Stockholm Resilience Centre

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Reducing shark bycatch in tuna fisheries: adaptive spatio-temporal management options for the eastern Pacific Ocean

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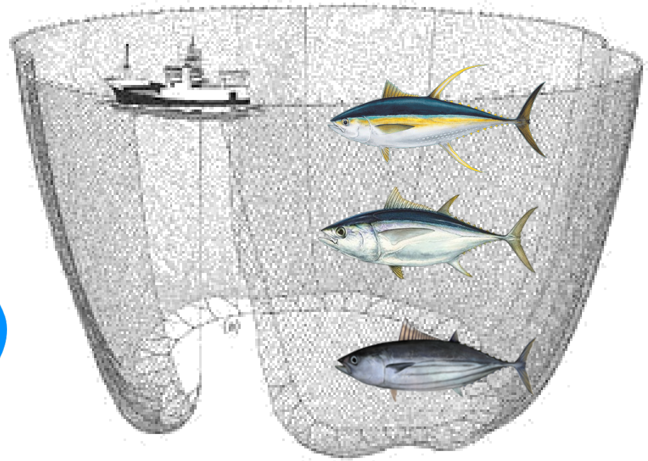
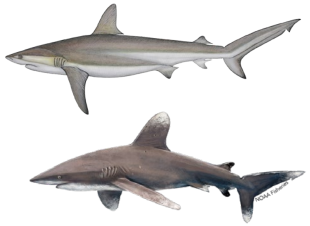


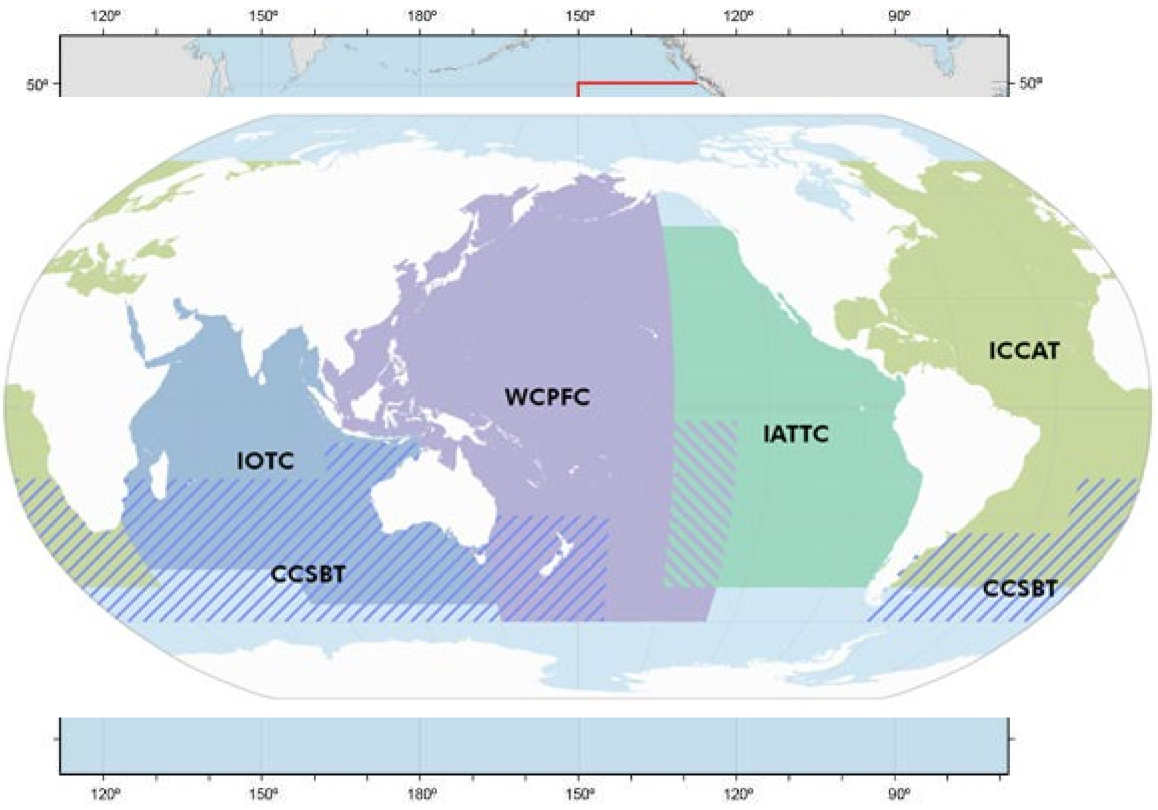


Reducing the impact of fisheries on non-target biodiversity

- RFMOs are responsible for the management of species with trans-jurisdictional distributions, including tunas—have an explicit **mandate to reduce impacts on non-target species or species belonging to the same ecosystem** as the target species.

- RFMOs can implement a range of management measures to reduce the impact of their fisheries on ecosystems and the broader environment.

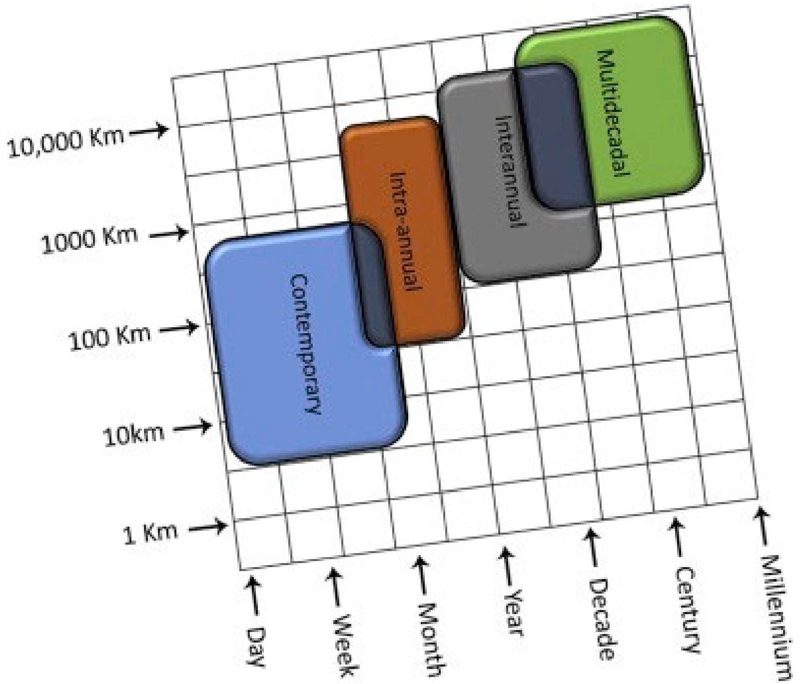
- These **measures can be classified into two groups**:
  - input control (e.g., the amount of fishing effort, type and dimensions of fishing gear, where and how fishing is allowed)
  - output control (e.g., how much can be caught or landed for any given species) measures.



https://www.iattc.org/HomeENG.htm

Input control measure: spatio-temporal management

- The task of disentangling the spatial (where) and temporal (when) overlap of multiple target and non-target species requires an in-depth exploration of risk and trade-offs across scenarios and species groups
- Spatial management measures can be "static", when, for example, a fixed area is closed to fishing (currently the most common measure used), or "dynamic", when the area can change across space and time.
- Aim: to identify areas of relatively high bycatch rates of vulnerable species that coincide with relatively low tuna catches, which we defined as "**high fishing inefficient**" areas and that could be considered potential areas for the application of "dynamic" spatial mitigation management measures.



