Persistent hotspots of billfish (by)catch pervade the high seas of the tropical Pacific Ocean

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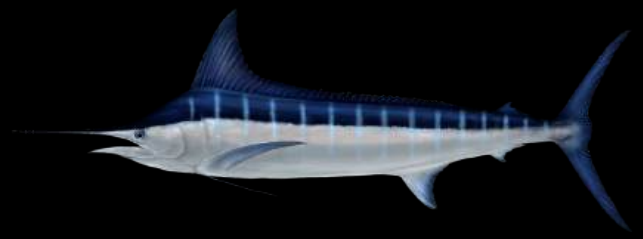
WHOI

Wild Oceans

Oceanic Pacific Billfishes



Striped Marlin

- Overfished
  - Western/Central North
  - Southwest
- Healthy
  - Eastern Tropical

Blue Marlin

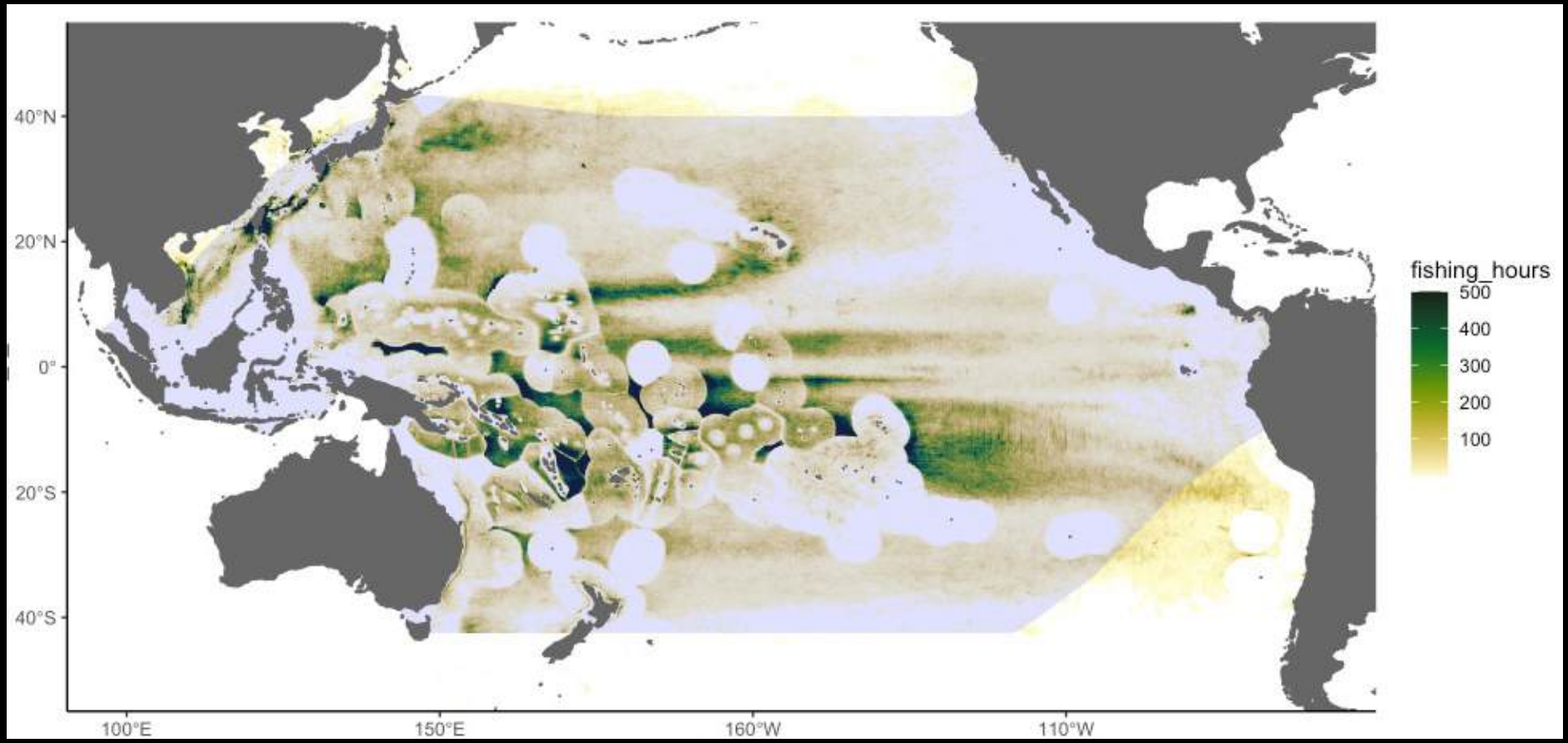
- Near full exploitation
  - Panmictic

Shortbill Spearfish

- No stock assessment
  - Likely North-South stock delineation

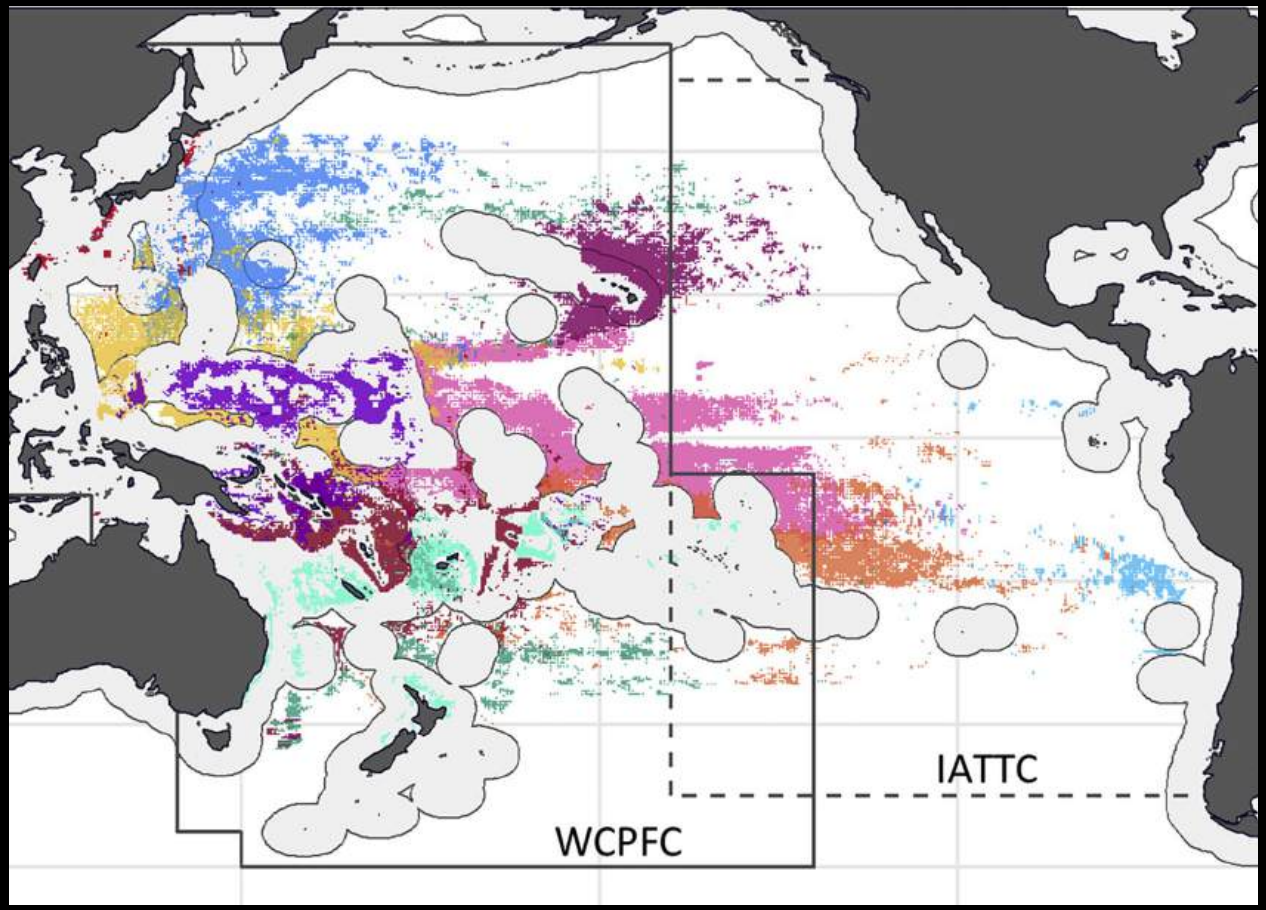
Longlines responsible for > 90% of landings

