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SILKY AND HAMMERHEAD SHARK CATCHES IN CENTRAL AMERICAN COASTAL ARTISANAL FISHERIES

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SUMMARY

The primary responsibility of the Inter-American Tropical Tuna Commission (IATTC) is to ensure the biological sustainability of principal tuna and tuna-like species in its convention area of the eastern Pacific Ocean. The Antigua Convention—entering into force in 2010—also calls for an ecological approach to managing EPO tuna fisheries and explicitly stipulates that a responsibility of the IATTC to ensure the sustainability of non-target species that are dependent or associated with tuna and tuna-like species.

In the industrial tuna fisheries that operate in areas beyond national jurisdictions (ABNJ) in the EPO (e.g., purse-seine and longline) incidental catch of sharks (i.e., "bycatch") is common. In contrast, in the exclusive economic zones (EEZs) of coastal states in the EPO, sharks support significant artisanal (i.e., subsistence) and commercial domestic shark fisheries[1] in primarily longline, gillnet and hook and lines fisheries that target sharks specifically (as well as capturing them incidentally). Unlike the industrial fisheries of the EPO, the catch and effort of these coastal fisheries are often poorly monitored, if at all. Therefore, there is a limited understanding of the composition and magnitude of sharks catches from these fisheries from which the base management measures, as appropriate. The limited surveys taken place in the region (SAC-11-13) have indicated that the effort and catch of this fishery may be substantial even in comparison to that of the industrial fleet. Therefore, there is a critical need to quantify shark catches from all relevant fisheries to inform stock assessment, management, and other ecological studies. Of the shark species shared by industrial and artisanal fleets in the EPO, silky and hammerhead sharks comprise a significant proportion of total interactions. As such these species were identified in 2016 by the IATTC as species of potential conservation concern, and thus various resolutions have been developed in an attempt to manage the catches of these species. In an ecological risk assessment conducted by IATTC staff for 32 shark species caught in EPO pelagic fisheries both silky and hammerhead were among the most vulnerable species, thus highlighting the need to better understand the extent of catches from all mortality sources in the EPO.

Aiming to improve shark data collection in EPO coastal states, the staff at IATTC has conducted extensive research since 2014 to develop a robust sampling methodology aimed at improving data collection for

[1] In the context of this proposal, "shark fishery" means any fishery in which sharks are taken, either as a target or bycatch species. It is recognized that these fisheries are multi-specific and interact with various species or groups of large pelagic fishes (e.g., tunas, billfishes, mahi-mahi and sharks).

shark fisheries[1] in Central America. This region is believed to account for a significant portion of the EPO shark catch, making it a critical area for data collection improvements. This work, funded by the FAO-GEF ABNJ ("Tuna 1") project, IATTC Capacity Building Fund, and the European Union, was completed in December 2021.

This analysis provides an estimate of the order of magnitude of catches of silky (*Carcharhinus falciformis*) and hammerhead (*Sphyrnidae spp.*) sharks in the artisanal fisheries in five Central American countries (Costa Rica, El Salvador, Guatemala, Nicaragua, Panama) that border of the eastern Pacific Ocean (EPO). In 2020 and 2021, field technicians visited landing sites (e.g. beaches, ports, harbors) and collected samples of the number and weight of these, and other, species of sharks caught during individual fishing trips by surveyed pangas (small fishing boats generally less than 10-12 m; SAC-11-13), along with fisher-reported estimate of the number of trips per week and a range of associated metadata (e.g., latitude, longitude, primary fishing gears, vessel horsepower).

This field program provided important estimates of catches of sharks by pangas throughout the study region. However, due to logistical and budgetary constraints, only a small fraction of the total number of landing sites identified and the number of trips by vessels recorded at sampled sites were sampled. As such, generating an estimate of the order of magnitude of total catches of silky and hammerhead sharks in the region requires two general steps:

1. **Interpolating catches at sampled sites**: This means estimating catches in un-surveyed weeks at sites that were surveyed at least once, and
2. **Extrapolating catches at un-surveyed sites**: This means estimating catches at sites that were never surveyed but were identified as places where sharks might be landed.

Using the survey data as well as models for interpolation and extrapolation, we estimated that shark catches of silky and hammerhead totaled roughly 5,000 and 12,500 t, respectively, in 2021. Hammerhead catches in Panama primarily came from a fishery targeting neonate hammerheads (one year or less in age), whereas catches of silky sharks were represented by a variety of life stages mostly in Guatemala, El Salvador, and Nicaragua. While these results provide an estimate of the order of magnitude of the catches of silky and hammerhead sharks in the artisanal fisheries of the Central American EPO, our findings are sensitive to uncertainty in several parameters, particularly the representativeness of the sampled sites, the total number of pangas per site, and the conversion factors used to convert from processed to whole shark weight.