Crespo *et al.*, 2020

IATTC: eastern Pacific Ocean tuna purse seine fishery (1995-2021)

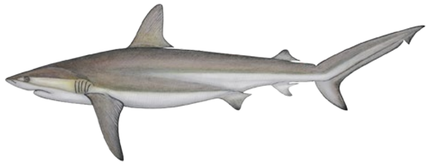
- The fishery is centered around three tropical tuna species—yellowfin tuna, bigeye tuna, and skipjack tuna (i.e., small [<2.5 kg], medium [2.5-15 kg], large [>15 kg])

- The fishery is comprised of three principal set-types:
  - Free school sets
  - Sets associated with floating objects
  - Dolphin sets

- Analyses were undertaken using data collected by fisheries scientific observers onboard large purse seine vessels in the EPO as part of the Agreement on the International Dolphin Conservation Program (AIDCP) observer program.

- Observers collected operational and catch information for target and non-target species from nearly 100% of sets made by class-6 (>363 t) tuna purse seine vessels (IATTC, 2006).

IATTC: eastern Pacific Ocean tuna purse seine fishery (1995-2021)



Set type	Number of sets	FAL bycatch (numbers)	FAL BPUE (numbers per set)	OCS bycatch (numbers)	OCS BPUE (numbers per set)
Floating object	187,431	526,413	2.81	40,863	0.22
Dolphin	222,663	30,240	0.14	912	0.004
Non-associated	94,476	29,484	0.31	1,109	0.01

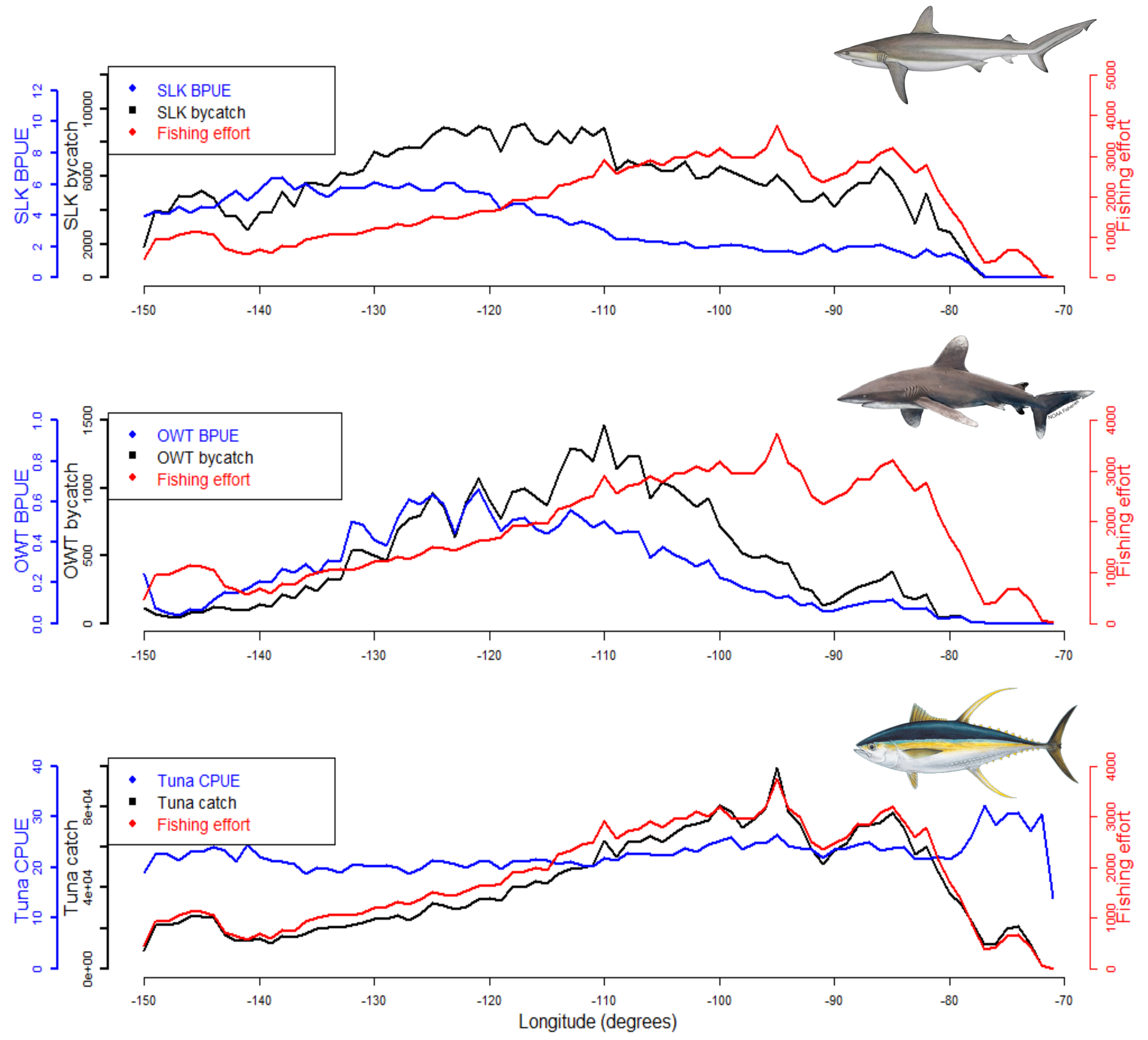
- Because of their life histories and ecological significance and current concerns over their conservation status, we focused our analyses on two of the most frequently-caught and potentially vulnerable shark bycatch species in the fishery: the silky shark (*Carcharhinus falciformis*) & the oceanic whitetip shark (*Carcharhinus longimanus*).
- The study focused on floating obeject purse seine sets given their disporportionately high shark bycatch rates compared to the other two set-types.

Carcharhinus falciformis

Carcharhinus longimanus

Exploratory analysis

- For our analysis, we aggregated data for all size classes of silky and oceanic whitetip sharks, whereas all size and species data for the three main tropical tuna species—were aggregated into a single “tuna” category.
- The tuna catch and shark bycatch estimates were also aggregated at 1°x1 resolution and by month.
- Preliminary data exploration suggests the existence of areas of fishing innefficiency.

