can employ high sample sizes across a breadth of animal life stages, regions, and timeframes to reconstruct habitat use of highly migratory animals. Through these isotopic approaches, population-level estimates of movement dynamics are feasible on scales that may not be readily available from conventional tagging or telemetry studies.

Reference: *Madigan, D. J., Shipley, O. N., Carlisle, A. B., Dewar, H., Snodgrass, O. E., & Hussey, N. E. (2021). Isotopic tracers suggest limited trans-oceanic movements and regional residency in North Pacific Blue Sharks (*Prionace glauca*).* Frontiers in Marine Science*, 8, 489.*

Spatial distribution, temporal changes, and knowledge gaps in Basking Shark sightings in the California Current Ecosystem

The Basking Shark, one of the largest fish species, is found worldwide in temperate and tropical waters. Though historical documents have recorded their presence in the California Current Ecosystem (CCE), Basking Sharks are now only rarely observed in this part of their range. We compiled recent and historical data from systematic surveys (1962–1997) and other sources (1973–2018) (Figure 3) to (i) examine temporal patterns of Basking Shark sightings in the CCE, and (ii) determine the spatial, temporal, and environmental drivers that have affected Basking Shark presence and distribution here for the last 50 years. We first calculated variation in Basking Shark sightings and school size over time. We then generated species distribution models using the systematic survey data and evaluated the performance of these models against the more recent non-systematic sightings data. The sightings records indicated that the number of shark sightings was variable across years, but the number and probability of sightings declined in the mid-1980s. The systematic survey data showed that a maximum of 4,000 sharks were sighted per year until the 1990s, after which there were no sightings reported. In parallel, there was more than a 50% decline in school size from the 1960s to the 1980s (57.2 to 24.0 individuals per group). During the subsequent decades in the non-systematic data (>1990), less than 60 sharks were sighted per year. There were no schools larger than 10 reported, and the mean school size in the last decade (2010s) was 3.53 individuals per group. Low sea surface temperature, high chlorophyll-a concentration, increased sightings probability, and prevailing climatic oscillations (e.g., El Nino-Southern Oscillation index, North Pacific Gyre Oscillation, Pacific Decadal Oscillation) were correlated with Basking Shark presence. Lastly, we observed a significant shift in the seasonality of sightings, from fall and spring during the systematic survey period to summer after the 2000s. Coordinating the documentation of fisheries mortalities and sightings throughout the Pacific basin would facilitate more robust population estimates and identify sources of mortality. Additionally, monitoring shark fin markets and developing region-specific genetic markers would help ensure that Convention on International Trade in Endangered Species (CITES) regulations are being followed.

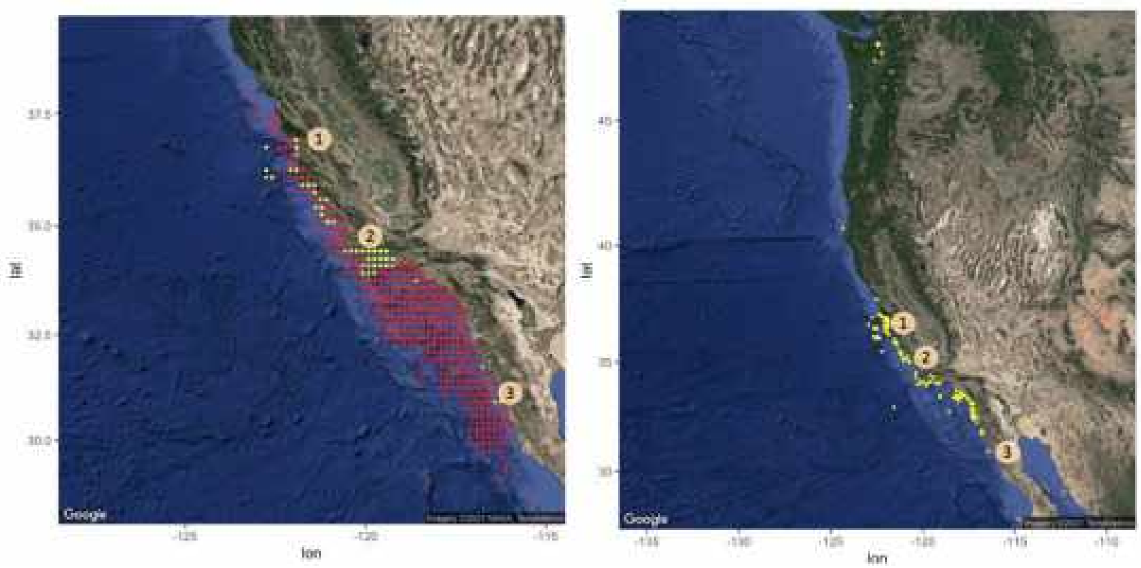

Figure 3. Maps of sightings data collected from 1962 to 2018, from systematic surveys (left; 1962–1997) and non-systematic data (right; 1973–2018) along the western coast of the United States and Mexico. Presences are denoted in yellow. Those above 46° latitude were observed in the bay near Seattle, WA (United States). Sightings from drift gillnet records have been excluded in this figure because of NOAA confidentiality policies. Centroids of blocks where sharks were not found, based on systematic surveys by pilots who had reported a Basking Shark at least once, are marked in red. Numbers indicate shark hotspots identified in both this and previous studies, in (1) Monterey Bay, (2) Santa Barbara, and (3) Baja California.

Reference: *McInturf, A. G., Muhling, B., Bizzarro, J. J., Fangue, N. A., Caillaud, D., & Dewar, H. Spatial distribution, temporal changes, and knowledge gaps in Basking Shark (*Cetorhinus maximus*) sightings in the California Current Ecosystem.* Frontiers in Marine Science*, 77.*

Validated band pair periodicity of juvenile Common Thresher Sharks in the Northeastern Pacific Ocean

Validation of the periodicity of band pair formation in elasmobranch vertebrae is essential for accurate age estimation. This study validated the vertebral band pair deposition rate for juvenile Common Thresher Sharks in the northeastern Pacific Ocean (NEPO) using oxytetracycline (OTC) tagging and recapture (Figure 4). A total of 37 Common Thresher Sharks marked with OTC from 1998 through 2013, were recaptured with times at liberty ranging from 0.53 to 3.81 years with an average of 1.27 years (± 0.92 years standard deviation, SD). Shark size ranged from 63 to 128 cm fork length (FL) at the time of injection with OTC and from 83 to 168 cm FL for those measured at recapture. Vertebral band pair counts distal to the OTC marks indicate one band pair (1 translucent and 1 opaque) is deposited annually for the Common Thresher Shark within the size range examined in the NEPO (Figure 4). This finding supports previous age and growth assumptions that have formed the basis of management decisions, and will support future studies and stock assessments of this species.

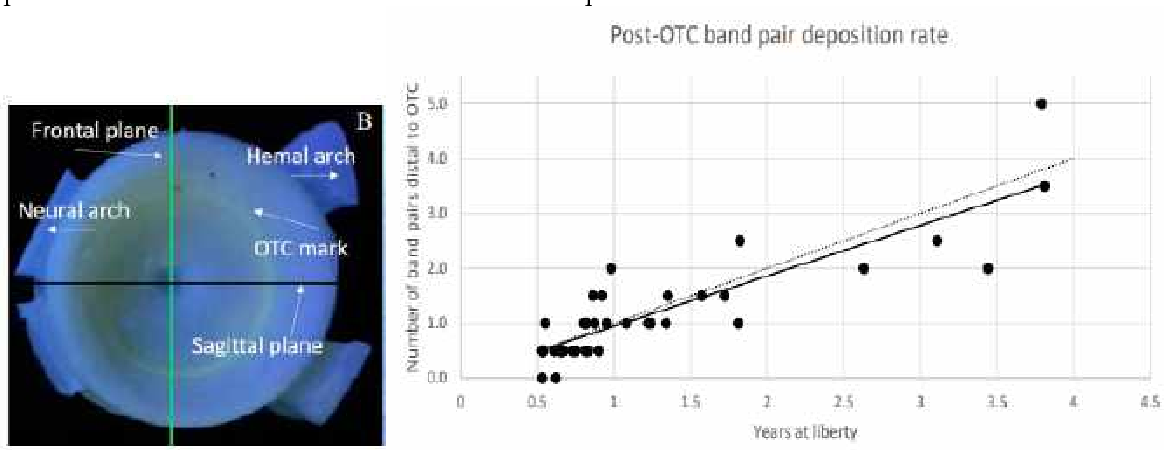

Figure 4: Left: Oxytetracycline mark fluorescing under UV light; section is cut along the green line. Right: Number of vertebral band pairs after the oxytetracycline mark compared to days at 674 liberty for Common Thresher Sharks tagged and recaptured in the northeastern 675 Pacific (1998-2013). The solid line represents the relationship of band pairs to days at liberty; the 676 dotted line represents a deposition rate of 1 band pair per year.

Reference: *Spear, N., Kohin, S., Mohan, J., Wells, J.D. Validated band pair periodicity of juvenile Common Thresher Sharks (*Alopias vulpinus*) in the Northeastern Pacific Ocean. Accepted for publication in* Fisheries Bulletin.

TRADE INFORMATION FOR SHARKS

The Unites States engages in the export, import, and re-export of shark products. A summary of those activities including the country, product type, volume, and value, for calendar year 2021, can be found below in Tables 2, 3, and 4. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database, which can be accessed from the "Product by country/association" option under the "Annual Data" heading on this website: https://www.fisheries.noaa.gov/national/sustainable-fisheries/foreign-fishery-trade-data.

Table 2. 2021 Exports of Shark Products by Country.

Country Name	Product Name	Volume (kg)	Value (USD)
SOUTH KOREA	SHARK DOGFISH FRESH	1,668	7,152
DOMINICAN REPUBLIC	SHARK FINS PREPARED/PRESERVED IN ATC	3,418	35,294
UNITED KINGDOM	SHARK DOGFISH FRESH	6,032	29,102

UNITED KINGDOM	SHARK DOGFISH FRESH	1,380	7,320
NETHERLANDS	SHARK DOGFISH FRESH	206,553	1,189,942
NETHERLANDS	SHARK DOGFISH FRESH	2,786	15,021
FRANCE	SHARK DOGFISH FRESH	36,582	194,608
FRANCE	SHARK DOGFISH FRESH	3,821	18,351
ITALY	SHARK DOGFISH FRESH	2,213	13,442
ITALY	SHARK DOGFISH FRESH	13,387	79,361
UNITED KINGDOM	SHARK NSPF FRESH	4,220	22,472
ITALY	SHARK NSPF FRESH	1,608	7,022
CANADA	SHARK NSPF FRESH	8,093	38,051
CANADA	SHARK NSPF FRESH	65,589	222,442
CANADA	SHARK NSPF FRESH	145,602	270,024
MEXICO	SHARK NSPF FRESH	205,463	455,673
THAILAND	SHARK DOGFISH FROZEN	121,236	294,000
THAILAND	SHARK DOGFISH FROZEN	84,150	204,066
SINGAPORE	SHARK DOGFISH FROZEN	166,416	403,560
SOUTH KOREA	SHARK DOGFISH FROZEN	40,856	104,361
SOUTH KOREA	SHARK DOGFISH FROZEN	4,371	10,599
CHINA - HONG KONG	SHARK DOGFISH FROZEN	78,804	191,100
UNITED KINGDOM	SHARK DOGFISH FROZEN	81,762	406,848
UNITED KINGDOM	SHARK DOGFISH FROZEN	86,524	427,179
BELGIUM	SHARK DOGFISH FROZEN	98,090	358,806
BELGIUM	SHARK DOGFISH FROZEN	281,598	823,414
FRANCE	SHARK DOGFISH FROZEN	105,823	381,960
FRANCE	SHARK DOGFISH FROZEN	458,383	1,663,062
GERMANY	SHARK DOGFISH FROZEN	76,787	239,139
PORTUGAL	SHARK DOGFISH FROZEN	10,677	63,000
AUSTRALIA	SHARK DOGFISH FROZEN	7,008	45,000
BRAZIL	SHARK DOGFISH FROZEN	138	3,133
INDIA	SHARK NSPF FROZEN	9,301	17,021
CHINA - HONG KONG	SHARK FINS FROZEN	5,371	33,680
CHINA - HONG KONG	SHARK FINS FROZEN	32,257	78,222
MEXICO	DOGFISH AND OTHER SHARK MEAT FRESH	1,360	12,546
BELGIUM	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	3,000	23,346
BELGIUM	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	2,000	14,000

FRANCE	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	3,000	23,148
FRANCE	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	50,629	289,117
MEXICO	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	1,743	8,243
GUATEMALA	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	1,099	5,199
KUWAIT	DOGFISH AND OTHER SHARK MEAT FROZEN	1,048	3,041
CHINA	DOGFISH AND OTHER SHARK MEAT FROZEN	115,025	333,680
CHINA - HONG KONG	DOGFISH AND OTHER SHARK MEAT FROZEN	4,219	12,240
GERMANY	DOGFISH AND OTHER SHARK MEAT FROZEN	221,116	1,653,510
GERMANY	DOGFISH AND OTHER SHARK MEAT FROZEN	12,132	122,977
UNITED KINGDOM	SHARK DOGFISH FRESH	18,009	91,320

Table 3. 2021 Imports of Shark Products by Country.

Country Name	Product Name	Volume (kg)	Value (USD)
SPAIN	SHARK NSPF FROZEN	3,798	35,659
TAIWAN	DOGFISH AND OTHER SHARK FILLET FRESH	6,804	19,500
MEXICO	DOGFISH AND OTHER SHARK FILLET FRESH	2,494	12,648
SURINAME	DOGFISH AND OTHER SHARK FILLET FRESH	7,965	44,952
NICARAGUA	DOGFISH AND OTHER SHARK FILLET FRESH	2,925	22,575
MEXICO	DOGFISH AND OTHER SHARK MEAT FROZEN	7,245	34,674
SPAIN	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	499	2,753
TRINIDAD & TOBAGO	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	11,340	104,250
CANADA	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	454	2,650
MEXICO	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	33,079	123,671
PANAMA	DOGFISH AND OTHER SHARK FILLET FRESH	401	2,384

Table 4. 2021 Re-exports of Shark Products by Country.

Country Name	Product Name	Volume (kg)	Value (USD)
COLOMBIA	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	6,295	29,779
MEXICO	SHARK FINS PREPARED/PRESERVED IN ATC	1,526	4,241
DOMINICAN REPUBLIC	SHARK FINS PREPARED/PRESERVED IN ATC	2,479	21,584
COSTA RICA	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	1,791	7,282

U.S. REGULATORY CHANGES IN 2021

U.S. National Level Updates
April 15, 2021, NMFS issued a positive 90-day finding on a petition to list shortfin mako sharks (*Isurus oxyrinchus*) under the Endangered Species Act (ESA) and designate critical habitat. A status review is underway to determine if ESA listing is warranted.