Pacific Longline Effort



Global Fishing Watch

Functional Longline Fleets of the Pacific



- West Tropical Foreign
- Tropical Distant Water
- USA Offshore
- Southwest Foreign
- Southwest Domestic
- Southeast Distant Water
- Taiwan Offshore
- Japan Offshore
- Northwest Domestic
- East Distant Water
- Dual-hemisphere Distant Water

Fleets are: **Multi-national** **Multi-jurisdictional** **Multi-specific**

Frawley et al. 2022
One Earth

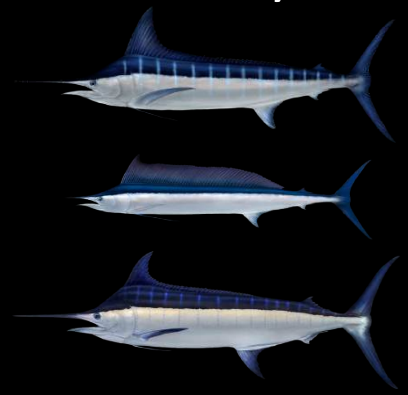
Identifying Billfish (By)catch Hotspots

Phase 1 – Billfishes

- Build predictive species distribution models (SDMs)
- Predict daily occurrence

Phase 2 – Longline Fleets

- Build predictive vessel distribution models (VDMs)
- Predict daily occurrence



Overlap

Dynamic (By)catch Susceptibility

How changing ocean conditions create hotspots of risk

Data – Billfish SDMs

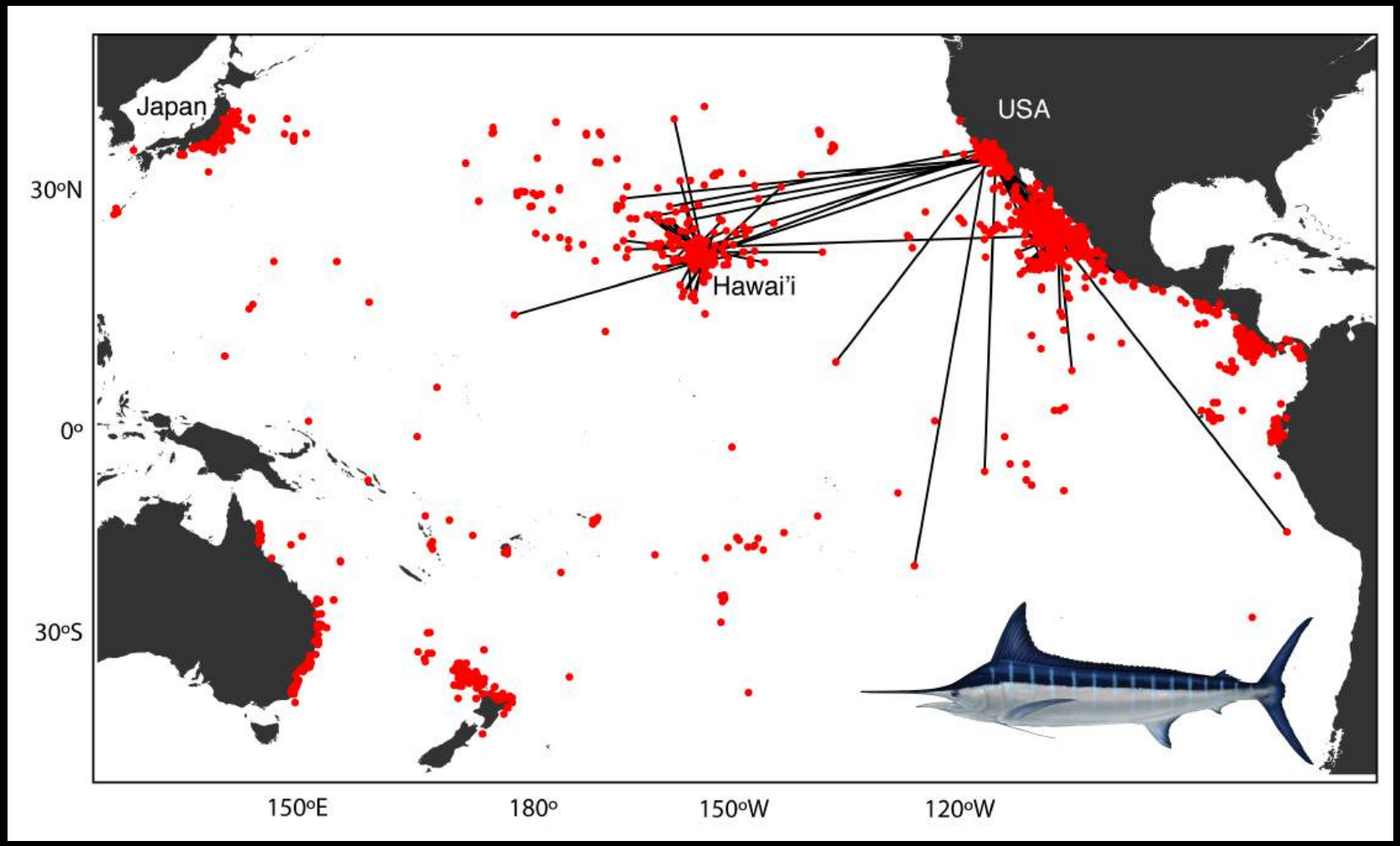
Billfish Data Sources

- Conventional Tagging
- Hawai`i Longline Observer
- Taiwan Longline Logbook
- IATTC Longline & Purse-Seine Observer

Modeling Approach

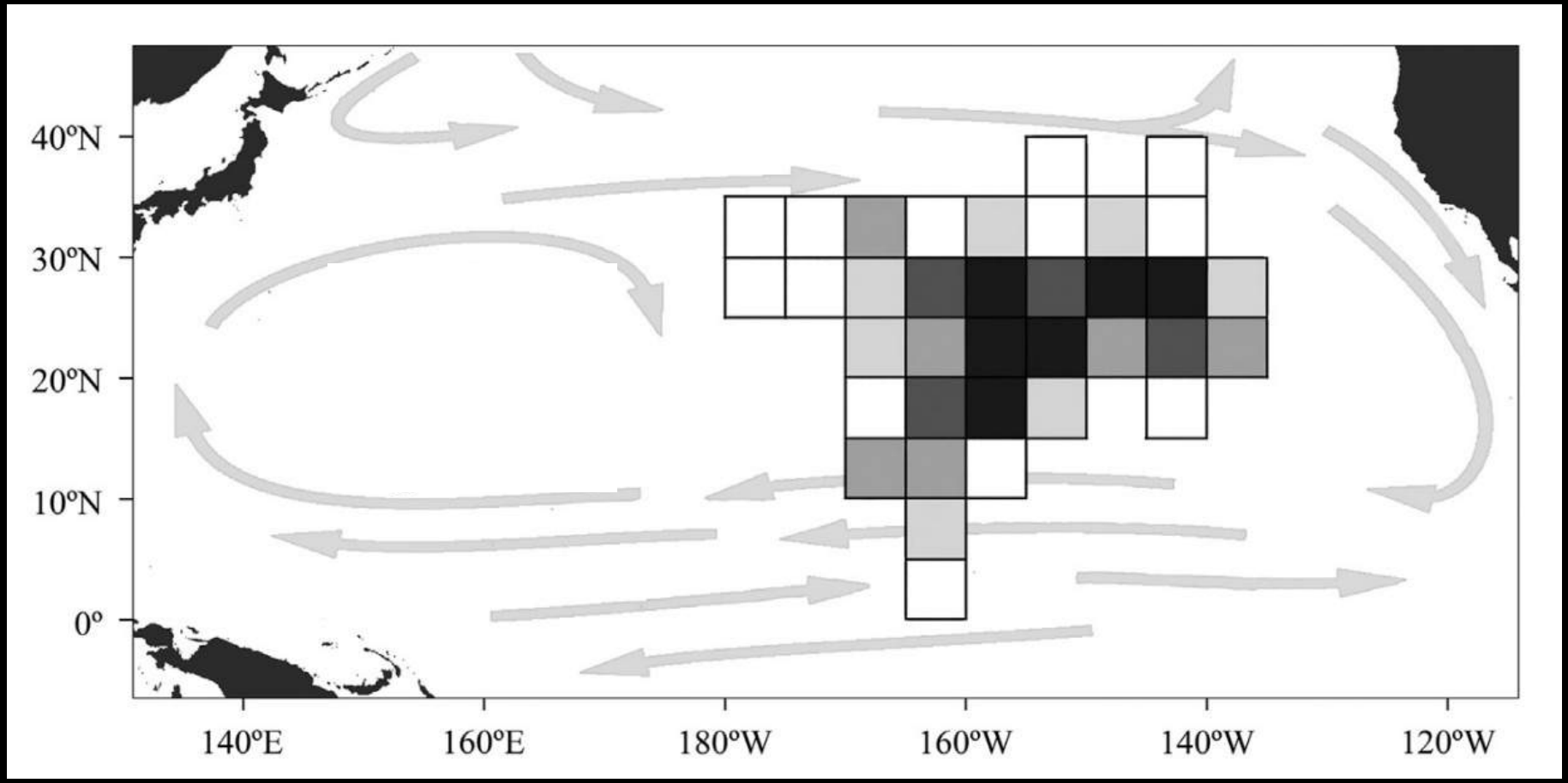
- Boosted Regression Tree (BRT)
- 12 variables: daily, 0.25^{o} resolution
- 27 years of training data (1997-2023)
- N = 121,000 – 534,000 records per species