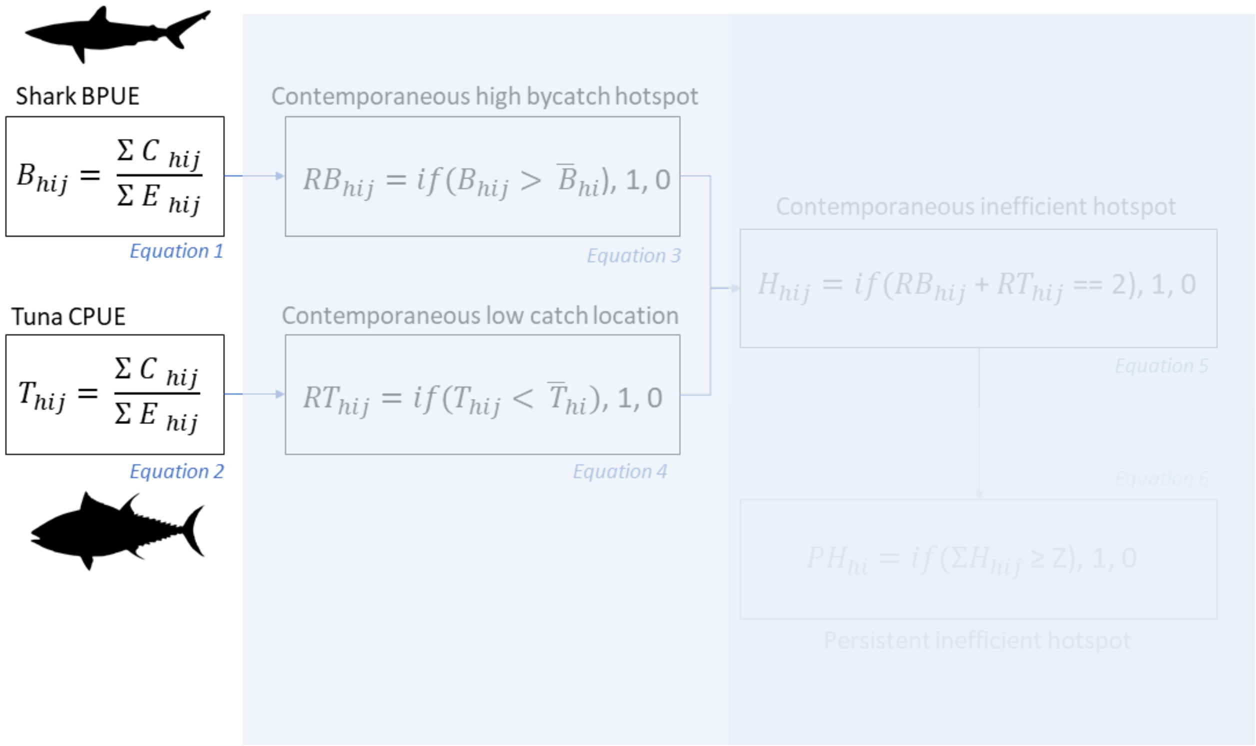


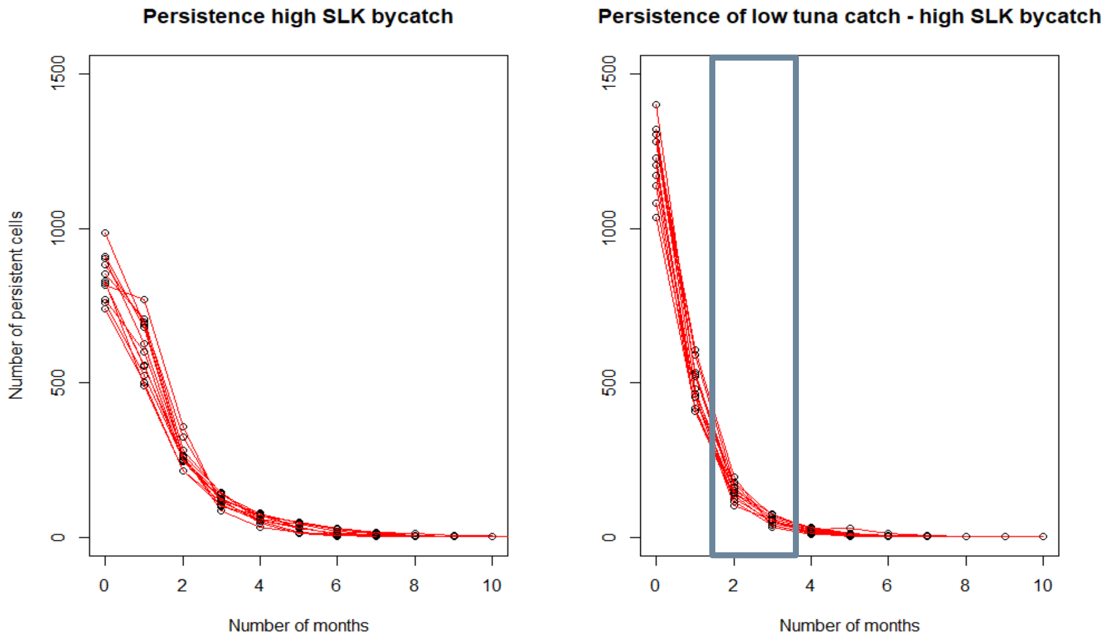
Average catch, CPUE and fishing effort across latitudes

Spatio-temporal optimization analysis

- *Tuna CPUE (C) and shark BPUE (B) were calculated by dividing the total catch (C) of each species group by the total fishing effort (E - number of sets) across every cell (h), month (i) and year (j) combination.*