U.S. West Coast States Updates
There were no new rules or legislation pertaining to shark conservation implemented in 2021 in California, Oregon, or Washington.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
Sustainable Fisheries Division
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802

April 1, 2021

Jean-François Pulvenis, Acting Executive Director
Inter-American Tropical Tuna Commission (IATTC)
8901 La Jolla Shores Drive
La Jolla, California 92037-1508

Subject: Data Submissions under Resolutions Related to Elasmobranchs

Dear Mr. Pulvenis:

The United States is submitting this letter and enclosed report on calendar year 2020 information pursuant to the following IATTC resolutions:

- Resolution C-05-03: *Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean*
- Resolution C-11-10: *Resolution on the Conservation of Oceanic Whitetip Sharks Caught in Association with Fisheries in the Antigua Convention Area*
- Resolution C-15-04: *Resolution on the Conservation of Mobulid Rays Caught in Association with Fisheries in the IATTC Convention Area*
- Resolution C-16-05: *Resolution on the Management of Shark Species*
- Resolution C-16-06: *Conservation Measures for Shark Species, with Special Emphasis on the Silky Shark, for the Years 2017, 2018, and 2019*

Please contact William Stahnke at (562) 980-4088 or william.stahnke@noaa.gov with any questions.

Sincerely,

Lyle Enriquez
Highly Migratory Species Branch Chief

cc: David Hogan, Department of State
William Fox, Jr., U.S. Commissioner to the IATTC
Ryan J. Wulff, Alternate U.S. Commissioner to the IATTC
Mike Thompson, Alternate U.S. Commissioner to the IATTC
John Zuanich, Alternate U.S. Commissioner to the IATTC
Administrative File: 150413SWR2013SF00273:WJS

Enclosure

Below is relevant information for U.S. deep-set and shallow-set longline fisheries under the respective elasmobranch resolutions. The IATTC maintains all observer information for U.S. purse seine vessels and as such already has access to reports of observed interactions with mobulids, oceanic white tip sharks, silky sharks, and hammerhead sharks caught in that fishery.

C-11-10
In 2020, NMFS observers recorded five oceanic whitetip sharks caught by U.S. deep-set longline vessels fishing in the eastern Pacific Ocean (EPO). One was returned dead and four were returned alive.

C-15-04
In 2020, NMFS observers recorded no catches of mobulid rays in the U.S. deep-set longline fishery in the EPO.

C-16-05
In 2020, NMFS observers recorded nine silky sharks caught by U.S. deep-set longline vessels fishing in the EPO. Two were returned alive, one returned alive in good condition, and six were returned dead.

In 2020, NMFS observers recorded two hammerhead (smooth hammerhead) sharks caught by U.S. deep-set longline vessels fishing in the EPO. One was returned alive and one was returned dead.

C-16-06
The U.S. observer program does not collect weights and only opportunistically collects lengths of individual fish, and as such cannot report on the percent by weight of silky sharks caught during trips with total lengths <100 cm. However, below are the percentages of silky sharks observed caught (regardless of size) by number of individual fish caught by trip.

As mentioned under C-16-05, in 2020, nine silky sharks were observed caught in three deep-set longline trips (Table 1).

Table 1. Total numbers of silky shark caught on each trip, expressed as a percentage of total catch by number of individuals.

Trip Number in 2020	Total number of fish caught on trip	Total number of silky sharks caught on trip	Percentage of silky shark catch for trip, by number
1	1046	7	0.67%
2	881	1	0.11%
3	1218	1	0.08%

2020 U.S. SHARK REPORT TO THE INTER-AMERICAN TROPICAL TUNA COMMISSION: AS REQUIRED PER RESOLUTION C-05-03

Inter-American Tropical Tuna Commission Resolution C-05-03 (*Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean)* was adopted by the IATTC in 2005. Under paragraph 11, the Resolution requires that members and cooperating non-members (CPCs) provide the IATTC Secretariat with a comprehensive annual report that includes data on sharks caught in association with fisheries managed by the IATTC, including "catches, effort by gear type, landing, and trade of sharks by species, where possible, in accordance with IATTC reporting procedures, including available historical data." In addition, the Resolution encourages CPCs to conduct research on sharks to identify ways to increase the selectivity of fishing gears, identify shark nursery areas, and provide assistance to developing countries to increase the collection of data on shark catches in those countries. Thus, this report is being submitted to the IATTC Secretariat to provide updates on relevant shark research conducted by the United States in 2020, to fulfill the U.S. reporting obligations for 2021, and to provide updates on any domestic U.S. regulations that could impact sharks and shark fisheries in the IATTC Convention Area.

DATA SUBMITTED SEPARATELY

Catch, effort, and landings data on sharks caught by U.S.-flagged vessels in any fishery for tuna and tuna-like species in the IATTC Convention Area were submitted with the annual report to the IATTC as required under Resolution C-03-05 (*Resolution on Data Provision*). The catch and effort data by fishing gears will be provided at Level 3, the international standard for such data.

UPDATES ON SHARK RESEARCH IN 2020 (FROM THE SOUTHWEST FISHERIES SCIENCE CENTER)

I. SUPPORTING U.S. OBLIGATIONS OF INTERNATIONAL AGREEMENTS

SWSFC staff provides scientific advice on stock status of pelagic sharks to international and domestic fishery management organizations. SWFSC participation in international collaborations on pelagic shark stock assessments is organized primarily through the Shark Working Group (SHARKWG, chaired by Dr. Mikihiko Kai, National Research Institute of Far Seas Fisheries) of the ISC. There were no assessments, working group reports or working papers in 2020.

II. ADVANCING PELAGIC SHARK RESEARCH

The SWFSC's shark research program focuses on pelagic sharks that occur along the U.S. Pacific coast, including shortfin mako (*Isurus oxyrinchus*), blue sharks (*Prionace glauca*), basking sharks (*Cetorhinus maximus)*, and three species of thresher sharks: common thresher (*Alopias vulpinus*)*,* bigeye thresher (*Alopias superciliosus),* and pelagic thresher (*Alopias pelagicus)*. Center scientists are studying the sharks' life history, foraging ecology, distribution, movements, stock structure, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks.

A. Foraging Ecology of Pelagic Sharks

The California Current is a productive eastern boundary current that provides important habitat across life stages for a number of highly migratory shark species. One of the main reasons sharks come to the California Current is to take advantage of the seasonally high abundance of prey. Consequently, understanding foraging ecology and food-web connections is critical as we move towards ecosystem management and also for predicting shifts in abundance and distribution with short- and long-term climate change. To better understand the foraging ecology of pelagic sharks in the California Current, SWFSC researchers have been analyzing the stomach contents since 1999.

Stomach Content Analysis

Introduction/Background

This study offered the first comprehensive analysis of the diets of nine top predators that co-occur in the California Current Large Marine Ecosystem (CCLME) [shortfin mako (*Isurus oxyrinchus*), blue (*Prionace glauca*), thresher (*Alopias vulpinus*), bigeye thresher (*Alopias superciliosus*) sharks, broadbill swordfish (*Xiphias gladius*), short-beaked common dolphin (*Delphinus delphis delphis*), Eastern North Pacific long-beaked common dolphin (*Delphinus delphis bairdii*), northern right whale dolphin (*Lissodelphis borealis*), and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)]. Comparisons among predators provides insights into potential competition, niche overlap, and degrees of diet specialization. Also, given the shifts towards integrated ecosystem assessments and ecosystem management, there is movement away from looking at species in isolation. Consequently, all nine predators are included in this report although the sharks are the main focus.

The primary goals of this research were to better understand their foraging ecology in the CCLME, and how and why diets changed in space, time, by size and with sex. This study also examined dietary diversity, richness, and niche overlap to provide insight into the level of specialization, and potential competition among species. Detailed data on diets from diverse species provides insights into links among trophic levels, the reliance of predators on commercially important species, as well as the potential impacts of predator removal. This type of information is key to understanding ecosystem and trophic dynamics.

Methods

Stomachs for the nine predator species were collected by federal fishery observers aboard large-mesh drift gillnet vessels during years 1990-2014. While historically the fishery spanned the U.S. West Coast, since 2001, the majority of the fishery has operated in the Southern California Bight (SCB) between Point Conception, California and the U.S.-Mexico border. Stomachs from *D. d. bairdii* and *L. obliquidens* were also obtained from stranded animals. Prey were weighed, counted and identified to the lowest possible taxonomic group. Data analyses included prey accumulation curves and relative indices of importance including the standard metrics Index of relative (IRI) and Geometric index of importance (GII). The % GII is the arithmetic mean between %N, %F and %W of a prey item and it is based on a multivariate approach to vector geometry. Because of its basis in vector geometry, it provides a more precise method for interpreting stomach contents although numeric comparisons among species are complicated. To examine patterns in prey importance, including the impacts of size, regions, season and sea surface temperature, a number of additional analyses were conducted including redundancy analysis (RDA) and generalized additive modelling (GAM).

Results/Discussion

The stomachs of 2044 predators were analyzed and 1,676 contained prey. For each of the fish species, other than bigeye thresher sharks, more than 150 individuals were examined. Table 2 provides a summary of the diet composition by number of (individual) prey (as a percentage, %N) for all predators. Table 3 illustrates the top three prey categories for each predator ranked by %GII.

Table 2. Percent composition by number (%N) of prey for the nine. Predator sample size includes only stomachs with food. Prey sample size is count of prey individuals of any taxa

	Teleosts	**Cephalopods**	**Other taxa**	**Predator Sample size**	**Prey Sample size**
Mako	64.80	30.83	4.37	366	1790
Blue	3.83	67.71	28.46	150	1307
Thresher	82.79	16.58	0.63	434	6520
Bigeye thresher	81.20	18.30	0.50	45	399
Swordfish	31.16	65.71	3.13	292	5244
D. d. delphis	72.38	26.33	1.29	259	55009
D. d. bairdii	52.80	33.95	13.25	49	3072
L. borealis	69.90	29.74	0.36	56	18570
L. obliquidens	50.23	49.77	0.00	25	3008

Overall, across predators, fish and squid were the most important prey items. Mako, thresher, bigeye thresher sharks, *D. d. delphis* and *L. borealis* all had more than 60% teleosts in their diet with fish being the most important for the two thresher species. Blue sharks and swordfish both consumed less fish, with cephalopods making up over 65% of the diet. Blue shark was the only species in which other taxa (in this case 28.5%) were of major importance in the diet. Shortfin mako fed on teleosts, cephalopods, elasmobranchs and marine mammals in broad agreement with previous research. Blue sharks specialized on cephalopods but fed across a broad range of species. These results are in contrast with those from previous studies in this geographic area that reported teleosts and crustaceans to be more important blue shark diets. Bigeye thresher shark fed on teleosts, cephalopods and crustaceans from a range of habitats. Broadbill swordfish fed primarily on cephalopods, mesopelagic and epipelagic teleosts similarly to results from some studies in other geographic areas although the relative importance of squid and fish varied across studies. Thresher sharks had a predominance of coastal pelagic species in their diet, similar to previous studies from the same area. Fish dominated the diets of all cetaceans, although cephalopods were also important. Note that for all cetaceans, other than stranded animals, the most dominant fish species were myctophids and other mesopelagic fish.

There were two notable differences in our findings in comparison to other studies in the same region. First, in this study, jumbo squid were more important in the diets of mako, blue, bigeye thresher sharks and swordfish than reported previously. For example, Jumbo squid was found to be rare or of minimal importance in previous blue shark diet studies in this area. The increased importance of jumbo squid as prey is likely tied to its range expansion in the CCLME during the 2000s (see below). Another interesting difference was the lack of northern anchovy in blue shark diets. While they, an important prey item in previous studies, northern anchovy were not detected in this study (see below).

Table 3. Top three prey items ranked by % GII for the nine predators in the study

Top 3 prey items		%GII							%GII 2way					
									DGN				strandings	
		Mako	**Blue**	**Thresher shark**	**Bigeye thresher**	**Swordfish**	***D. d. delphis***	***L. borealis***	***D. d. delphis***	***D. d. bairdii***	***L. borealis***	***L. obliquidens***	***D. d. bairdii***	***L. obliquidens***
Pelagic teleosts	**Mexican lampfish, *T. mexicanus***							40.2						
	Dogtooth lampfish, *C. townsendi*						30.5		58.0					
	Bigfin lampfish, *S. californiensis*						32.2							
	California headlightfish, *D. theta*										67.9			
	Barracudinas, Paralepididae				15.9									
	Duckbill barracudina, *Magnisudis atlantica*				16.7									
	Pacific saury, *Cololabis saira*	23.3												
	Northern anchovy, *Engraulis mordax*			31.9									53.6	40.0
	Pacific sardine, *Sardinops sagax*	7.3		18.4										
	Unidentified Teleostei			16.6										
Demersal	**Plainfin midshipman, *P. notatus***													33.3
	California lizardfish, *S. lucioceps*												33.6	
	Pacific hake, *M. productus*									43.8				
Cephalopods	***Argonauta* sp.**		12.7											
	***Abraliopsis* sp.**					16.3	36.7	40.9	66.0		75.9	40.6		
	***Gonatus* spp.**		23.4						59.8	35.8	70.1			
	Boreopacific gonate squid, *Gonatopsis borealis*					29.1						41.4		
	Jumbo squid, *Dosidicus gigas*	24.9	18.7		26.8	44.2								
	Market squid, *D. opalescens*							50.1		69.4		50.0	63.9	68.3

Multiple metrics were used to compare diet composition across species. Considering all four shark species, thresher sharks and blue sharks had the lowest similarity and the lowest niche overlap (Fig 1). When comparing across all species, threshers and swordfish had the lowest similarity and the lowest niche overlap (Fig. 2). This is likely related to the thresher sharks reliance on small, schooling, coastal pelagic species and their associated foraging mode (using their tail to stun prey) as well as differences in preferred habitat. Interestingly, swordfish and bigeye threshers had the highest degree of niche overlap. These two species have adaptations that enhance foraging in deep, cool waters, including large eyes and cranial endothermy, allowing them to effectively exploit prey associated with the deep scattering layer. Bigeye thresher sharks are less specialized in diet than common thresher sharks (Fig. 3).