Conventional Tagging



~5,000 – 70,000 records per species

Hawai`i Longline (Observer)

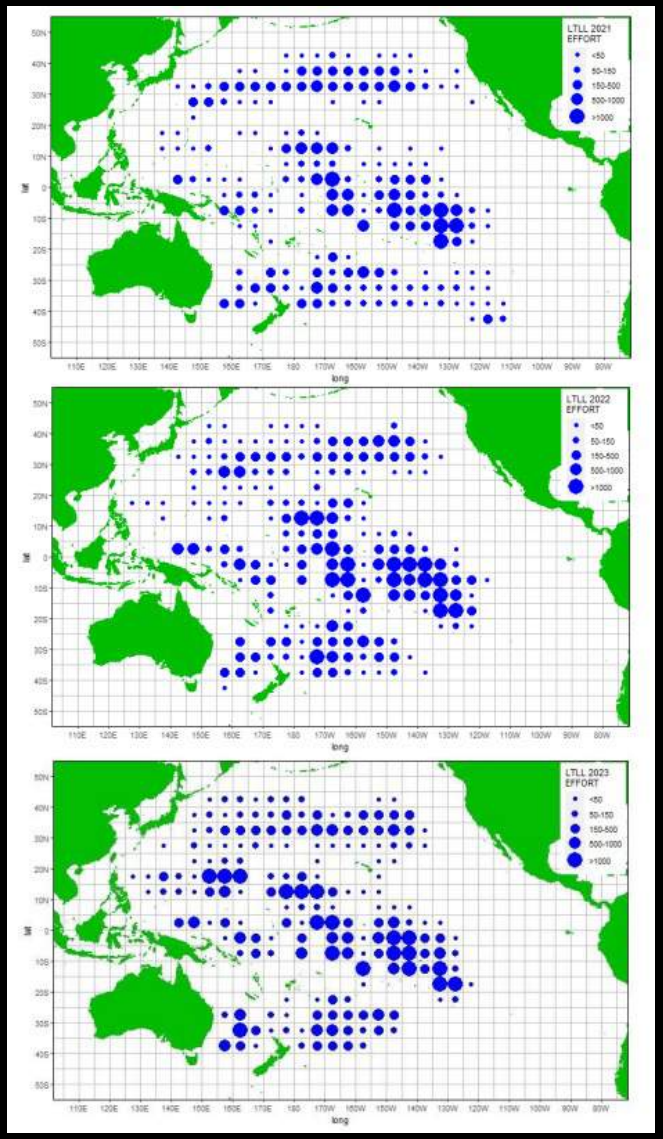


~19,000 – 42,000 records per species

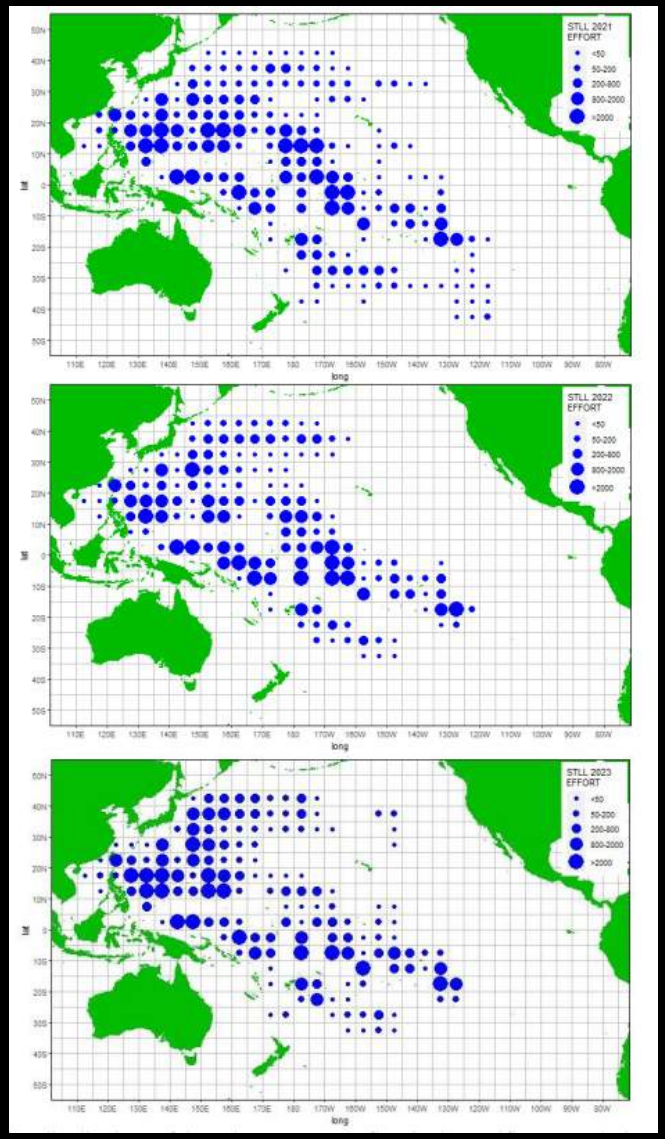
Portner et al. 2017
Deep Sea Res I

Taiwan (Chinese Taipei) Longline (Logbook)