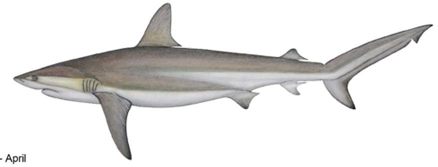
*26 years * 12 months = 312 months*



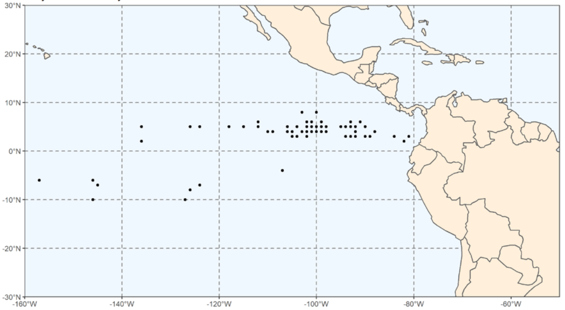


2 month scenario

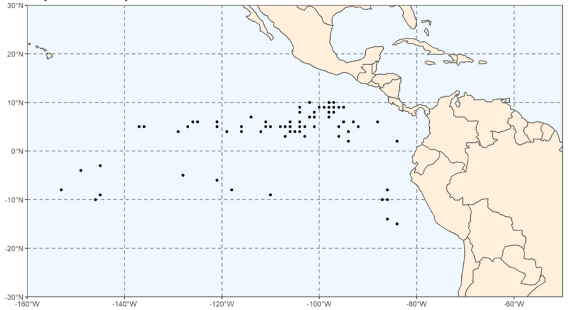
Carcharhinus falciformis



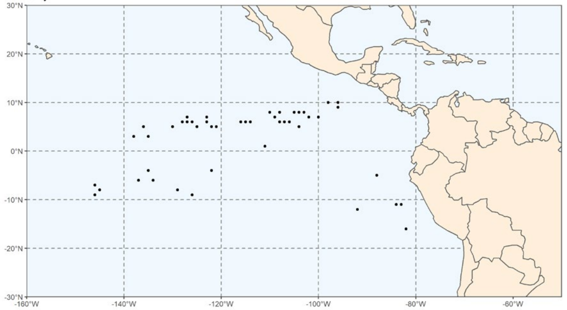
Silky shark - January



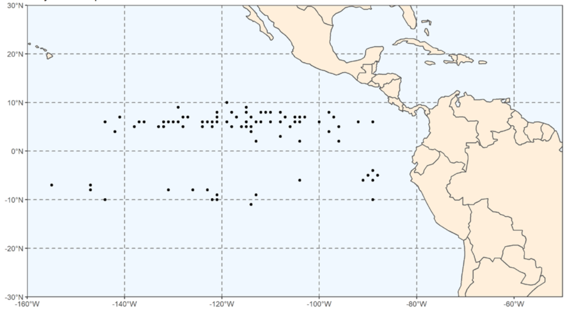
Silky shark - Feburary



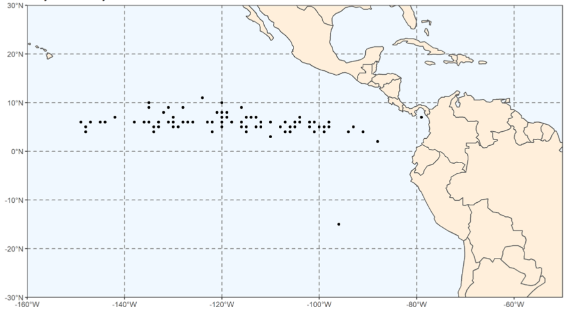
Silky shark - March



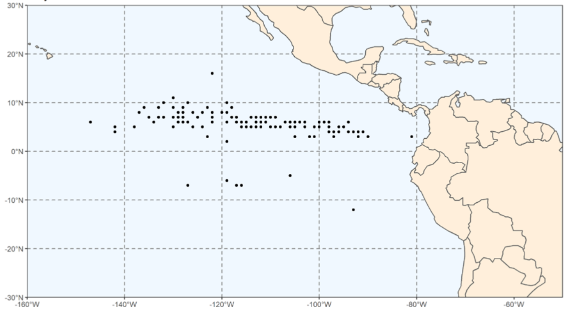
Silky shark - April



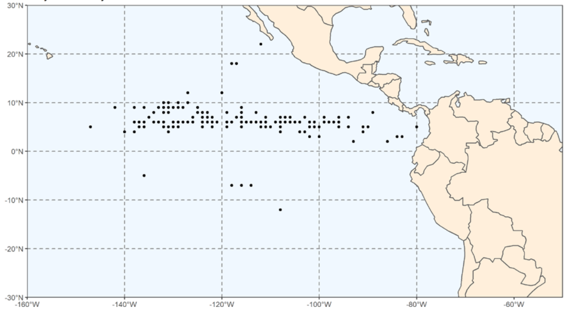
Silky shark - May



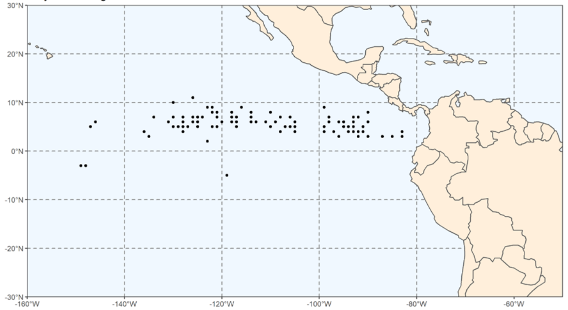
Silky shark - June



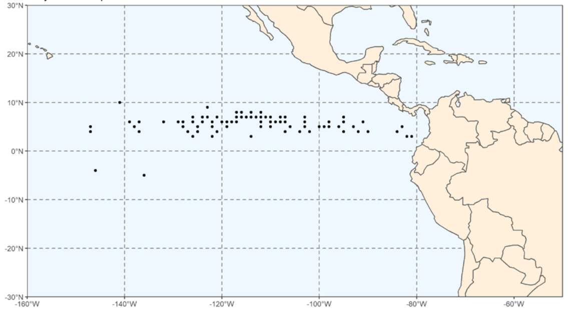
Silky shark - July



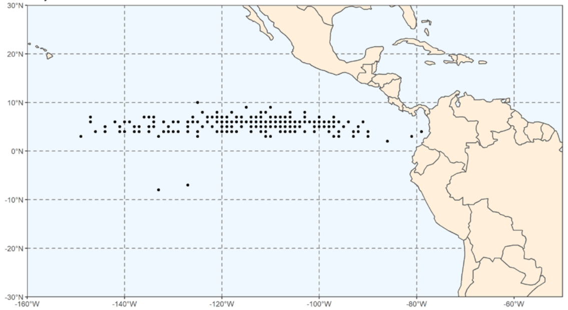
Silky shark - August