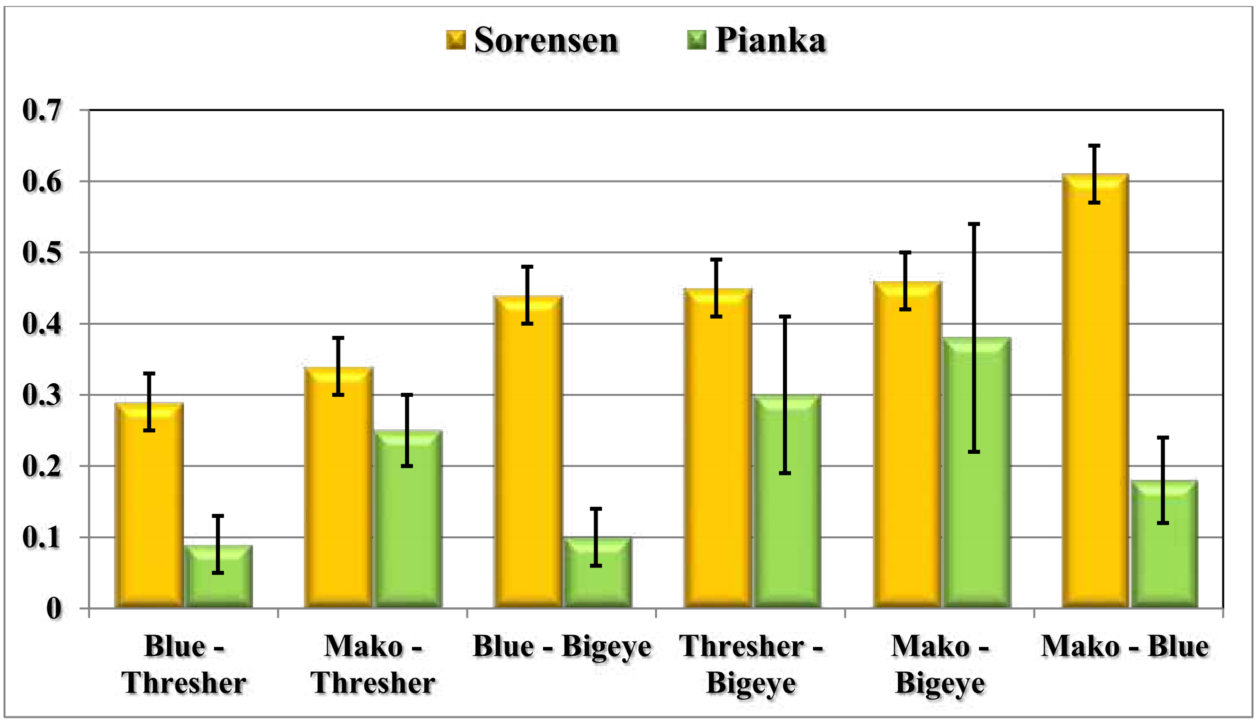

Figure 1. Shark comparisons. Sorensen Index of Similarity of diets based on presence/absence of prey only (yellow) and Pianka's index of Niche Overlap (green) based on prey counts. Zero indicated no similarity/ no overlap and one indicates identical diets/complete overlap. Mean value of the index based on 10,000 bootstraps estimates; SE=std error.

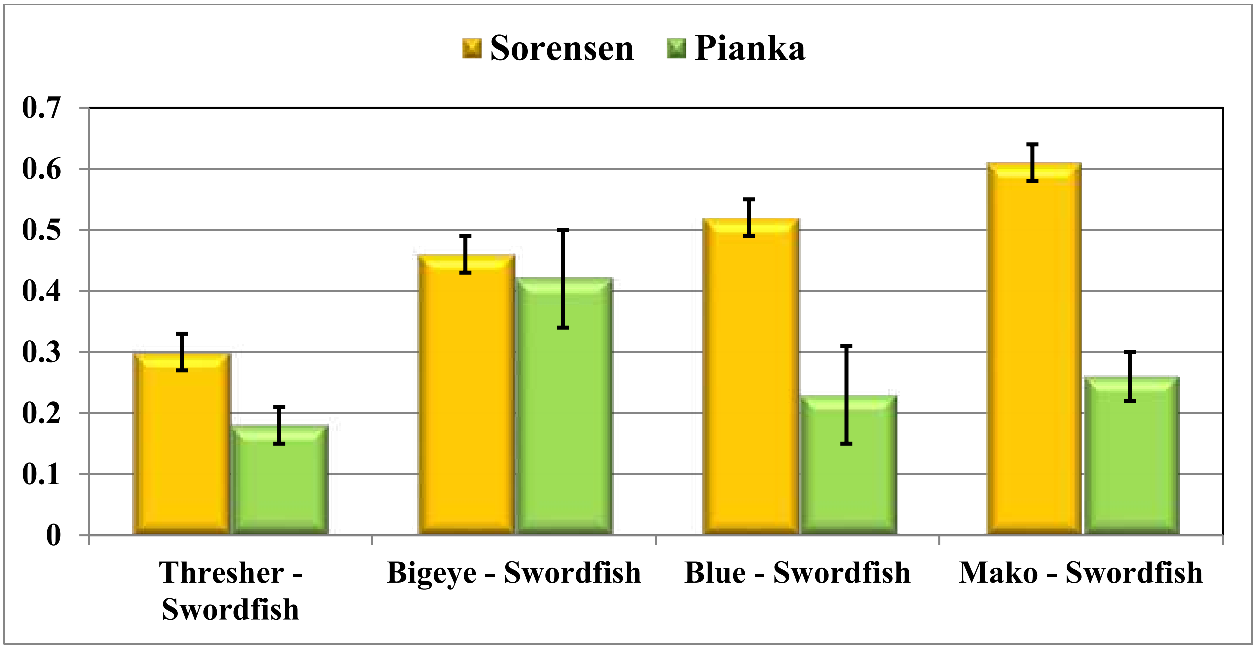

Figure 2. Sharks and swordfish comparisons. Sorensen index of similarity of diets and Pianka's index of Niche Overlap. See description in Figure 1 caption.

Examining the richness and evenness provides insights into diet diversity and specialization. Simply speaking, high richness indicates a diverse diet and high evenness indicates less specialization. Rarefied diet richness was the highest in mako and the lowest in *D. d. delphis*. Species evenness was the highest for *L. borealis* and the lowest for thresher shark. When just compared to other sharks and swordfish, threshers had both the lowest richness and evenness indicating they have a higher degree of specialization (Fig. 3). Again, this is likely associated with their reliance on small schooling coastal pelagic prey.

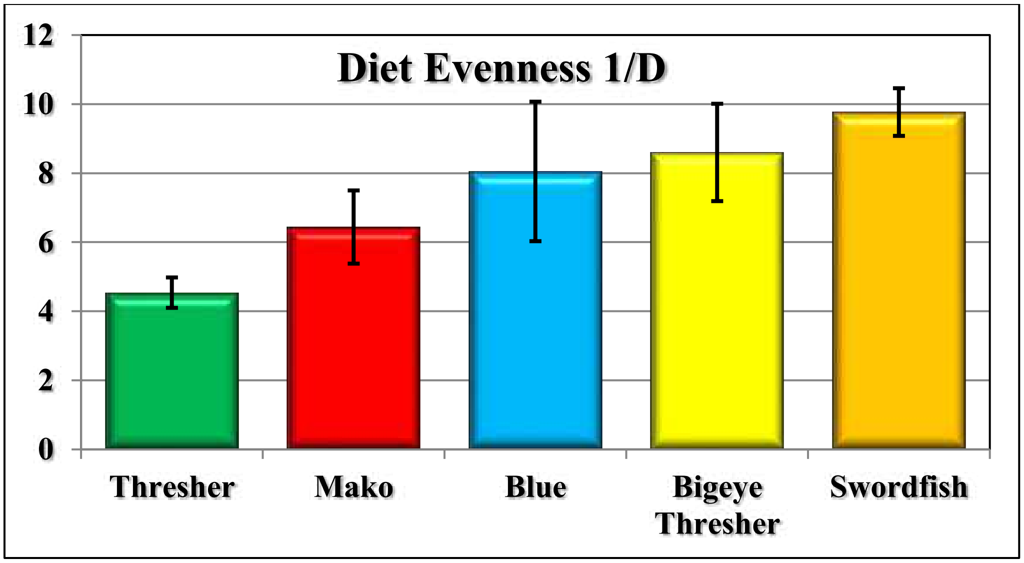

Figure 3. Comparisons of Diet Evenness among sharks and swordfish. D=Simpson's index of diversity. Mean value of the index based on 10000 bootstraps estimates; SE=std error.

Significant inter-annual shifts were observed for a number of species. After 2010, the overall importance of jumbo squid in the diets of swordfish, mako and blue sharks declined. These results reflect a decline in the abundance of jumbo squid off California after their range expansion into U.S. waters 2002-2010. After 2010, makos relied more on Pacific saury and blue sharks relied more *Gonatus* spp (squid). These changes demonstrate the ability of these predators to shift between available forage species. The dietary importance of sardines and anchovies also varied across years. The relative importance of Pacific sardine was greatest for mako and blue sharks around 2005-2007. The abundance of sardines in the CCLME that was high during the mid-2000s, a period followed by a dramatic decline in the biomass (Hill et al. 2017). A similar pattern is apparent for northern anchovy, which declined in thresher shark stomachs after 2007. Analysis of northern anchovy stock size from 1951–2011 suggested that the population was near an all-time low from 2009–2011 (MacCall et al. 2016). Again, the shift in diet reflects the ability of these predators to target different prey, even the thresher sharks, which is the most specialized of the species examined. Shifts in prey species are linked to large- and small-scale climactic and oceanographic shifts and are highly complex. These results indicate the potential of using stomach content as an indicator of shifts in the forage base over time.

Preti, A. 2020. Trophic ecology of nine top predators in the California Current. Ph.D. Dissertation. The School of Biological Sciences, University of Aberdeen, Scotland, UK

TRADE INFORMATION FOR SHARKS

Table 4. 2020 Exports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database, which can be accessed from: https://www.fisheries.noaa.gov/national/sustainable-fisheries/foreign-fishery-trade-data.

Country Name	Product Name	Volume (kg)	Value (USD)
AUSTRALIA	SHARK DOGFISH FROZEN	16,056	74,000
BELGIUM	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	3,205	22,000
BELGIUM	SHARK DOGFISH FROZEN	62,296	180,833
CANADA	SHARK NSPF FRESH	204,958	459,264
CHINA	SHARK DOGFISH FROZEN	34,653	89,155
CHINA - HONG KONG	SHARK DOGFISH FROZEN	44,049	106,820
CHINA - HONG KONG	SHARK FINS	3,058	145,309
CHINA - HONG KONG	SHARK NSPF FROZEN	10,808	19,780
DOMINICAN REPUBLIC	SHARK FINS PREPARED/PRESERVED IN ATC	2,401	25,458
FRANCE	DOGFISH AND OTHER SHARK MEAT FROZEN	3,627	10,523
FRANCE	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	73,841	502,625
FRANCE	SHARK DOGFISH FRESH	54,000	318,643
FRANCE	SHARK DOGFISH FROZEN	941,500	3,182,633
FRANCE	SHARK NSPF FROZEN	23,016	68,501
GERMANY	DOGFISH AND OTHER SHARK MEAT FROZEN	213,590	1,529,024
GERMANY	SHARK DOGFISH FROZEN	118,264	326,506
ISRAEL	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	3,018	14,278
ITALY	SHARK DOGFISH FRESH	12,504	73,014
ITALY	SHARK DOGFISH FROZEN	10,960	31,958
MEXICO	DOGFISH AND OTHER SHARK FILLET FRESH	3,644	25,850
MEXICO	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	69	3,901
MEXICO	SHARK DOGFISH FRESH	12,473	25,850
MEXICO	SHARK FINS PREPARED/PRESERVED IN ATC	8,618	38,803
MEXICO	SHARK NSPF FRESH	222,047	496,051

NETHERLANDS	SHARK DOGFISH FRESH	267,093	1,531,105
NETHERLANDS	SHARK DOGFISH FROZEN	1,170	6,974
NORWAY	SHARK DOGFISH FROZEN	47,128	114,285
PERU	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	709	3,354
SAUDI ARABIA	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	4,555	21,545
SINGAPORE	SHARK DOGFISH FROZEN	155,365	376,762
SOUTH AFRICA	SHARK FINS PREPARED/PRESERVED IN ATC	7,513	20,875
SOUTH KOREA	DOGFISH AND OTHER SHARK MEAT FRESH	75,273	287,500
SOUTH KOREA	SHARK DOGFISH FROZEN	96,088	230,604
SWEDEN	SHARK NSPF FROZEN	75,009	137,270
THAILAND	SHARK DOGFISH FROZEN	96,195	233,275
UNITED KINGDOM	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	2,231	10,555
UNITED KINGDOM	SHARK DOGFISH FRESH	27,480	139,777
UNITED KINGDOM	SHARK DOGFISH FROZEN	283,125	1,210,127

Table 5. 2020 Imports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database, which can be accessed from: https://www.fisheries.noaa.gov/national/sustainable-fisheries/foreign-fishery-trade-data.

Country Name	Product Name	Volume (kg)	Value (USD)
CANADA	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	2,386	10,783
MEXICO	DOGFISH AND OTHER SHARK FILLET FRESH	4,475	20,609
MEXICO	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	17,723	41,072
MEXICO	SHARK NSPF FRESH	943	2,603
MEXICO	SHARK NSPF FROZEN	1,119	5,550
NICARAGUA	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	2,912	8,685
SPAIN	SHARK NSPF FROZEN	1,645	17,316
SURINAME	DOGFISH AND OTHER SHARK FILLET FRESH	2,055	5,436
TRINIDAD & TOBAGO	DOGFISH, OTHER SHARK, RAYS AND SKATES (RAJIDAE) FILLET FROZEN	10,206	95,535

Table 6. 2020 Re-exports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database, which can be accessed from: https://www.fisheries.noaa.gov/national/sustainable-fisheries/foreign-fishery-trade-data.

Country Name	Product Name	Volume (kg)	Value (USD)
CANADA	SHARK NSPF FRESH	719	2,827

U.S. REGULATORY CHANGES IN 2020

U.S. National Level Updates

There were no new rules or legislation pertaining to shark conservation that were implemented in 2020 at the Federal level.

U.S. West Coast States Updates

There were no new rules or legislation pertaining to shark conservation that were implemented in 2020 in California, Oregon, or Washington.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
Sustainable Fisheries Division
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802

July 22, 2019

Dr. Guillermo Compeán, Director
Inter-American Tropical Tuna Commission (IATTC)
8901 La Jolla Shores Drive
La Jolla, California 92037-1508

Re: Submissions under Resolutions Related to Elasmobranchs

Dear Dr. Compeán:

This letter and enclosed report are submitted pursuant to several resolutions, all of which pertain to data on elasmobranchs:

- Resolution C-05-03: *Resolution on the Conservation of Sharks aught in Association with Fisheries in the Eastern Pacific Ocean*
    - 2017 and 2018 information (2018 research updates will be sent separately)
- Resolution C-11-10: *Resolution on the Conservation of Oceanic Whitetip Sharks Caught in Association with Fisheries in the Antigua Convention Area*
    - 2018 information
- Resolution C-15-04: *Resolution on the Conservation of Mobulid Rays Caught in Association with Fisheries in the IATTC Convention Area*
    - 2018 information
- Resolution C-16-05: *Resolution on the Management of Shark Species*
    - 2018 information
- Resolution C-16-06: *Conservation Measures for Shark Species, with Special Emphasis on the Silky Shark, for the Years 2017, 2018, and 2019*
    - 2017 and 2018 information

Please contact Taylor Debevec at 562-980-4066 or Taylor.Debevec@noaa.gov if there are any questions regarding the United States' reporting under these resolutions.