We present here a brief summary of our methods, key results, and discussion points.

1. METHODS

Samples for the species in question were taken at 79 sites across the study region, representing 5% of the 1,444 landing sites identified throughout the region (SAC-11-13). These sampling sites were primarily selected based on the predominant locations where silky sharks were landed, along with budgetary, logistical, and accessibility concerns.

Fishers land sharks in a variety of forms throughout the region, ranging from unprocessed whole animals to highly processed trunks (i.e., missing head, fins, tail, and viscera). Our goal was to estimate the weight of whole sharks landed by the fishery. As such, we needed to convert processed weights into whole shark weights. Along with identifying and weighing the catch, technicians on occasion collected data on the processing form in which the catch was observed. Based on these data, we calculated the proportion of each processing, or 'cut', type in each of the study area countries. We then categorized each of the cut types by the presence or absence of the trunk, head, fins, and viscera, and calculated conversion factors from processed to whole weights for each processing type for each species based on the combination of body parts present and the proportion of total body weight made up of each body part based on the values reported in Vannuccini (1999). We then calculated a raising factor for converting from processed to whole weight in each country based on the raising factors for each cut type and species and the relative proportion of the catch made up by each cut type for each species in each country.

At the sampled sites, sampling was conducted at 13% of the combinations of sampled landing sites and week of the years. We developed an "interpolation" model using a random forest that splits predictions into predicted presence/absence and catch conditional on presence that predicted the average catch per week per panga at the un-sampled weeks at these sampled sites. This interpolation model estimates unobserved catches at these sites based on the most recent observed catches at that site, along with a range of covariates including the site location, the time of year, the composition of the fishing fleet, and landing port attributes.

We built a separate "extrapolation" model using a random forest that splits predictions into predicted presence/absence and catch conditional on presence for predicting the average catch per week per panga at the un-surveyed sites. We collected a range of data for all 1,444 possible landing sites, including the composition of the fishing fleet and attributes of the landing port location. The extrapolation model makes use of these data, without depending on any data that is only available at the surveyed sites, to predict the average catch per week per panga per species.

Collectively, the survey data, along with the interpolation and extrapolation, provide estimates of the average catch per week per panga for every week of the study period for each of the identified landings sites throughout the region. In order to arrive at our estimates of total catch we then needed to estimate the number of pangas per landing site. We used 7 databases containing information on the number of pangas at landing sites, though most landing sites were only represented in a few of these. Based on expert opinion, we ranked the databases in order of reliability and assigned the number of pangas for the most reliable database available at each site. We then multiplied this estimate of the number of pangas per landing site times the estimated catch per week per panga to arrive at an estimate of the total catch per species per week at each landing site.

2. RESULTS

For 2021, our model estimated a total catch of roughly 12,500 t of hammerheads and 5,000 t of silky sharks across the coastal artisanal fisheries in the five Central American countries included in this analysis. Capture of hammerheads peaked in mid 2021, corresponding to a spike in the catch of neonates in Panama. Hammerhead catches primarily come from the extrapolation model, indicating that a large number of un-surveyed sites have attributes that suggest the presence of hammerhead captures based on the surveyed sites. Silky shark catches were much higher during the few months sampled in 2020, but declined over the study period to a steady and lower level throughout 2021. Unlike hammerheads, our estimate of silky catch is primarily composed of estimates from the interpolation model, indicating that most of the catch comes from un-surveyed weeks at surveyed sites (Figure 1).