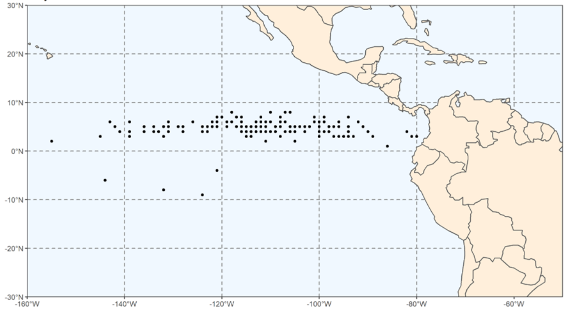
Silky shark - September



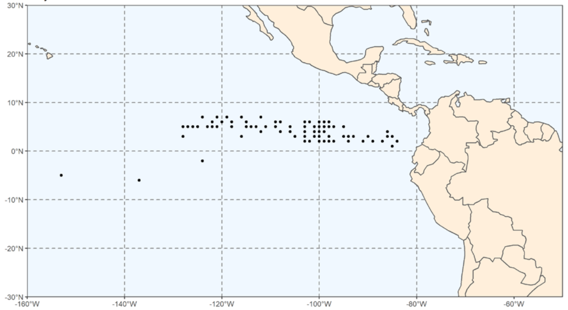
Silky shark - October



Silky shark - November

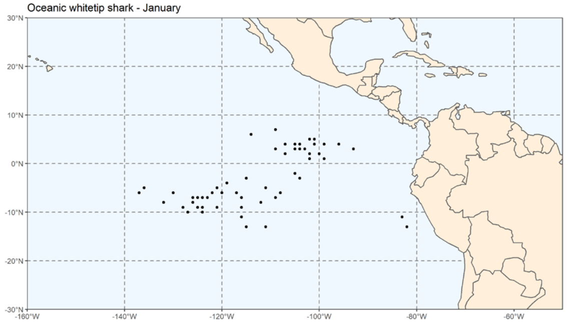


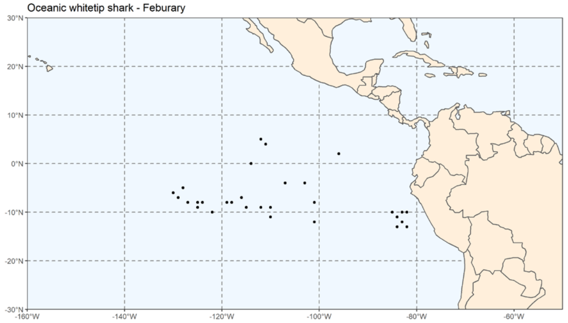
Silky shark - December

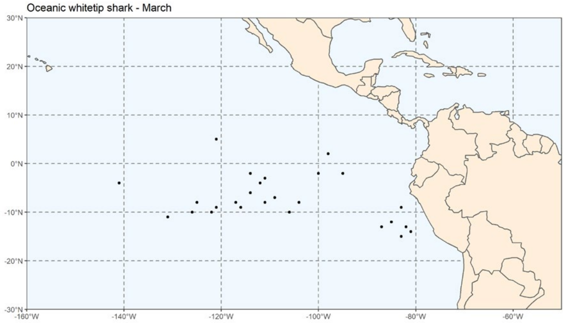


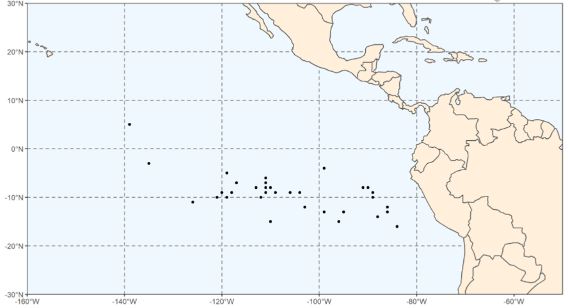
2 month scenario

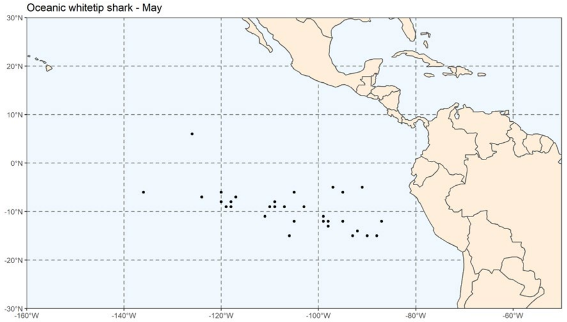
Carcharhinus longimanus

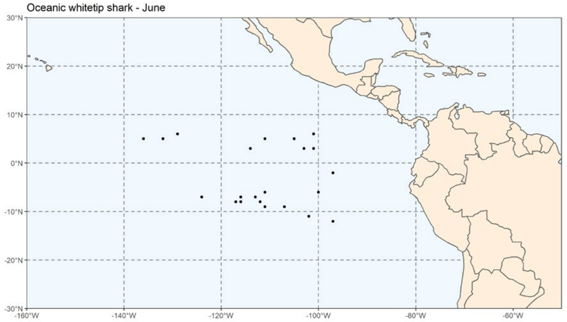

Oceanic whitetip shark - January

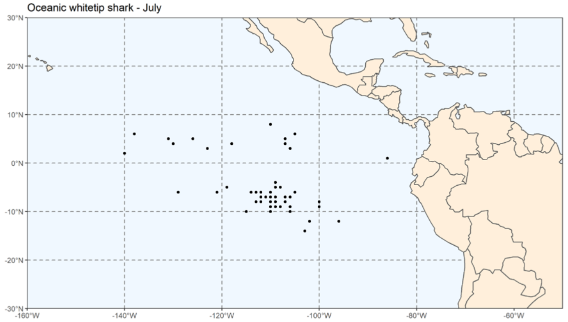

Oceanic whitetip shark - Feburary

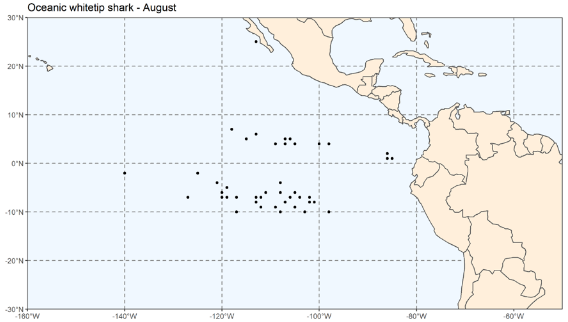

Oceanic whitetip shark - March

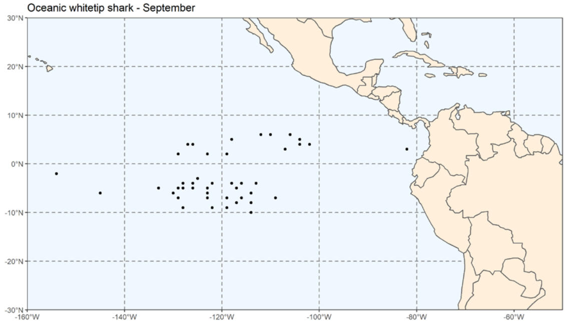