Sincerely,

Rachael Wadsworth

Rachael Wadsworth
Acting Highly Migratory Species Branch Chief

cc: Drew Lawler, Alternate U.S. Commissioner
David Hogan, Department of State
William Fox, Jr., U.S. Commissioner to the IATTC
Mike Thompson, Alternate U.S. Commissioner to the IATTC
John Zuanich, Alternate U.S. Commissioner to the IATTC
Ryan J. Wulff, NMFS WCR
150413SWR2013SF00273:TD

Below is relevant information for U.S. longline fisheries under the respective elasmobranch resolutions. The IATTC maintains all observer information for U.S. purse seine vessels and as such already has access to observed interactions with oceanic white tips, mobulids, silky sharks, and hammerhead sharks caught in that fishery.

C-11-10
In 2018, there were two observed oceanic whitetip sharks caught by U.S. longline vessels fishing in the eastern Pacific Ocean (EPO) recorded by NMFS observers; one with shallow-set longline gear (returned dead) and one with deep-set longline gear (returned alive).

C-15-04
In 2018, there were no observed mobulid caught by U.S. longline vessels fishing in the EPO recorded by NMFS observers.

C-16-05
In 2018, there were two silky sharks caught by U.S. longline vessels fishing in the EPO recorded by NMFS observers; both with deep-set longline gear (one returned alive, one returned dead).

In 2018, there was one hammerhead (smooth hammerhead) caught by U.S. longline vessels fishing in the EPO recorded by NMFS observers; it was caught with deep-set longline gear and returned dead.

C-16-06
The United States observer program does not collect individual lengths or weights of fish and as such cannot report on the percent of silky sharks caught <100 cm total length by weight during trips. However, we can report here the percent of silky sharks observed caught (regardless of size) by number of individual fish caught by trip.

In 2017, twenty silky sharks were observed caught in nine deep-set longline trips:

Trip Number in 2017	Total number of fish caught on trip	Total number of silky sharks caught on trip	Percent of silky shark catch for trip, by number
1	768	1	0.13%
2	1,092	3	0.27%
3	1,037	1	0.10%
4	1,251	1	0.08%
5	663	1	0.15%
6	1,325	1	0.08%
7	943	5	0.53%
8	906	4	0.44%
9	1,066	3	0.28%

As mentioned under C-16-05, in 2018, two silky sharks were observed caught. They were caught on two different deep-set longline trips:

Trip Number in 2018	Total number of fish caught on trip	Total number of silky sharks caught on trip	Percent of silky shark catch for trip, by number
1	827	1	0.12%
2	908	1	0.11%

2017 AND 2018 U.S. SHARK REPORT TO THE INTER-AMERICAN TROPICAL TUNA COMMISSION: AS REQUIRED PER RESOLUTION C-05-03

Inter-American Tropical Tuna Commission Resolution C-05-03 (*Resolution on the Conservation of Sharks Caught in Association with Fisheries in the Eastern Pacific Ocean)* was adopted by the IATTC in 2005. Under paragraph 11, the resolution requires that members and cooperating non-members (CPCs) provide the IATTC Secretariat with a comprehensive annual report that includes data on sharks caught in association with fisheries managed by the IATTC, including "catches, effort by gear type, landing, and trade of sharks by species, where possible, in accordance with IATTC reporting procedures, including available historical data." In addition, the resolution encourages CPCs to conduct research on sharks to identify ways to increase the selectivity of fishing gears, identify shark nursery areas, and provide assistance to developing countries to increase the collection of data on shark catches in those countries. Thus, this report is being submitted to the IATTC Secretariat to provide updates on relevant shark research conducted by the United States in 2016, to fulfill the U.S. reporting obligations for 2017 and 2018, and to provide updates of any domestic U.S. regulations that could impact sharks and shark fisheries in the IATTC Convention Area.

DATA SUBMITTED SEPARATELY

Catch, effort, and landings data on sharks caught by any U.S.-flagged vessel in any fishery for tuna and tuna-like species in the IATTC Convention Area was submitted with the annual report to the IATTC as required under Resolution C-03-05 (*Resolution on Data Provision*) by June 30. The catch and effort data by fishing gears will be provided at Level 3, the international standard for such data.

UPDATES ON SHARK RESEARCH IN 2017

SWSFC staff provided scientific advice on stock status of pelagic sharks to international and domestic fishery management organizations. SWFSC participation in international collaborations on pelagic shark stock assessments is organized primarily through the Shark Working Group (SHARKWG, chaired by Dr. Mikihiko Kai, National Research Institute of Far Seas Fisheries) of the ISC. In 2017 SWFSC scientists involved in the ISC SHARKWG worked on a new shortfin mako shark assessment with the goal of producing a full stock assessment early in 2018.

North Pacific Shortfin Mako Shark

In 2017, the ISC SHARKWG prepared data to conduct an assessment of shortfin mako sharks in the North Pacific in 2018. The objective was to update the fishery data time-series from the 2015 indicator analysis

(ISC 2015), review the latest biological research, and develop a fully integrated age-structured model. Participants from Japan, Taiwan, Mexico, Canada, and the U.S. contributed data and/or analytical work.

SWFSC and PIFSC scientists provided full catch time-series of mako sharks caught, landed, and released in U.S. commercial and recreational fisheries (Kinney et al. 2017) as well as information on the size and sex composition of mako sharks taken in several observed fisheries. The SHARKWG developed two models for consideration at the April 2018 working group meeting in La Jolla. The first is a fully integrated assessment model developed with Stock Synthesis (SS) (Carvalho *et al.* in prep), and the second a virtual population analysis (VPA) model (Kanaiwa *et al.* in prep). The SS model takes a matrix approach where several base-case scenarios are considered in order to account for uncertainty in many key model parameters. The VPA model was developed primarily to provide a point of comparison to the SS model. The SHARKWG will provide the results of both approaches in the April 2018 meeting.

Scientists from the SWFSC and PIFSC will be responsible for the bulk of the writing of the assessment report. This assessment report will closely follow the structure of the previous assessment report on blue sharks in the North Pacific Ocean (ISC 2017), which was completed by the ISC SHARKWG in 2017. One key difference, however, will be that the stock assessment report for mako sharks is unlikely to contain future projections.

Common Thresher Shark

The SWFSC is also involved in shark assessments outside of the ISC. Scientists from SWFSC and the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) collaborated to complete a stock assessment of common thresher sharks along the west coast of North America (Teo *et al.* 2016 and 2018). This is the first stock assessment of common thresher sharks along the west coast of North America that incorporates information from all fisheries exploiting the population. This assessment was peer reviewed by a panel from NOAA's Center for Independent Experts (CIE) during June 26 – 28, 2017. The reproductive biology of the common thresher shark was the major axis of uncertainty in the assessment, and more work will need to be done on this subject before the next assessment of this stock.

V. ADVANCING PELAGIC SHARK RESEARCH

The SWFSC's shark research program focuses on pelagic sharks that occur along the U.S. Pacific coast, including shortfin mako, blue sharks, basking sharks (*Cetorhinus maximus)*, and three species of thresher sharks: common thresher, bigeye thresher (*Alopias superciliosus),* and pelagic thresher (*Alopias pelagicus)*. Center scientists are studying the sharks' biology, distribution, movements, stock structure, population status, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks.

Electronic Tagging Studies and Habitat Modeling

Starting in 1999, SWFSC scientists have used satellite technology to study the movements and behaviors of large pelagic sharks; primarily blue, shortfin mako, and common thresher sharks, while other species are tagged opportunistically. Shark tag deployments have been carried out in collaboration with a number of partners in the U.S., Mexico, and Canada, including the Tagging of Pacific Predators (TOPP) program. The goals of these projects are to document and compare the movements and behaviors of these species in the eastern North Pacific and California Current and to link these data to physical and biological oceanography. In recent years scientists in the Life History Program have teamed up with researchers at ERD to incorporate both electronic tagging data and catch data into habitat models (see discussion of EcoCast below).

Shortfin Mako Shark

Since 2002, over one hundred shortfin mako sharks have been tagged with either SPOT or PSAT tags, or both, during the SWFSC's collaborative electronic tagging study. Partners include the Tagging of Pacific Pelagics program, CICESE, the Guy Harvey Institute, and several recreational anglers.

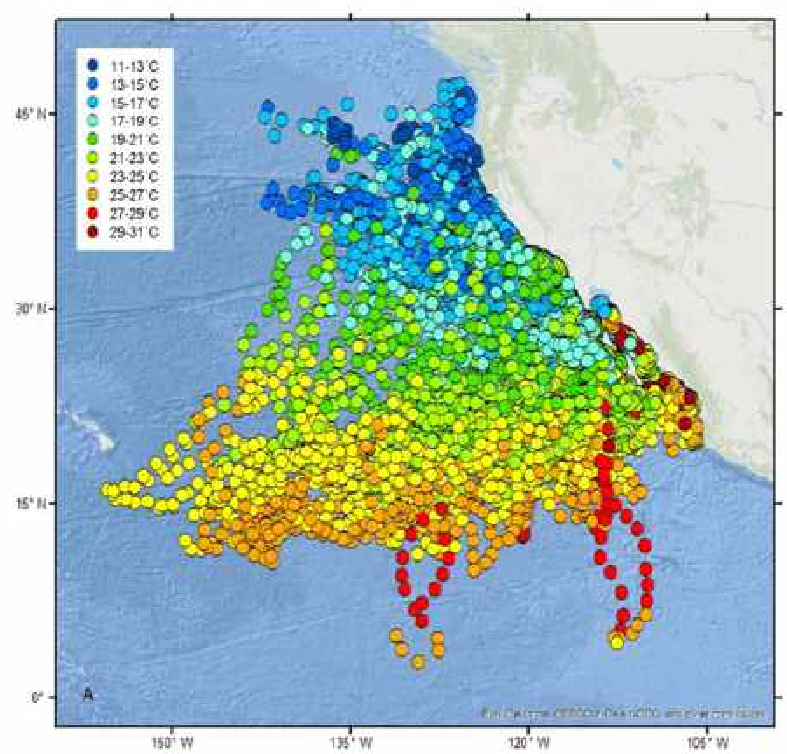

Figure 8. All filtered SPOT data colored according to remotely sensed SST.

Data from 55 PSAT tags and 89 SPOT tags are currently being analyzed and prepared for publication. This is an enormously rich data set that includes tracks throughout a large part of the eastern North Pacific. Tracks range from near the U.S.-Canada border to the subtropics, into the Sea of Cortez and out near Hawaii. These data provide new insights into the range of sharks from the eastern North Pacific and fill data gaps in regions where there are currently no available catch data, including from the U.S. EEZ to 140 W and in tropical waters. Tracks longer than six months showed that mako sharks tagged in the summer spent the summer and fall months near southern California after which they dispersed to the north, south, and offshore. Tags which recorded data for more than 12 months showed that the majority of tagged makos returned to the SCB the following summer. Larger sharks spent more time offshore and outside the U.S. EEZ than smaller sharks. Across their distribution they experience a broad range of sea surface temperature (11.2 - 31.2°C) and are not constrained to a narrow range as has been suggested in other studies using limited datasets (**Figure 8**). Their movements along the coast are linked to shifts in primary productivity with movement both to the north and south in the California Current being linked to pulses of higher chlorophyll *a* concentrations at lower and higher latitudes. A comparison of habitat-use across regions show considerable diversity in vertical movements. In some areas, a distinct diel pattern is apparent whereas in others there is no obvious pattern (**Figure 9**). There is some indication that vertical water column structure influences dive patterns. The high degree of variability in dive patterns suggests that they are likely foraging throughout the water column which is consistent with their diverse diet.

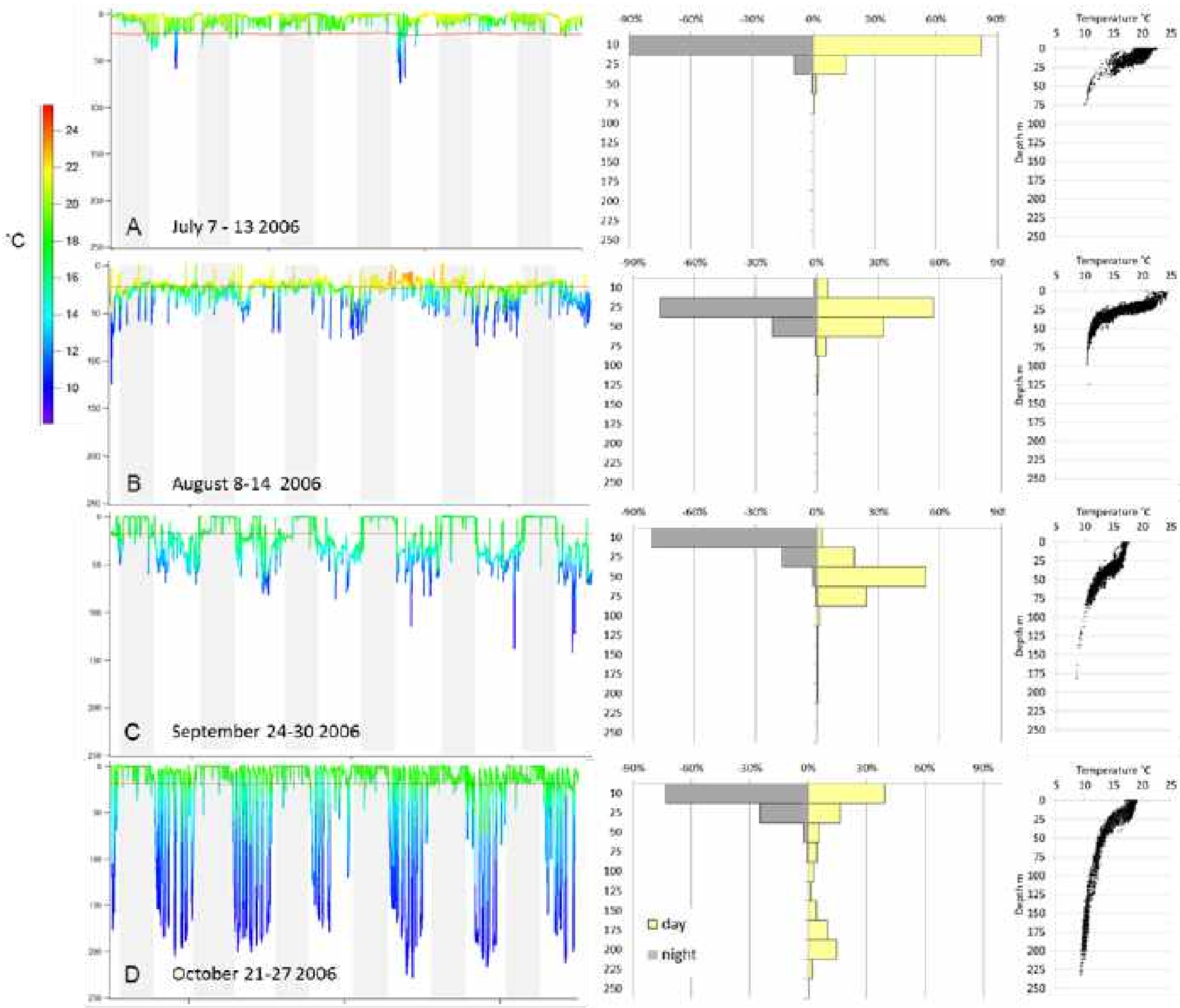

Figure 9. Vertical patterns from recovered PSAT data from tag 06-3PS, (174 cm FL M), overlaid with color coded temperature. Each plot displays 11 days of data A) in SCB between Santa Cruz Island and Catalina