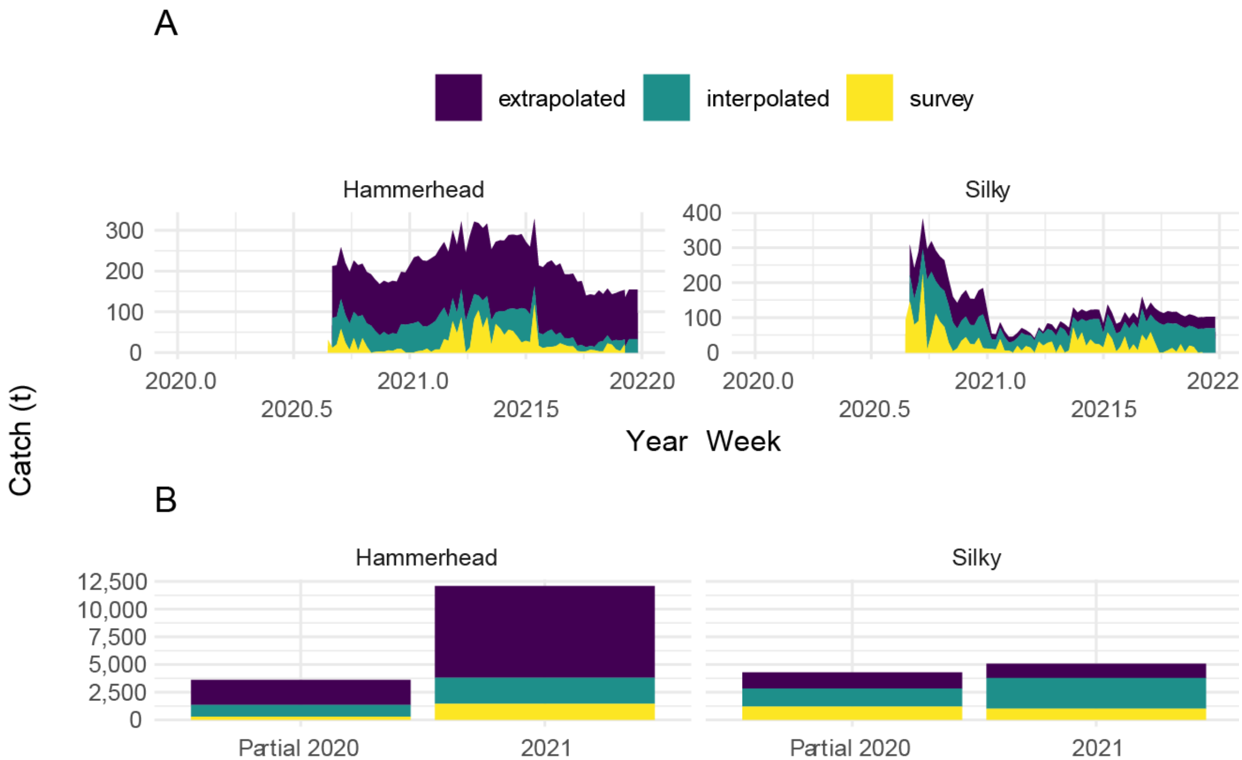

FIGURE 1. Predicted catch in metric tons (t) by species per week (A) and in total (B) broken out by the source of the catch estimate. 'Survey' indicates average catch per week per panga was taken from the survey data. 'Interpolated' means average catch per week per panga was estimated by the interpolation model from other observations at that site. 'Extrapolated' means average catch per week per panga was extrapolated from surveyed sites. Note that predictions only begin after the 35th week of 2020 to account for the beginning of the sampling program.

When focusing on specific countries samples, hammerhead catches across all models were estimated to come almost entirely from Panama. Surprisingly, neither the survey data or any of the models estimated any silky shark catch in Panama. Silky shark data in the survey came primarily from Guatemala, followed by El Salvador and then Costa Rica (Figure 2). Catches from the interpolation and extrapolation models came almost entirely from El Salvador and Guatemala.