Oceanic whitetip shark - April

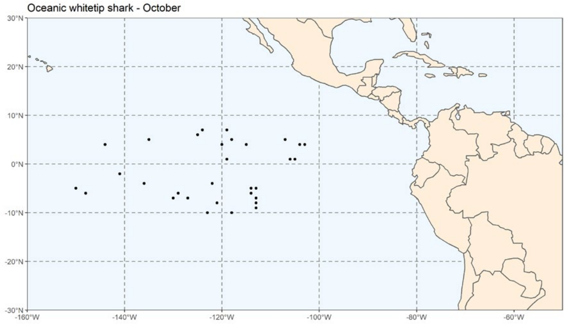

Oceanic whitetip shark - May

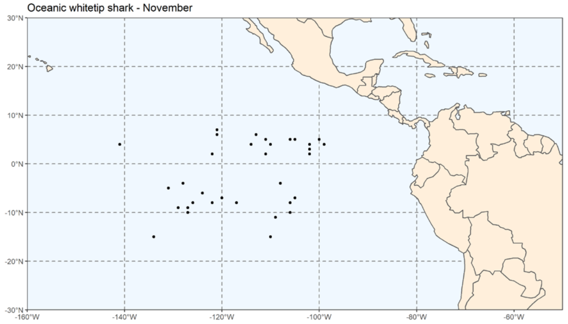

Oceanic whitetip shark - June

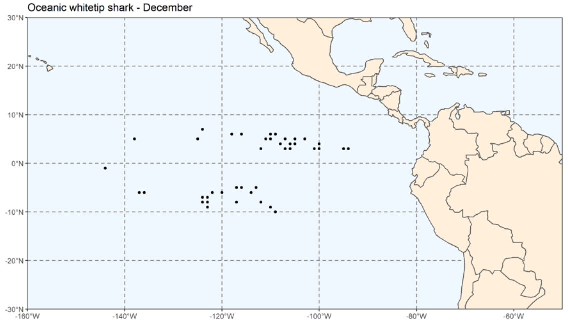

Oceanic whitetip shark - July


Oceanic whitetip shark - August


Oceanic whitetip shark - September

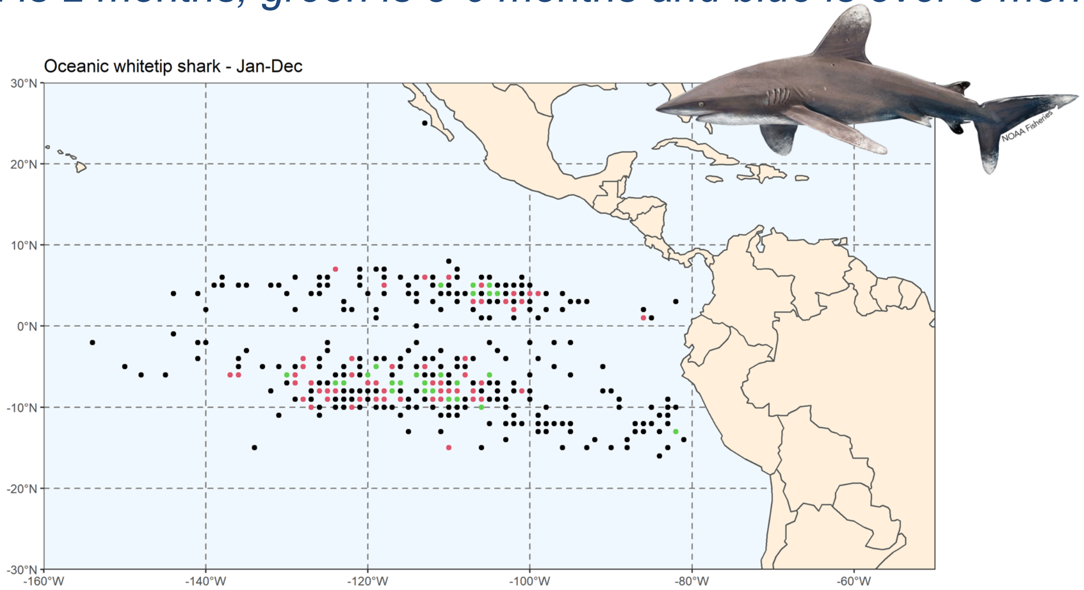

Oceanic whitetip shark - October


Oceanic whitetip shark - November


Oceanic whitetip shark - December

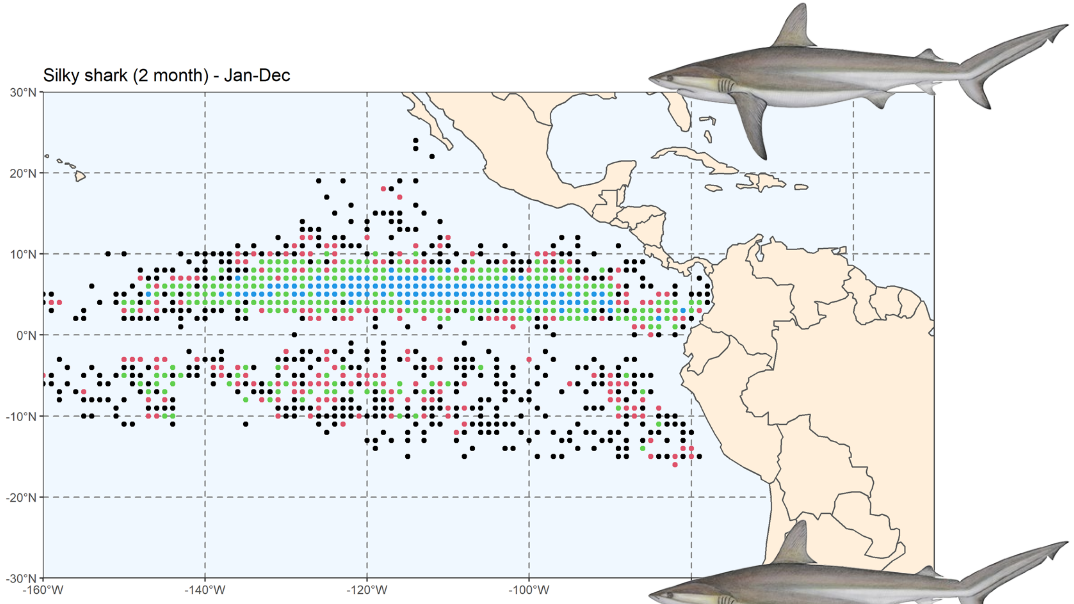
Areas of high fishing inefficiency

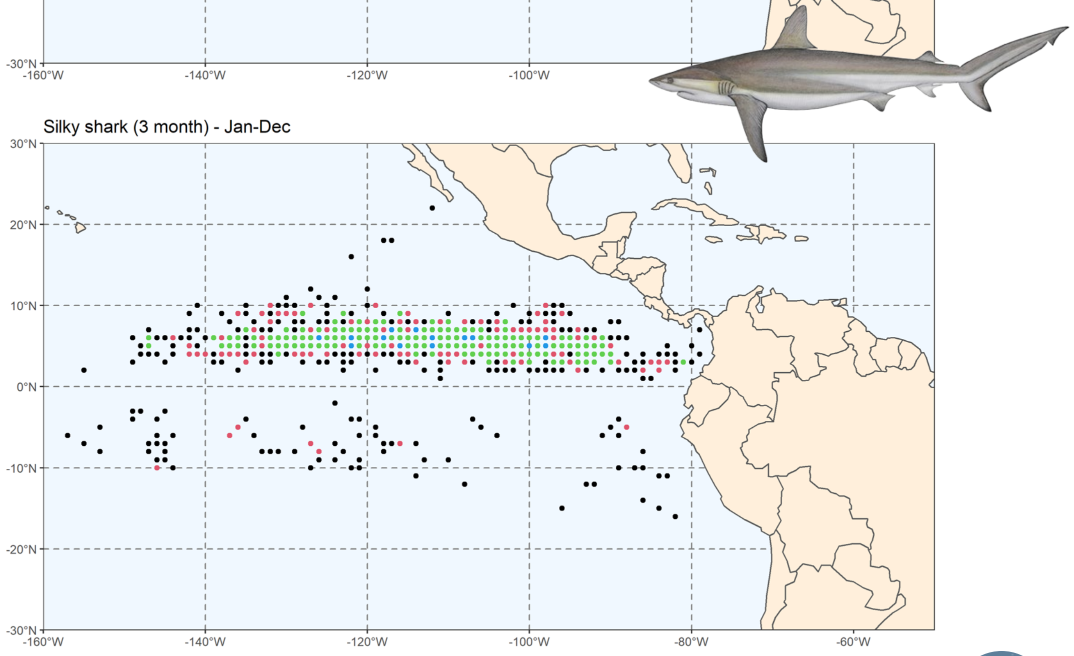
The color of the dots reflects the number of months a cell is proposed for closure throughout the year, where black is 1 month, red is 2 months, green is 3-6 months and blue is over 6 months.