Island, B) in Sebastian Vizcaino Bay, Baja California, Mexico, C) just off Point Conception and D) SCB in the nearshore Santa Monica Bay

Blue Shark

The SWFSC has been deploying satellite tags on blue sharks since 2002 to examine movements and habitat use in the eastern North Pacific. To date, a total of 100 sharks (51 males and 49 females) have been tagged with some combination of SPOT (n=95) and/or PSAT tags (n=60), with 55 sharks carrying both tag types. The majority of sharks were tagged in the SCB, with a few additional deployments off Baja California Sur, Mexico, or southwest Canada. Five sharks died shortly after tagging and seven PSAT tags were recovered providing archival data on temperature, depth, and light levels. Satellite tag deployment durations for both tag types are substantially shorter than for mako sharks. For the 37 PSAT tags that provided data only 8 remained attached until the programmed pop-up date and the average deployment duration was 115 days. The mean SPOT tag track duration was 88 days, however, six tags transmitted for 337 days or more allowing for an examination of seasonal patterns.

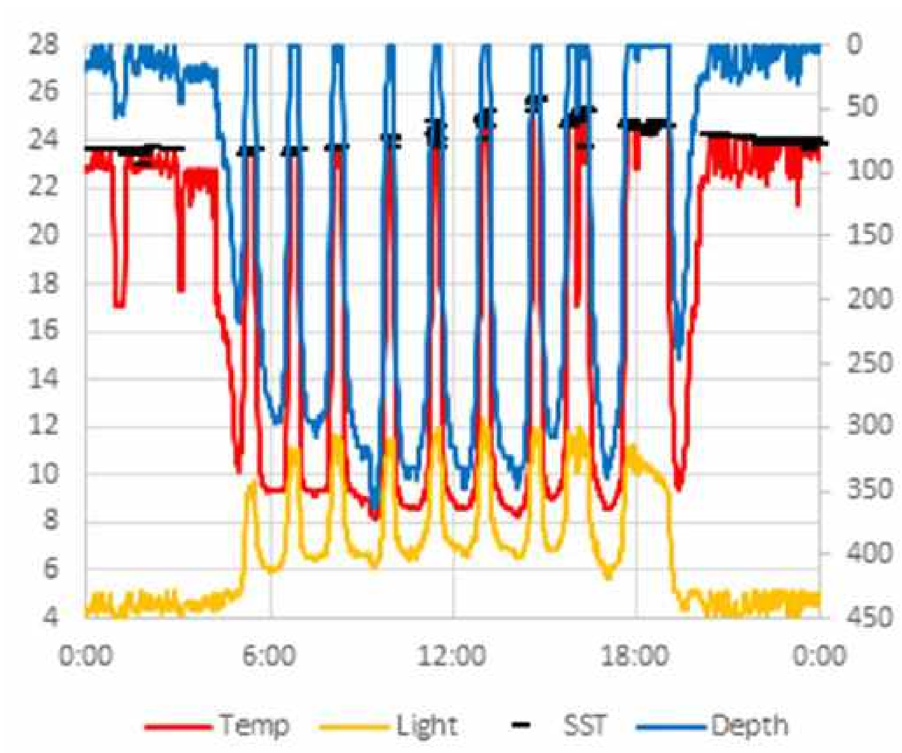

Figure 10. Archival data collected showing the 2oC increase in afternoon temperature associated with solar heating and not frontal activity.

Efforts to characterize habitat often focus on frontal activity where prey tend to accumulate. Fronts are often inferred from a change in SST. A close examination of archival data collected from blue sharks revealed that significant increases in SST can also be associated with warming during the day and not linked to frontal activity. In some instance the temperature increased by 2^{o}C in the early afternoon associated with solar heating. The fact that the increase in SST was not due to sharks being on a front was confirmed by examining the temperature depth profile over the same time period. Solar heating may confer some advantage for behavioral thermoregulation, allowing sharks to warm more quickly after dives into deep water. This result has important implications for using archival data to characterize habitat and for correcting light-based geolocations estimates by matching the SST recorded by the satellite tags to satellite derived SST. Both measurements should be taken at night.

EcoCast

Both electronic tagging data and catch data for blue sharks in the California Current have been incorporated into EcoCast to help fishers avoid blue sharks during Drift gillnet fishing activities. Motivations to reduce blue sharks landings include reducing bycatch as blue sharks have no marketable value and are discarded at sea. In addition, catching blue sharks increases haul back time, reduces efficiency and can damage gear. Given that the overall viability of a fishery depends on target species catch, EcoCast combines habitat preferences for both target (swordfish) and non-target species which includes sea lions and leatherback sea turtles in addition to blue sharks. The resulting product is updated daily based on environmental conditions and can be used by fishers to identify locations where target catch is maximized and bycatch is minimized (**Figure 11**). Current efforts are focused on beta testing EcoCast with fishers.

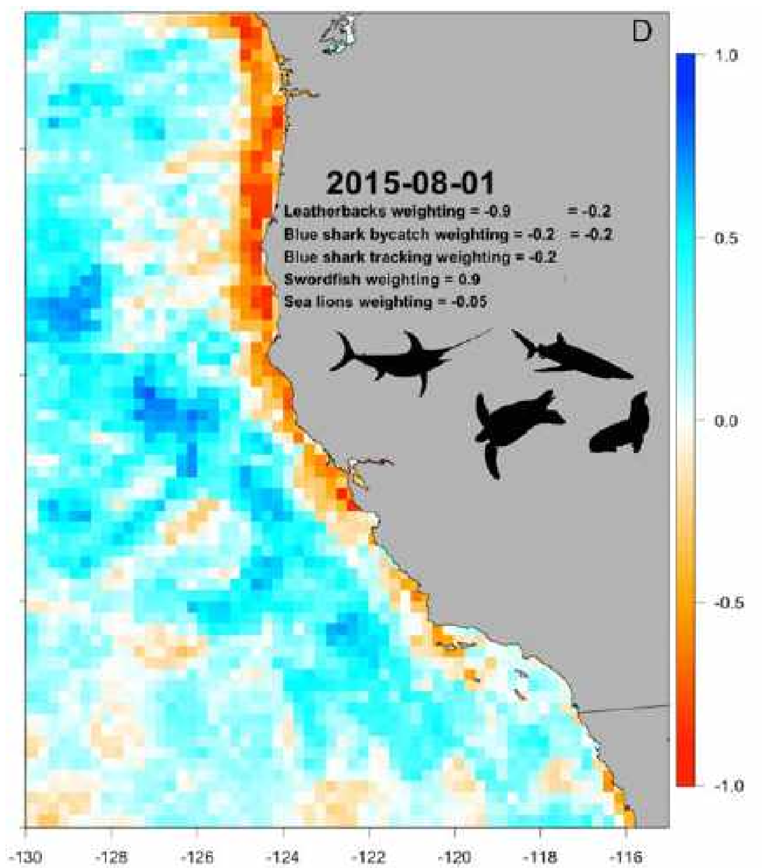

Figure 11. EcoCast model predictions for August 1, 2015, integrating habitat probabilities for swordfish, leatherback turtles, blue sharks, and California sea lions.

Common Thresher Shark

Since 2004, scientists at the SWFSC have been opportunistically tagging common thresher sharks with electronic tags during the annual neonate thresher shark and HMS abundance surveys. To date 29 common thresher sharks have been released with either PSAT3, SPOT4, or both since 2004. Depth data indicate that threshers spend much more time near the surface in the mixed layer than they do at greater depths, and that vertical excursions below the mixed layer primarily occur during the day, potentially due to their unique hunting strategy which relies on visual prey detection. Work in 2015, 2016, and 2017 focused on developing a Bayesian movement model to provide a quantitative approach to inferring the effects of various environmental conditions on the horizontal movement of threshers. This work resulted in a 2017 (Kinney et al. 2017) publication which focused on the method of applying this Bayesian approach to limited movement data, such as what is available for thresher sharks.

Using this Bayesian movement model, SWFSC researchers aim to understand what biological and environmental variables influence whether threshers remain within the SCB or move into the surrounding waters in a predictable manner. Analysis suggests that fork length and the spring season are the strongest predictors of thresher shark movement out of the SCB, with their posteriors shifted furthest from zero. A paper on threshers using this data limited Bayesian method is nearing completion and will be published sometime in 2018 (Kinney et al. in prep).

Age Validation Studies

Age and growth of mako, common thresher, and blue sharks are being estimated from band formation in vertebrae. In addition to being important for studying basic biology, accurate age and growth curves are needed in stock assessments. SWFSC scientists are validating ageing methods for these three species based on band deposition periodicity determined using oxytetracycline (OTC). Since the beginning of the program in 1997, more than 4000 individuals have been injected with OTC. While the SWFSC is no longer running surveys we occasionally receive sharks that have been injected with OTC from fishers and ageing studies are ongoing. In addition, the SWFSC has been leading shark international efforts to standardize ageing methods through the ISC shark working group.

Shortfin Mako Shark

During 2017 shortfin mako vertebra from an established reference collection, made up of vertebra from ISC member nations (U.S., Japan, Mexico, Taiwan) were used to create a conditional age at length dataset to use in the mako shark assessment. Researchers formatted this data for SS and included it in the current mako shark assessment SS data file. It is currently unclear how this dataset will affect the outcome of the model (which is set to be completed in 2018), but it is a step forward in terms of using aeging data within the model to help estimate growth.

Foraging Ecology of Pelagic Sharks

The California Current is a productive eastern boundary current that functions as an important nursery and foraging ground for a number of highly migratory predator species. To better understand niche separation and the ecological role of spatially overlapping species, SWFSC researchers have been analyzing the stomach contents of pelagic sharks since 1999. Stomachs are obtained primarily from the CA DGN observer program, but with decreasing effort in the fishery, fewer shark stomachs have been available for analysis in recent years.

Stomach Content Analysis

Stomach content analysis of blue, shortfin mako, thresher, and bigeye thresher sharks is ongoing. Data are finalized for the period 2002-2014.

For the mako shark, jumbo squid was the most important prey item by weight and combined indices. Pacific saury (*Cololabis saira*) was the second most important prey by GII and IRI but the most important for frequency of occurrence and the most abundant by number. Other dominant teleost prey included Pacific sardine, Pacific mackerel, striped mullet (*Mugil cephalus*) and jack mackerel. Makos also preyed on marine mammals and other elasmobranchs. One mako preyed on a short-beaked common dolphin (*Delphinus delphis*), blue sharks were found inside five mako stomachs, and one mako fed on four tope sharks (*Galeorhinus galeus*).

Squids of the genus *Gonatus* ranked first for GII and IRI and frequency of occurrence for the blue shark. Jumbo squid ranked second for GII and IRI but they were the most important in weight. Other dominant prey included octopuses of the genus *Argonauta*, and the flowervase jewell squid (*Histioteuthis dofleini*). One blue shark fed on an unidentified cetacean and another one fed on elephant seal (*Mirounga angustirostris*). Three blue sharks fed on elasmobranchs spiny dogfish (*Squalus acanthias*) and tope shark, and one ingested a common tern (*Sterna hirundo*). Forty-seven blue shark stomachs (23% of all stomach samples) contained prey that was bitten in chunks and were found in a fresh state of digestion (states 1 and 2) which were interpreted as prey caught in the net. One blue shark stomach contained a skipjack tuna head with a piece of net in his mouth. Other net-caught prey taxa included scombridae (F=31), ocean sunfish (*Mola mola*) (F=8), broadbill swordifish (F=3), opah (F=2), unidentified elasmobranchs (F=2), and Pacific pomfret (*Brama japonica*) (F=1). One stomach contained 21 pork steaks wrapped in paper and another stomach contained vegetables (onions, bell peppers, shredded carrots) and a tea bag, all these items were likely discarded at sea and scavenged by the blue sharks. Similar fresh chunks of prey were observed in one mako stomach and no thresher or bigeye thresher shark stomachs.

For the thresher shark, northern anchovy (*Engraulis mordax*) ranked first in both the GII and IRI and had the highest number and weight. Pacific sardine ranked second in both the GII and IRI. Other dominant identified prey included market squid, Pacific hake, and Pacific mackerel. Pacific saury, Jack mackerel (*Trachurus symmetricus*) and Duckbill barracudina (*Magnisudis atlantica*) were found in at least 16 stomachs. Pelagic red crab was the most frequent crustacean (F=12).

Jumbo squid was the most important prey (for GII and IRI) for the bigeye thresher shark, it was also the most frequent prey with the highest weight. Duckbill barracudina and other Paralepididae ranked second and third. Other important prey included Pacific hake, Pacific mackerel, Pacific saury and *Gonatus* spp. squids. Fourteen individuals of king-of-the-salmon were present in two bigeye thresher stomachs.

In 2017 analytical efforts focued on univariate indices to estimate richness, diversity, similarity of diet for the four shark species. Across species, rarified diet richness estimated with Menhinick's index was significantly lower in thresher than in the other three species. Mako had a significantly higher richness than bigeye thresher. Bigeye thresher presented a significantly higher species richness (*1/D*) than the thresher. The diversity of a diet or unevenness estimated with the Shannon entropy index was significantly lower for thresher than in the other three species.