Large-Scale

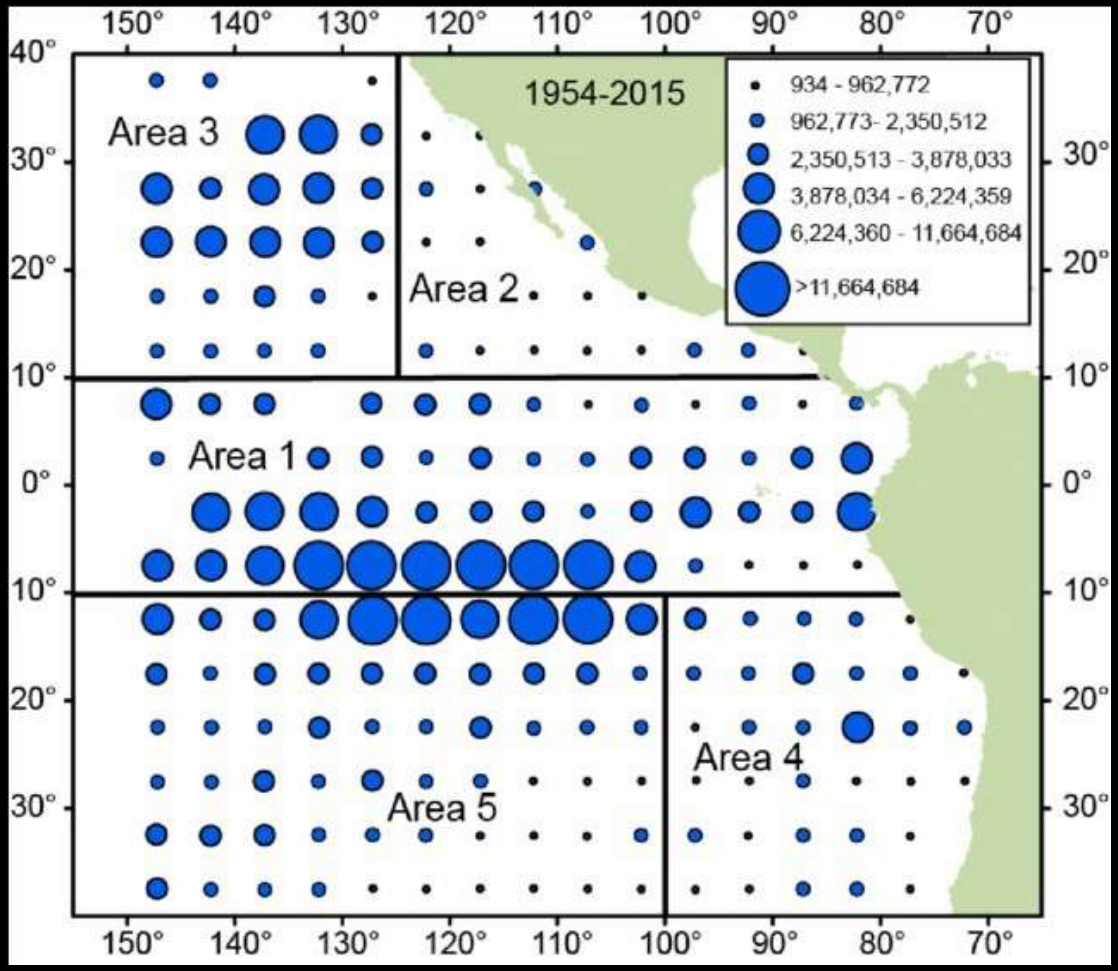


Small-Scale



~61,000 – 486,000 records per species

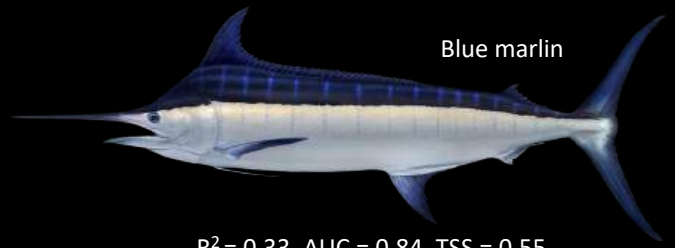
IATTC Longline & Purse-Seine (Observer)