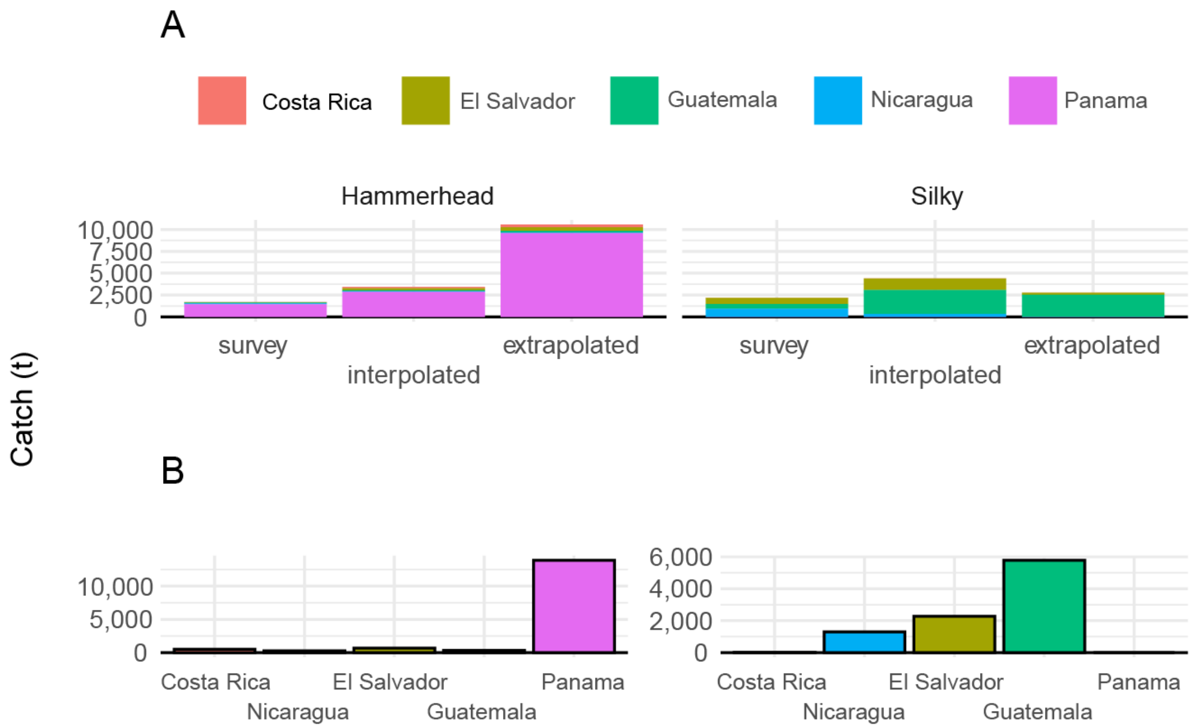

FIGURE 2. Total estimated catch (t) of silky and hammerhead sharks over the study period by (A) model type, and country and (B) country. 'Survey' indicates average catch per week per panga was taken from the survey data. 'Interpolated' means average catch per week per panga was estimated by the interpolation model from other observations at that site. 'Extrapolated' means average catch per week per panga was extrapolated from surveyed sites.

3. DISCUSSION

The catch data collected throughout this sampling program provided an important snapshot of shark fishing practices in the artisanal fisheries of the Central American EPO. Based on these data, we were able to estimate the order of magnitude of catches of hammerhead and silky sharks in the region. To put our catch estimates in context, SAC-05 INF-F estimated a total catch of silky sharks of about 16,000 t of silky sharks across many of the countries and fleets in the EPO, of which about 2,500 t came from the Central American coastal shark fisheries (excluding pangas). Our analyses add another 5,000 t of silky sharks caught by the Central American artisanal panga fishery, which were not included in previous estimates. We have no point of comparison for our estimated hammerhead catches, but it is instructive to note that the estimated volume of hammerhead catch is much higher than silky sharks. Specifically, the estimated hammerhead catch of 12,500 t for 2021 for the Central American panga EPO fisheries alone is equal to roughly 80% of the total reconstructed catch of silky sharks across all EPO regions and fleets reported in SAC-05 INF-F.

These samples represent only one and a half years of sampling, taken at a time when these fisheries were being severely impacted by COVID-19 pandemic. Silky sharks in particular had much higher catches in the later months of 2020 than in 2021. The reason for this is unclear, but if late 2020 catches are more indicative of 'normal' operations in this fishery relative to the severely constrained operations in 2021, it is possible that recent catches of silky sharks have historically been higher than those estimated here for 2021. We do not, however, see a similar downward catch trend in hammerheads through the year, where catches were highest in early 2021. Considering this peak in catch is mostly comprised of neonates caught in Panama, it may reflect targeting of seasonal hammerhead pupping grounds. While our analysis provides an estimate of the order of magnitude of catches over the study period, it is not clear how well these numbers represent the likely past or future of catch volumes in these fisheries. Regardless of this seasonality aspects, our study confirms that order of magnitude catches of silky shark and hammerheads are in line with those estimated by the IATTC staff in SAC-11-13 using data coming from interviews with fishermen in the region.

These results depend on several models and assumptions. The raising factors for converting from processed to whole weight were based on best available information, but these relationships were estimated many years ago and were not from the EPO (Vannuccini 1999). A small, targeted study within the region is needed to develop relationships between whole weight to the various processed forms of sharks in the coastal EPO fisheries.

Our model also assumed that each landing site had a constant number of pangas active throughout the study period—though the number of panga trips per week could vary over time—and that this number of pangas could be accurately estimated from the available data. It is likely that in reality the number of pangas vary over time, and while many of the data sources reported similar numbers of pangas per site, these estimates are likely to be highly uncertain due to the possibility that boats were at sea during sampling, or lack of clarity whether observed pangas in fact actively fish. Future work should consider efficient strategies for estimating the number of active fishing pangas in space and time throughout the region.

Another important consideration is the identification of landing sites and the assignment of relative survey efforts to these sites. Survey sites were not collected at random, and so it is unclear to what extent the sites that were never visited can be effectively modeled based on the dynamics of the sampled sites. Future research should both consider how to better identify pangas and landing sites throughout the region over time, and how to apportion survey effort in a way that balances cost efficiency with statistical power and the need to reduce the potential for biased estimates.

In summary, the survey data collected in the region enabled us to provide an estimate of the order of magnitude of silky and hammerhead shark catches in the artisanal fisheries of five countries in Central America. While the precision of these estimates is low, they indicate that these fisheries likely capture a meaningful amount of silky and hammerhead sharks, and therefore need to be considered in future monitoring, assessment and management plans in order to fulfill the IATTC's responsibilities under the Antigua Convention.

REFERENCES

Vannuccini, Stefania. 1999. *Shark utilization, marketing and trade*. FAO fisheries technical paper 389. Rome: Food; Agriculture Organization of the United Nations.