Different similarity indices give somewhat different results. Sørensen similarity results suggested that mako and blue shark diets were the most similar, followed by mako and bigeye, and the least similar were blue and thresher diets. SMH results on the other hand suggested that mako and bigeye diets had the greatest similarity, followed by thresher and bigeye and blue and thresher were again the least similar. Niche overlap estimated with the Pianka index was the greatest for mako and bigeye thresher, followed by thresher and bigeye and the lowest overlap was for blue and thresher.

As a guide to whether levels of similarity differ significantly between pairs of species, non-overlap of 95% confidence limits can be used. Thus, for the Sørensen index, the similarity between mako and blue is significantly greater than the similarities between any other pair of species. The similarity between blue and thresher is significantly lower than the similarity between bigeye thresher and the other species (and significantly lower than the similarity between blue and mako, as already evident from the previous result). In the case of the SMH and Pianka indices, none of the differences in similarity are significant (for both indices, all six sets of 95% confidence limits are overlapping, although in a few cases the overlap is small).

Thresher Reproductive Biology

In 2015, the Southwest Fisheries Science Center, in collaboration with Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), initiated the first bilateral Northeast Pacific common thresher shark stock assessment which was published in 2016. This assessment used reproductive parameters estimated by Smith et al. (2008) for the Northeast Pacific. However, given the dramatic differences in the estimates of age at first reproduction for females for the Atlantic and Pacific Oceans (216 cm FL versus 160 cm FL respectively), SWFSC scientists reexamined the data and specimens used by Smith in her study. Due to concerns about the species ID and other inconsistency, it was determined that additional analyses and samples would be needed to provide a validated estimate for the eastern North Pacific. The SWFSC is currently working towards examining and obtaining additional specimens where the species ID can be validated. Until that time the stock assessment is being run with life history parameters derived in the Atlantic Ocean.

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<u>Updates on Shark Research in 2018</u>

<u>I. SUPPORTING U.S. OBLIGATIONS OF INTERNATIONAL AGREEMENTS</u>

SWSFC staff provided scientific advice on stock status of pelagic sharks to international and domestic fishery management organizations. SWFSC participation in international collaborations on pelagic shark stock assessments is organized primarily through the Shark Working Group (SHARKWG, chaired by Dr. Mikihiko Kai, National Research Institute of Far Seas Fisheries) of the ISC. SWFSC scientists involved in the ISC SHARKWG worked on a shortfin mako shark assessment in 2018 and produced the first full stock assessment for this species in the North Pacific. SWFSC scientists are also working to prepare for the upcoming assessment of blue sharks in 2020.

North Pacific Shortfin Mako Shark

In 2017-18, the ISC SHARKWG conducted an assessment of shortfin mako sharks in the North Pacific. The Working Group analyzed fishery data, updated biological parameters, and developed a fully integrated age-structured model. Participants from Japan, Taiwan, Mexico, Canada, and the U.S. contributed data and/or analytical work to the assessment.

SWFSC and PIFSC scientists provided full catch time-series of mako sharks caught, landed, and released in U.S. commercial and recreational fisheries as well as information on the size and sex composition of mako sharks taken in several observed fisheries (Carvalho 2017, Kinney et al. 2017). The SHARKWG developed two models for shortfin makos in 2017-18, the first was a fully integrated assessment model developed with Stock Synthesis (SS) (ISC 2018), and the second was a virtual population analysis (VPA) model (Kanaiwa et al. 2017). The VPA model was primarily used to provide a point of comparison to the SS model. The 2018 ISC North Pacific shortfin mako shark stock assessment was presented at the ISC plenary in Korea (July 2018), and later to the Scientific Committee of the WCPFC in Taiwan (August 2018), where it was accepted as the best scientific information available for stock status determination. The results indicated that the stock is likely not in an overfished condition and overfishing is likely not occurring relative to MSY-based abundance and fishing intensity reference points.

Blue Shark

In November 2018, SWFSC scientists attended the ISC SHARKWG meeting in Taiwan to discuss future projects and research directions for the upcoming blue shark assessment in 2020. The group laid out a work plan and prioritized projects for the coming assessment. SWFSC scientists presented preliminary work on redefining Hawaiian longline fisheries with spatiotemporal consideration of blue shark size data (Kinney et al. 2018). This work was presented to the group as a proof of concept and was intended to encourage the sharing of spatially explicit size and sex information for blue sharks in order to allow the same analysis to be done on the wider data set of blue sharks caught in various longline fisheries in the North Pacific. The work was positively received and each nation is currently providing their data to allow this work to carry forward. Participants from Japan, Taiwan, and Mexico also presented updates to catch and important biological parameters for use in the upcoming blue sharks assessment.

II. ADVANCING PELAGIC SHARK RESEARCH

The SWFSC's shark research program focuses on pelagic sharks that occur along the U.S. Pacific coast, including shortfin mako, blue sharks, basking sharks (*Cetorhinus maximus)*, and three species of thresher sharks: common thresher, bigeye thresher (*Alopias superciliosus),* and pelagic thresher (*Alopias pelagicus)*. Center scientists are studying the sharks' biology, distribution, movements, stock structure, population status, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks.

A. Electronic Tagging Studies and Habitat Modeling

Starting in 1999, SWFSC scientists have used satellite technology to study the movements and behaviors of large pelagic sharks; primarily blue, shortfin mako, and common thresher sharks, while other species are tagged opportunistically. Shark tag deployments have been carried out in collaboration with a number of partners in the U.S., Mexico, and Canada, including the Tagging of Pacific Predators (TOPP) program. The goals of these projects are to document and compare the movements and behaviors of these species in the eastern North Pacific and California Current and to link these data to physical and biological oceanography.

In recent years, Life History Program scientists have teamed up with researchers at ERD to incorporate electronic tagging data and catch data into habitat models. These models combine location information with environmental data from ROMs models and satellite imagery to provide a quantitative estimate of habitat preferences across physical and biological oceanographic parameters. The modeling approach used, known as EcoCast, has a number of applications. The information on habitat preferences provides insight into abundance and distribution, and how these might shift seasonally and with climate variability. By combining habitat envelopes from target and non-target species, it is possible to create maps that allow fisheries to avoid bycatch species and maximize efficiency (Hazen et al. 2018).

Shortfin Mako Shark

Since 2002, over one hundred shortfin mako sharks have been tagged with either SPOT or PSAT tags, or both, during the SWFSC's collaborative electronic tagging study. Partners include the TOPP program, CICESE, the Guy Harvey Institute, and several recreational anglers. In 2018, researchers analyzed data from 55 PSAT tags and 89 SPOT tags and prepared multiple papers for publication. The first paper described the overall patterns of movements across seasons and size classes in the eastern North Pacific. The main findings were presented in previous reports.

The second paper explores whether vertical movements are consistent with optimal foraging theory, and constrained when animals are in a prey patch. In pelagic environments prey tend to be patchily distributed in time and space both horizontally and vertically. Optimal foraging theory states that it is in a predator's best interest to maximize time in a prey patch and minimize time traveling between patches. This has been demonstrated for horizontal movements, where movements are constrained during foraging, but not for vertical movements. Using data from double tagged mako sharks, researchers examined vertical movements during transient and resident behaviors where animals were presumed to be foraging. Results indicate that, as with horizontal movements, maximum depths are significantly shallower and vertical movements are more constrained during periods of resident behavior. Additionally, water column structure also influenced vertical habitat use, with sharks using more of the water column in warmer waters. Results suggest an expansion of vertical habitat use when sharks switch to transient behaviors, which may increase the probability of locating prey resources, and that temperature may influence the degree of habitat expansion.

Blue Shark

The SWFSC has been deploying satellite tags on blue sharks since 2002 to examine movements and habitat use in the eastern North Pacific. To date, 100 sharks (51 males and 49 females) have been tagged with some combination of SPOT (n=95) and/or PSAT tags (n=60), with 55 sharks carrying both tag types. **Figure 1** shows the geolocation data for both SPOT and PSAT data as a function of month. PSAT data was recently analyzed, and preliminary analysis indicates apparent patterns. Similar to mako sharks, blue sharks traveled to the North Equatorial Current where they exhibited residential behavior. A few large individuals with longer tracks returned to the Southern California Bight in subsequent years. Researchers are currently analyzing general patterns of movement and behavior for publication.

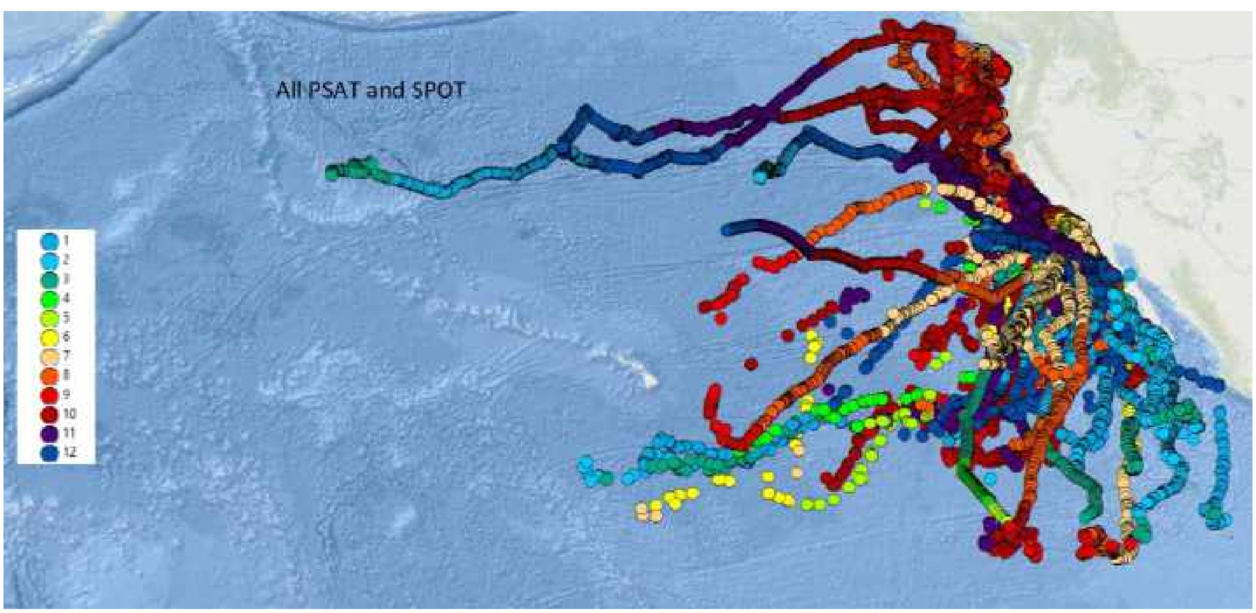

Figure 1. Argos based geolocations from SPOT tags and light and SST based geolocation estimates from PSAT tags for blue sharks tagged since 2002.

One important element for management is determining whether there are differences in distribution with sex and size. Blue sharks have clear habitat separation between sex and size in the open ocean (Nakano and Seki 2003). Using solely the SPOT data, researchers compared the mature males and immature females in coastal waters (**Figure 2** below). The sample size for mature females and immature males was not large enough to include. Researchers found that immature females are found at higher latitudes in the summer months and undergo a seasonal southward migration along the U.S. West Coast, similar to patterns observed in the North Atlantic (Vandeperre *et al.*, 2014). This more northern distribution translated into small females experiencing cooler SST (12-15C) than the larger males (>15C). Researchers also found some overlap between adult males and immature females in the fall months, indicating the importance of the Southern California Bight for multiple size classes. Additional work is needed to better characterize the full range of mature females and immature males. This work was accepted for publication in Diversity and Distributions in 2018 (Maxwell et al. *in press).*

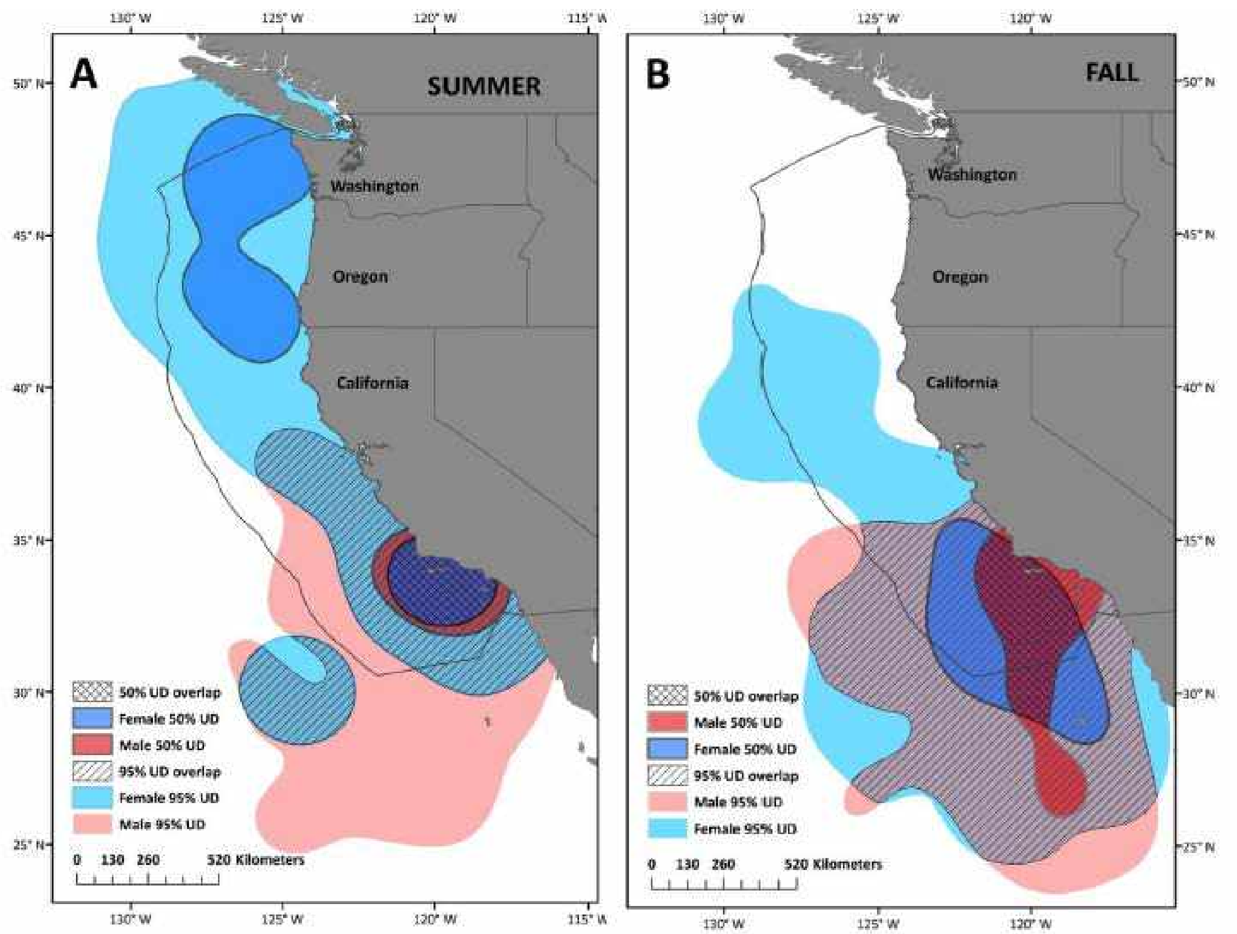

Figure 2. Home range (50 and 95% utilization distributions, UDs) for immature females (blue shades) and mature males (red shades) in the (A) summer and (B) fall. Overlap of 50 and 95% UDs indicated via hatching. The solid black line indicates the U.S. Exclusive Economic Zone.