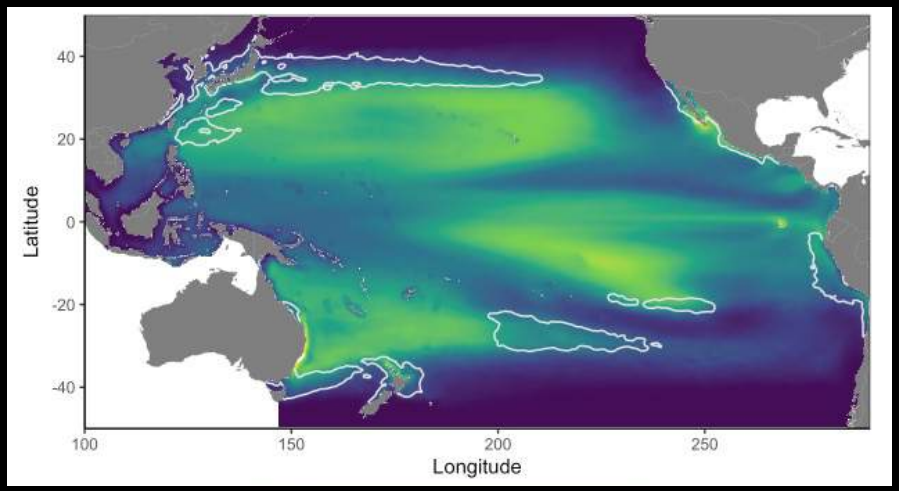
~13,000 – 50,000 records per species

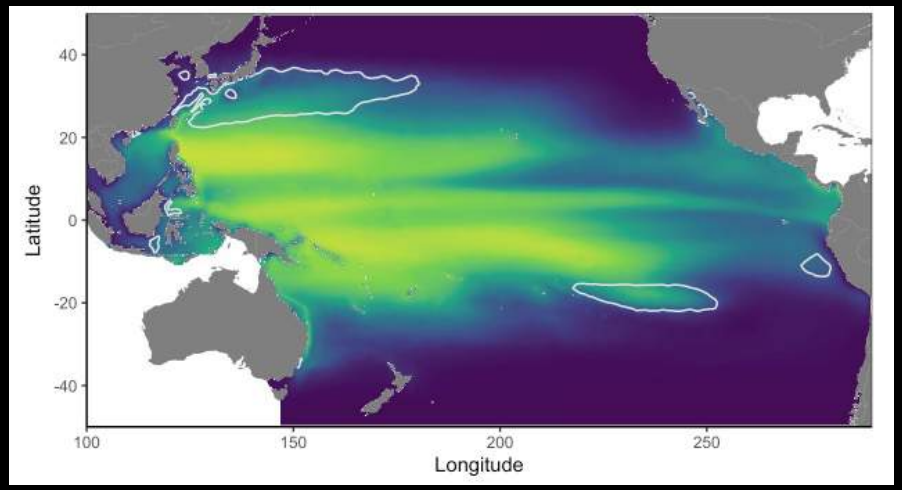
Griffiths et al. 2017 SAC-08-07d

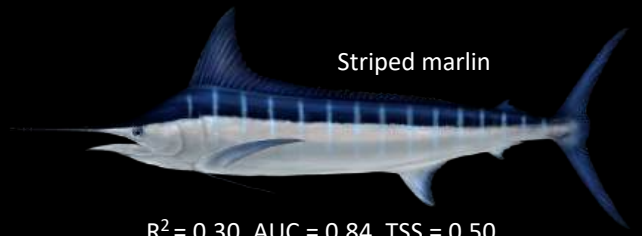
Billfish SDMs



R^2 = 0.33, AUC = 0.84, TSS = 0.55
Vars: SST (74%), SSH (10%), SSS (8%)

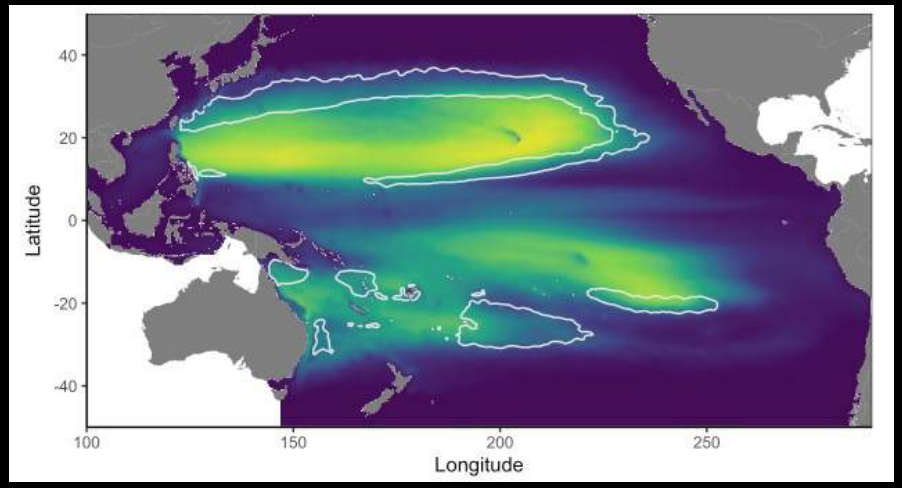






R^2 = 0.30, AUC = 0.84, TSS = 0.50