Carcharhinus longimanus

Had we closed these areas to fishing each month between 1995-2021, how would have shark bycatch been impacted?





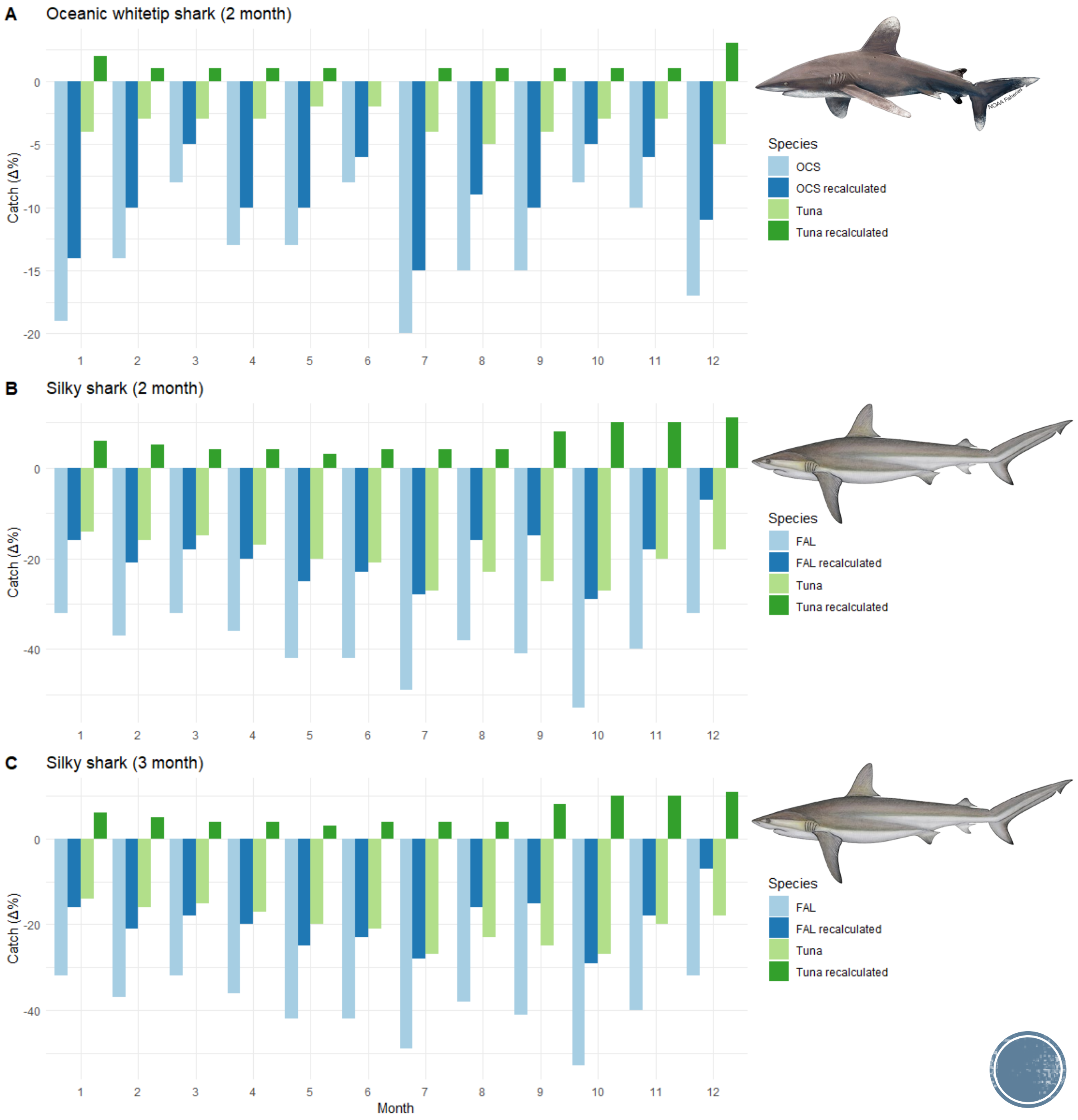
Carcharhinus falciformis

*Expected reduction in shark bycatch (**blue**) and tuna catch (**green**) under two different closure scenarios, without effort redistribution (**light**) and after redistributing fishing effort and recalculating captures (**dark**).*

(A) closure based on a 2-month persistence threshold for oceanic whitetip sharks.

(B) closure based on a 2-month persistence threshold for silky sharks.

(C) closure based on a 3-month persistence threshold for silky sharks.