Basking Shark

The eastern North Pacific basking shark population appears to have declined dramatically in the last 50 years. Where hundreds to thousands of individuals were observed off the U.S. West Coast in the early to mid-1900s, sighting even a few individuals is now rare. Due to concern over basking shark populations and the large data gaps, a research program was initiated in 2010 by the Southwest Fisheries Science Center, including an electronic tagging program. A publication on the results from this study was published in 2018 (Dewar et al. 2018).

For the publication, data from four sharks tagged with satellite tags in 2010 and 2011 were analyzed. The four sharks showed impressive plasticity in geographic movements and vertical behaviors depending upon the region and distance from shore, as has been shown in the Atlantic. Of the two tracks that progressed into winter months, one shark went south along the Baja Peninsula while the other shark moved southwest to waters just north of Hawaii (**Figure 3**). A comparison of vertical movements with acoustic back-scatter data in the Central Pacific reveals that basking sharks track a consistent scattering layer as they move between 450-470 m during the day and 250-300 m at night. Scatter data reveal the presence of small crustaceans and gelatinous zooplankton in this layer, however, the potential presence of smaller prey such as copepods cannot be resolved with the frequencies used in this study. Interestingly, basking sharks appear to leave daytime depths a few hours prior to sunset which is uncommon for most deep scattering layer (DSL) predators but has been observed in copepods. This suggests that copepods may still be important prey offshore, as they are in nearshore waters, however additional data are still needed.

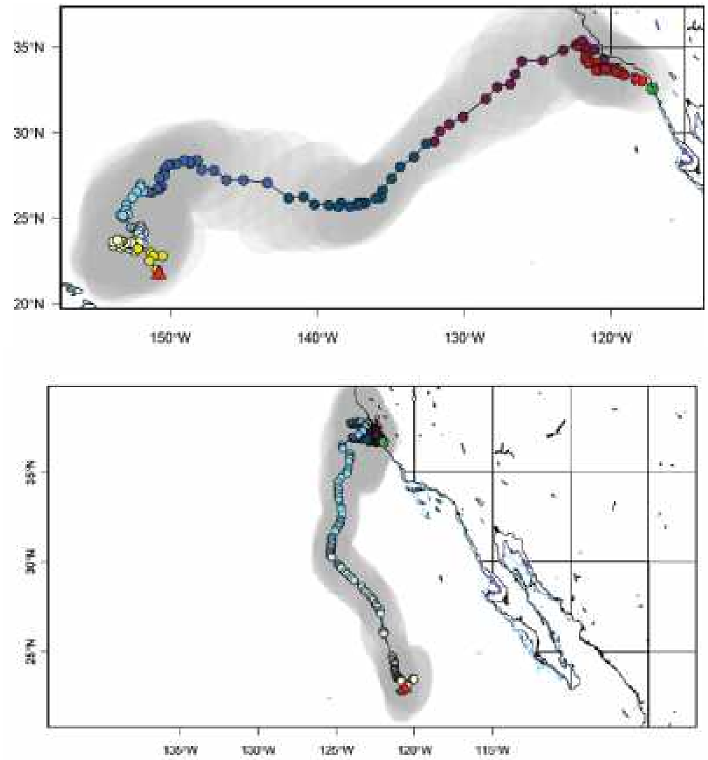

Figure 3. (Top) The track of a basking shark tagged on 6/7/2011 off San Diego. The tag released as programmed on 2/2/2012. (Bottom) The track of a basking shark tagged on 8/2/2011 off Monterey. The tag released as programmed on 1/29/2012. Green circles indicate tagging location; red triangles are pop-off locations.

Political Biograpgraphy

In addition to examining the movements and habitat use of individuals, electronic tagging data provides the opportunity to examine what political biogeographic regions they visit and how much time they spend there, which has implications for management. Tagging data collected by SWFSC on mako and blue sharks was included in a study examining the time 14 different species spent in the U.S. EEZ, U.S.-Mexico border, or on the high seas. The analyses focused on the geopolitical boundaries of the Pacific Ocean throughout species' annual cycles and their relative abundance in EEZ of the US and Mexico

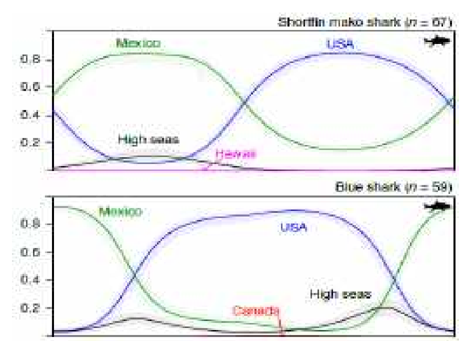

Figure 4. Seasonal Probability of Occurrence.

and the high seas (**Figure 4**). Analyses reveal that Blue Sharks spent from February – August on the High-Seas and then the fall in the U.S. EEZ. In contrast Mako sharks spent the winter and spring in the Mexican EEZ and the summer and fall in the U.S. EEZ. This research was published in Nature Ecology and Evolution in 2018.

Post-release mortality of blue shark from the CA Drift Gillnet Fishery

In the California large-mesh, drift gillnet fishery (DGN) that targets swordfish, blue sharks are a common bycatch species and nearly all are discarded. While approximately 32% of those discarded are released alive the post release mortality (PRM) is unknown. Beginning in 2007, observers aboard DGN vessels recorded the physical conditions of 247 blue sharks before release using a set of visual condition factors. Results from this initial survey revealed that of the sharks released alive, 43% were in good condition, 28% in fair condition and 28% in poor condition upon release. To determine PRM, observers tagged 15 sharks (3 in good, 10 as fair, and 2 in poor condition) with pop-up satellite tags. Eleven (73.3%) tagged sharks survived 30 days following release from the DGN gear, the fate of two (13%) was unknown (including one tag presumed ingested by another animal), and two (13%) suffered immediate mortalities. Of the sharks released in good condition, all three survived at least 30 days. Of the ten sharks released in fair condition, eight (80%) survived at least 30 days, one (10%) survived at least 18 days, and one (10%) died immediately. Of the two sharks released in poor condition, one (50%) survived at least 8 days and one (50%) was an immediate mortality, suggesting that sharks released in poor condition are unlikely to survive following release. Applying these PRM rates to the proportion of sharks that were released alive in the fishery, combined with those that died during capture, we estimate a PRM rate of 33.6% and an average total mortality rate of 89.3% for blue sharks caught in the CDGN fishery during the 1990-2015 seasons. These results were analyzed for publication in 2018. While a higher sample size from shark in fair or poor condition would have been ideal, additional efforts to tag sharks were not successful.

B. Age Validation Studies

Researchers are estimating the age and growth of mako, common thresher, and blue sharks from band formation in vertebrae. In addition to being important for studying basic biology, accurate age and growth curves are needed in stock assessments. SWFSC scientists are validating ageing methods for these three species based on band deposition periodicity determined using oxytetracycline (OTC). Since the beginning of the program in 1997, more than 4000 individuals have been injected with OTC. While the SWFSC is no longer running surveys, scientists occasionally receive sharks that have been injected with OTC from fishers and work is ongoing. A publication on the age validation of common thresher sharks was prepared for publication in 2018. In addition, the SWFSC has been leading international efforts to standardize ageing methods through the ISC Shark Working group. This effort has including hosting workshops and creating a reference vertebra library to allow for comparison of results across labs around the Pacific Basin. This reference library formed the basis for the new age at length curve used in the most recent ISC stock assessment for shortfin mako sharks in the Pacific.

In addition to using traditional methods of counting vertebral band pairs for aging, scientists at the SWFSC have collaborated with Texas A&M and CICESE, Ensenada Mexico to try a new approach. Elemental profiles were characterized in vertebrae, encompassing the complete life histories (birth to death) of shortfin mako, common thresher, and blue shark of known tag and recapture locations in the eastern North Pacific Ocean. All sharks had been injected with OTC at initial capture and were and subsequently recaptured after periods ranging from 215 days to 6 years. Vertebral band pairs forming over the liberty intervals were verified by counting the number of band pairs deposited since the OTC band. Preliminary results indicate that there are regular oscillations in vertebrae manganese (Mn) content that corresponds well with the number of validated band pairs, suggesting that Mn variation could be used to age sharks. Interestingly, enrichments in vertebrae barium (Ba) concentration were correlated with times when individuals occupied areas with high coastal upwelling indices, the timing and spatial intensity of which varied from year to year. Results collected to date indicate that vertebral chemostratigraphy has the potential to advance our knowledge of elasmobranch life history including age and growth estimation and environmental reconstruction. This research was submitted for publication in 2018.

C. Foraging Ecology of Pelagic Sharks

The California Current is a productive eastern boundary current that functions as an important nursery and foraging ground for a number of highly migratory predator species. To better understand niche separation and the ecological role of spatially overlapping species, SWFSC researchers have been analyzing the stomach contents of pelagic sharks since 1999. SWFSC obtains these stomachs primarily from the CA DGN observer program, but with decreasing effort in the fishery, fewer shark stomachs have been available for analysis in recent years.

Stomach Content Analysis

Stomach content analysis of blue, shortfin mako, thresher, and bigeye thresher sharks is ongoing. Data are finalized for the period 2002-2014 and are in the process of being submitted for publication.

For the mako shark, jumbo squid was the most important prey item by weight and combined indices. Pacific saury (*Cololabis saira*) was the second most important prey by GII and IRI but the most important for frequency of occurrence and the most abundant by number. Other dominant teleost prey included Pacific sardine, Pacific mackerel, striped mullet (*Mugil cephalus*) and jack mackerel. Makos also preyed on marine mammals and other elasmobranchs. One mako preyed on a short-beaked common dolphin (*Delphinus delphis*), five mako sharks had ingested blue sharks, and one mako fed on four tope sharks (*Galeorhinus galeus*).

Squids of the genus *Gonatus* ranked first for GII and IRI and frequency of occurrence for the blue shark. Jumbo squid ranked second for GII and IRI but they were the most important in weight. Other dominant prey included octopuses of the genus *Argonauta*, and the flowervase jewell squid (*Histioteuthis dofleini*). One blue shark fed on an unidentified cetacean and another one fed on elephant seal (*Mirounga angustirostris*). Three blue sharks fed on elasmobranchs spiny dogfish (*Squalus acanthias*) and tope shark, and one ingested a common tern (*Sterna hirundo*).

For the thresher shark, northern anchovy (*Engraulis mordax*) ranked first in both the GII and IRI and had the highest number and weight. Pacific sardine ranked second in both the GII and IRI. Other dominant identified prey included market squid, Pacific hake, and Pacific mackerel. Pacific saury, Jack mackerel (*Trachurus symmetricus*), and Duckbill barracudina (*Magnisudis atlantica*) were found in at least 16 stomachs. Pelagic red crab was the most frequent crustacean (F=12).

Jumbo squid was the most important prey (for GII and IRI) for the bigeye thresher shark; it was also the most frequent prey with the highest weight. Duckbill barracudina and other Paralepididae ranked second and third. Other important prey included Pacific hake, Pacific mackerel, Pacific saury and *Gonatus* spp. squids. Fourteen individuals of king-of-the-salmon were present in two bigeye thresher stomachs.

Across species, rarified diet richness estimated with Menhinick's index was significantly lower in thresher than in the other three species. Mako had a significantly higher richness than bigeye thresher. Bigeye thresher presented a significantly higher species richness (*1/D*) than the thresher. The diversity of a diet or unevenness estimated with the Shannon entropy index was significantly lower for thresher than in the other three species.

The results above as well as Generalized Additive Models, Redundancy Analysis, were finalized were compiled for publication in 2018.

Inter- and intra-specific patterns in contaminant accumulation

The historical research cruises, biological sampling program, and relationship with the federal observer program has provided the SWFSC with a large number of tissue samples across a range of species. In collaboration with Dr. Kady Lyons, we have been examining contaminant loads across sex and size for blue, mako, and thresher sharks. Results provide insight into foraging, maternal offloading, scaling effects, and the dynamics of movements. In 2018 results from the analyses of contaminants were examined for two papers that were submitted for publication. Overall results indicate that mako sharks have the highest contaminant loads followed by thresher sharks and finally blue sharks. The patterns of contaminant accumulation with across sizes differ for the three species and differences are likely linked to diet, physiology, location and maternal off-loading. Species-specific characteristics need to be considered when estimating contaminant exposure and its potential negative effects on shark health and human consumption safety.

Spiral valve parasites as indicators of shark feeding behavior and ecology

As an addition to classic diet analyses, this study is a preliminary attempt to analyze the parasite faunas of blue and thresher sharks caught in the California Current Large Marine Ecosystem (CCLME) north of the Mexican border, with the ultimate objective of investigating possible links between parasites, shark diet and the environment. The spiral valves of 18 blue and 19 thresher sharks caught in the CCLME from 2009 and 2013 were examined for parasites. Seven parasite taxa were found in blue sharks and nine in threshers. The tetraphyllidean cestode *Anthobothrium caseyi* (78% prevalence) was the most common parasite of blue sharks and the phyllobothriid cestode *Paraorygmatobothrium* sp. (90% prevalence) was the most common in threshers. A nematode of the genus *Piscicapillaria* found in threshers may be a new species. The adult form of the nematode *Hysterothylacium incurvum* – a parasite specific to swordfish – was found in both shark species, indicating predation on swordfish, probably via feeding on juvenile swordfish or on discards from fisheries. The adult acanthocephalan *Rhadinorhynchus cololabis* and remains of the parasitic copepod *Pennella* sp. – both specific to Pacific saury, *Cololabis saira* – were found in the intestines of threshers, indicating recent feeding on saury. This study paves the way for a wider one including more samples and more shark species with a view to providing a greater understanding of shark feeding behavior, migrations and stock structure. This study was prepared for publication in 2018 for *Fisheries Research.*

D. Thresher Reproductive Biology

In 2015, the Southwest Fisheries Science Center, in collaboration with Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), initiated the first bilateral Northeast Pacific common thresher shark stock assessment which was published in 2016. This assessment used reproductive parameters estimated by Smith et al. (2008) for the Northeast Pacific. However, given the dramatic differences in the estimates of age at first reproduction for females for the Atlantic and Pacific Oceans (216 cm FL versus 160 cm FL respectively), SWFSC scientists reexamined the data and specimens used by Smith in her study. Due to concerns about the species ID and other inconsistencies, it was determined that additional analyses and samples would be needed to provide a validated estimate for the eastern North Pacific. The SWFSC is currently working towards examining and obtaining additional specimens where the species ID can be validated. In the spring of 2018, SWFSC collected seven common thresher sharks in collaboration with local fishers, five females and two males. Four of the females under 200 cm FL were immature while a 234 cm FL female was pregnant with four pups ranging in length between 68 and 71 cm FL (**Figure 5**). The stomachs of the pups were distended and filled with yolk. Until the analyses of age at first reproduction is complete, the stock assessment is being run with life history parameters derived in the Atlantic Ocean.

Figure 5. Picture shows the four pups and distended uterus from a large female common thresher shark caught off Oceanside California in May of 2018.

TRADE INFORMATION FOR SHARKS

Table 1. 2017 Exports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database: http://www.st.nmfs.noaa.gov/st1/trade/index.html.

Country	Product Name	Kilos	Dollars
2017			
AUSTRALIA	SHARK DOGFISH FROZEN	30,576	188,000
Subtotal: AUSTRALIA		**30,576**	**188,000**
BELGIUM	SHARK DOGFISH FROZEN	170,663	572,275
BELGIUM	SHARK NSPF FROZEN	32,488	184,804
Subtotal: BELGIUM		**203,151**	**757,079**
CANADA	SHARK DOGFISH FRESH	1,212	2,917
CANADA	SHARK NSPF FRESH	237,690	502,397
Subtotal: CANADA		**238,902**	**505,314**
CENTRAL AFRICAN REP.	SHARK DOGFISH FROZEN	18,942	46,103

Subtotal: CENTRAL AFRICAN REP.		**18,942**	**46,103**
CHINA	SHARK DOGFISH FROZEN	62,230	185,844
Subtotal: CHINA		**62,230**	**185,844**
CHINA - HONG KONG	SHARK DOGFISH FROZEN	56,761	140,528
CHINA - HONG KONG	SHARK FINS	10,797	626,366
CHINA - HONG KONG	SHARK FINS FROZEN	68,014	164,934
CHINA - HONG KONG	SHARK NSPF FROZEN	16,391	70,074
Subtotal: CHINA - HONG KONG		**151,963**	**1,001,902**
COLOMBIA	SHARK NSPF FROZEN	526,215	1,358,733
Subtotal: COLOMBIA		**526,215**	**1,358,733**
COSTA RICA	SHARK FINS FROZEN	560	6,636
Subtotal: COSTA RICA		**560**	**6,636**
DOMINICAN REPUBLIC	SHARK DOGFISH FRESH	3,476	14,900
Subtotal: DOMINICAN REPUBLIC		**3,476**	**14,900**
FRANCE	SHARK DOGFISH FRESH	359,229	1,833,722
FRANCE	SHARK DOGFISH FROZEN	763,681	2,298,384
FRANCE	SHARK NSPF FRESH	1,000	5,644
FRANCE	SHARK NSPF FROZEN	39,775	128,969
Subtotal: FRANCE		**1,163,685**	**4,266,719**
GERMANY	SHARK DOGFISH FROZEN	97,155	336,426
GERMANY	SHARK NSPF FROZEN	20,004	131,000
Subtotal: GERMANY		**117,159**	**467,426**
HONDURAS	SHARK DOGFISH FROZEN	20,679	163,998
Subtotal: HONDURAS		**20,679**	**163,998**
IRELAND	SHARK FINS FRESH	2,105	9,026
Subtotal: IRELAND		**2,105**	**9,026**
ISRAEL	SHARK NSPF FRESH	12,956	22,850
Subtotal: ISRAEL		**12,956**	**22,850**
ITALY	SHARK DOGFISH FRESH	32,106	135,077
Subtotal: ITALY		**32,106**	**135,077**
JAPAN	SHARK DOGFISH FROZEN	11,858	28,755
JAPAN	SHARK NSPF FROZEN	9,160	35,251
Subtotal: JAPAN		**21,018**	**64,006**

MALAYSIA	SHARK DOGFISH FROZEN	12,002	78,015
Subtotal: MALAYSIA		**12,002**	**78,015**
MEXICO	SHARK DOGFISH FROZEN	13,712	26,551
MEXICO	SHARK FINS FROZEN	1,505	3,650
MEXICO	SHARK NSPF FRESH	223,042	363,608
Subtotal: MEXICO		**238,259**	**393,809**
NETHERLANDS	SHARK DOGFISH FRESH	250,611	1,227,570
NETHERLANDS	SHARK DOGFISH FROZEN	25,225	156,955
Subtotal: NETHERLANDS		**275,836**	**1,384,525**
SINGAPORE	SHARK DOGFISH FROZEN	53,759	189,976
Subtotal: SINGAPORE		**53,759**	**189,976**
SOUTH KOREA	SHARK DOGFISH FRESH	18,969	31,005
SOUTH KOREA	SHARK DOGFISH FROZEN	193,540	475,583
SOUTH KOREA	SHARK NSPF FROZEN	85,500	142,707
Subtotal: SOUTH KOREA		**298,009**	**649,295**
ST.KITTS-NEVIS	SHARK FINS PREPARED/PRESERVED IN ATC	318	2,610
ST.KITTS-NEVIS	SHARK NSPF FROZEN	505	2,959
Subtotal: ST.KITTS-NEVIS		**823**	**5,569**
THAILAND	SHARK DOGFISH FROZEN	197,735	479,513
THAILAND	SHARK FINS FROZEN	17,128	40,000
Subtotal: THAILAND		**214,863**	**519,513**
TRINIDAD & TOBAGO	SHARK FINS PREPARED/PRESERVED IN ATC	294	2,849
Subtotal: TRINIDAD & TOBAGO		**294**	**2,849**
UNITED ARAB EMIRATES	SHARK DOGFISH FROZEN	37,987	107,940
Subtotal: UNITED ARAB EMIRATES		**37,987**	**107,940**
UNITED KINGDOM	SHARK DOGFISH FRESH	61,938	287,871
UNITED KINGDOM	SHARK DOGFISH FROZEN	217,293	764,158
UNITED KINGDOM	SHARK FINS PREPARED/PRESERVED IN ATC	2,400	14,681
Subtotal: UNITED KINGDOM		**281,631**	**1,066,710**
URUGUAY	SHARK FINS FROZEN	1,000	2,885
Subtotal: URUGUAY		**1,000**	**2,885**

Grand Total: 2017		**4,020,186**	**13,594,699**

Table 2. 2018 Exports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database: http://www.st.nmfs.noaa.gov/st1/trade/index.html.

Country	Product Name	Kilos	Dollars
2018			
AUSTRALIA	SHARK DOGFISH FROZEN	38,931	225,300
Subtotal: AUSTRALIA		**38,931**	**225,300**
BELGIUM	SHARK DOGFISH FROZEN	109,009	323,852
BELGIUM	SHARK NSPF FROZEN	94,579	306,677
Subtotal: BELGIUM		**203,588**	**630,529**
BRAZIL	SHARK DOGFISH FROZEN	4,543	11,017
Subtotal: BRAZIL		**4,543**	**11,017**
CANADA	SHARK FINS	186	18,634
CANADA	SHARK NSPF FRESH	236,748	531,924
Subtotal: CANADA		**236,934**	**550,558**
CHINA	SHARK DOGFISH FROZEN	21,590	64,736
CHINA	SHARK FINS PREPARED/PRESERVED IN ATC	16,779	46,621
CHINA	SHARK NSPF FROZEN	21,590	65,688
Subtotal: CHINA		**59,959**	**177,045**
CHINA - HONG KONG	SHARK DOGFISH FROZEN	12,248	82,000
CHINA - HONG KONG	SHARK FINS	9,961	934,774
CHINA - HONG KONG	SHARK FINS FROZEN	12,435	97,300
Subtotal: CHINA - HONG KONG		**34,644**	**1,114,074**
CZECH REPUBLIC	SHARK DOGFISH FROZEN	19,061	52,778
CZECH REPUBLIC	SHARK NSPF FROZEN	17,653	52,542
Subtotal: CZECH REPUBLIC		**36,714**	**105,320**
FRANCE	SHARK DOGFISH FRESH	164,483	820,178
FRANCE	SHARK DOGFISH FROZEN	721,799	2,334,676
FRANCE	SHARK NSPF FROZEN	7,730	28,025

Subtotal: FRANCE		**894,012**	**3,182,879**
GERMANY	SHARK DOGFISH FROZEN	80,060	447,837
Subtotal: GERMANY		**80,060**	**447,837**
ITALY	SHARK DOGFISH FRESH	63,500	251,842
Subtotal: ITALY		**63,500**	**251,842**
MEXICO	SHARK DOGFISH FRESH	1,260	5,400
MEXICO	SHARK DOGFISH FROZEN	12,451	30,193
MEXICO	SHARK NSPF FRESH	224,253	356,994
MEXICO	SHARK NSPF FROZEN	5,452	8,396
Subtotal: MEXICO		**243,416**	**400,983**
NETHERLANDS	SHARK DOGFISH FRESH	246,306	1,306,354
NETHERLANDS	SHARK DOGFISH FROZEN	13,687	63,257
Subtotal: NETHERLANDS		**259,993**	**1,369,611**
PERU	SHARK DOGFISH FROZEN	1,477	3,581
Subtotal: PERU		**1,477**	**3,581**
SOUTH KOREA	SHARK DOGFISH FROZEN	39,175	95,000
SOUTH KOREA	SHARK FINS FRESH	4,086	27,000
Subtotal: SOUTH KOREA		**43,261**	**122,000**
THAILAND	SHARK DOGFISH FROZEN	420,773	1,196,352
Subtotal: THAILAND		**420,773**	**1,196,352**
TURKEY	SHARK DOGFISH FRESH	6,671	28,600
Subtotal: TURKEY		**6,671**	**28,600**
UNITED KINGDOM	SHARK DOGFISH FRESH	49,173	227,731
UNITED KINGDOM	SHARK DOGFISH FROZEN	211,315	794,630
UNITED KINGDOM	SHARK NSPF FRESH	990	4,606
UNITED KINGDOM	SHARK NSPF FROZEN	59,203	230,964
Subtotal: UNITED KINGDOM		**320,681**	**1,257,931**
Grand Total: 2018		**2,949,157**	**11,075,459**

Table 3. 2017 Re-exports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database: http://www.st.nmfs.noaa.gov/st1/trade/index.html.

Country	Product Name	Kilos	Dollars
	2017		

CANADA	SHARK FINS	81	8,068
CANADA	SHARK NSPF FRESH	1,559	5,511
Subtotal: CANADA		**1,640**	**13,579**
MEXICO	SHARK FINS PREPARED/PRESERVED IN ATC	16,691	46,376
Subtotal: MEXICO		**16,691**	**46,376**
Grand Total: 2017		**18,331**	**59,955**

Table 4. 2018 Re-exports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database: http://www.st.nmfs.noaa.gov/st1/trade/index.html.

Country	Product Name	Kilos	Dollars
2018			
CANADA	SHARK FINS FROZEN	12,412	59,727
CANADA	SHARK NSPF FRESH	1,435	7,947
Subtotal: CANADA		**13,847**	**67,674**
Grand Total: 2018		**13,847**	**67,674**

Table 5. 2017 Imports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database: http://www.st.nmfs.noaa.gov/st1/trade/index.html.

Country	Product Name	Kilos	Dollars
2017			
BURMA	SHARK FINS PREPARED/PRESERVED	71,158	231,876
Subtotal: BURMA		**71,158**	**231,876**
CANADA	SHARK DOGFISH FROZEN	17,244	31,119
CANADA	SHARK NSPF FRESH	41,818	208,000
Subtotal: CANADA		**59,062**	**239,119**
CHINA - HONG KONG	SHARK FINS	136	14,427
CHINA - HONG KONG	SHARK FINS FRESH	43,620	148,094
CHINA - HONG KONG	SHARK FINS FROZEN	64,526	140,019
CHINA - HONG KONG	SHARK NSPF FROZEN	10,092	20,572
Subtotal: CHINA - HONG KONG		**118,374**	**323,112**
INDIA	SHARK FINS PREPARED/PRESERVED	11,893	35,925
Subtotal: INDIA		**11,893**	**35,925**

ITALY	SHARK FINS PREPARED/PRESERVED	33	3,121
Subtotal: ITALY		**33**	**3,121**
MEXICO	SHARK NSPF FRESH	23,499	53,411
MEXICO	SHARK NSPF FROZEN	17,727	45,630
Subtotal: MEXICO		**41,226**	**99,041**
NEW ZEALAND	SHARK FINS	34,400	528,000
Subtotal: NEW ZEALAND		**34,400**	**528,000**
SPAIN	SHARK NSPF FROZEN	1,814	137,864
Subtotal: SPAIN		**1,814**	**137,864**
UKRAINE	SHARK FINS PREPARED/PRESERVED	19,952	30,598
Subtotal: UKRAINE		**19,952**	**30,598**
Grand Total: 2017		**357,912**	**1,628,656**

Table 6. 2018 Imports of Shark Products by Country. It is unknown what percentage of these sharks were caught in the IATTC Convention Area. Data are from the NOAA Fisheries foreign trade database: http://www.st.nmfs.noaa.gov/st1/trade/index.html.

Country	Product Name	Kilos	Dollars
2018			
BRAZIL	SHARK FINS FRESH	2,755	9,196
Subtotal: BRAZIL		**2,755**	**9,196**
CANADA	SHARK DOGFISH FROZEN	13,837	22,269
CANADA	SHARK NSPF FRESH	20,973	104,178
Subtotal: CANADA		**34,810**	**126,447**
CHINA - HONG KONG	SHARK FINS	1,513	145,390
Subtotal: CHINA - HONG KONG		**1,513**	**145,390**
ECUADOR	SHARK NSPF FRESH	1,437	11,825
Subtotal: ECUADOR		**1,437**	**11,825**
MEXICO	SHARK NSPF FRESH	6,567	22,169
Subtotal: MEXICO		**6,567**	**22,169**
TRINIDAD & TOBAGO	SHARK NSPF FRESH	828	4,015
Subtotal: TRINIDAD & TOBAGO		**828**	**4,015**
Grand Total: 2018		**47,910**	**319,042**