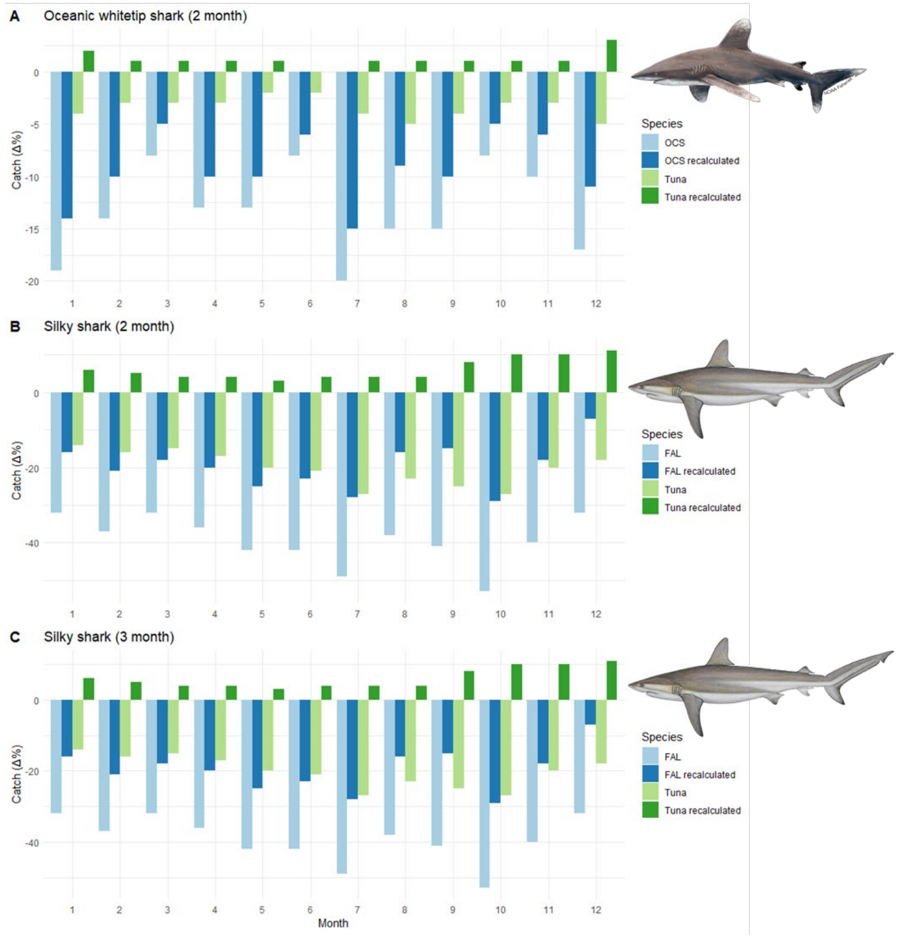
Results summary

- Reductions in bycatch averaged **41%** (n = 213,992) and **21%** (n = 110,418) for the **2- and 3-month thresholds** for silky sharks and **14%** (n = 5,588) for the **2-month** threshold for oceanic whitetip sharks.

- These closures would have impacted an average of **25%, 11% and 5% of fishing sets**, respectively.

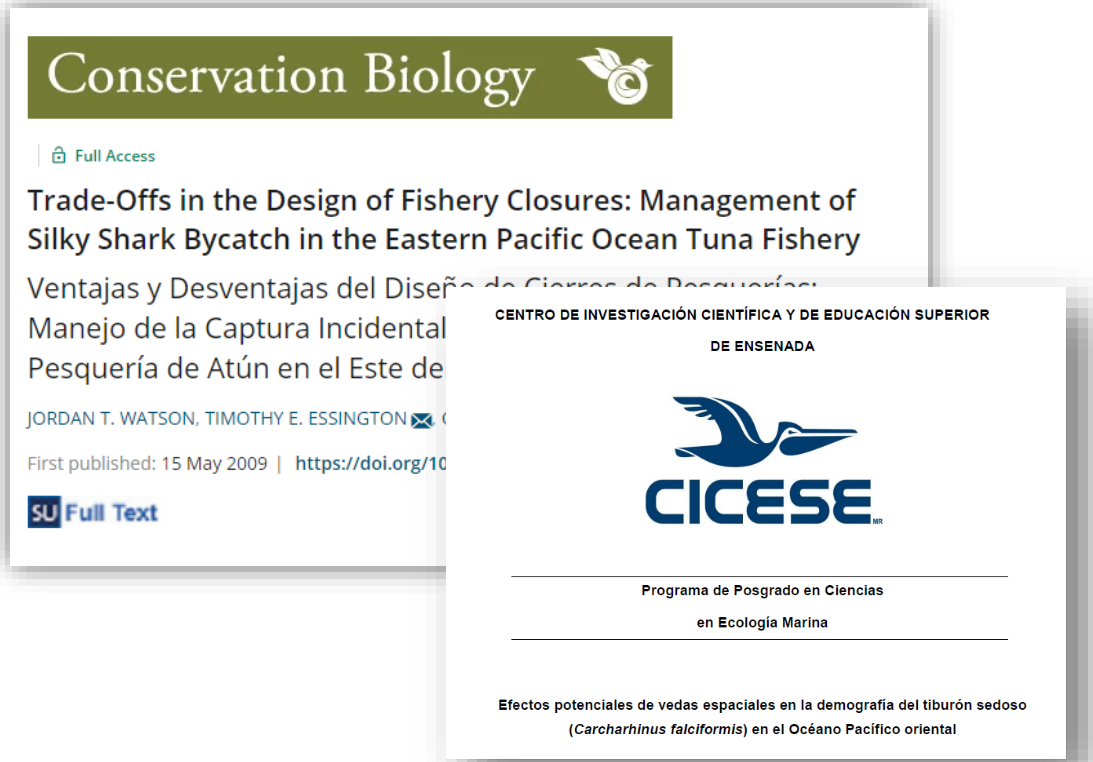
- Prior to fishing effort redistribution, these closures were predicted to result in an **average reduction in tuna catches of 20%, 9%, and 3%,** respectively.

- **After redistributing the fishing effort** within the investigated closures, results still showed a net decrease in shark bycatch across all scenarios—ranging from a 28% to 3% of reduction—and a projected increase of tuna catches across all scenarios between 1-11%



Conculsions (1/2)

- The practicality of our results depends on the premise that the management of tropical tunas in the region will limit the **fishing mortality to levels that will biologically sustain the population.**
- This is a critical reflection as directing **fisheries, which are often regulated through effort controls**, to areas of higher than average CPUE **could lead to excessive exploitation** of target species.
- The IATTC's high observer coverage and availability of **operational-level data from the purse seine fishery since the early 1990s has been instrumental** in our ability to conduct this analysis.
- Our results agree with a previous study in the region, which also explored spatial management opportunities for reducing one species of shark bycatch without jeopardizing tuna catches **Watson et al. (2009)** and **Roman-Verdesoto (2014).**



Conculsions (2/2)

- A **holistic bycatch strategy** by the IATTC should address several outstanding topics of importance across all fisheries within its convention area to improve sustainable fisheries management:
  - It would be important for future work to assess the **relative impacts of proposed closures on the catch and bycatch rates of other species**, especially after reallocating the displaced fishing effort.
  - **Alternative forms of fishing effort redistribution** exist and could be explored
  - Further research guided by the principles of **dynamic ocean management** may be required to determine if emphemeral (non-persistent areas) could be identified.
  - **Other type of mitigation actions** should be explored and considered in conjunction.

- Ensuring that the sustainability efforts of the purse seine fishery are effective will also require **adequate consideration of activities in the IATTC industrial, semi-industrial and artisanal longline fisheries**, which continue to catch a wide range of elasmobranch species, either incidentally or as a target.