Vars: SST (46%), SSH (15%), CHL (13%)

R^2 = 0.44, AUC = 0.90, TSS = 0.66
Vars: SSH (53%), SSS (16%), CHL (14%)



Data – Longline VDMs

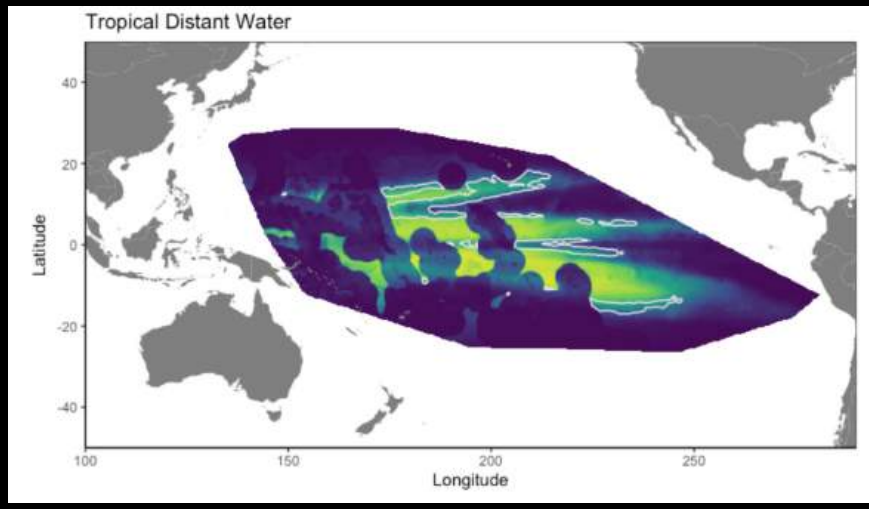
Vessel Data Sources

- Global Fishing Watch
- Functional fleet assignment
  - Frawley et al. 2022 *One Earth*
- 5 pre-existing VDMs
  - Frawley et al. 2024 *Fish and Fisheries*

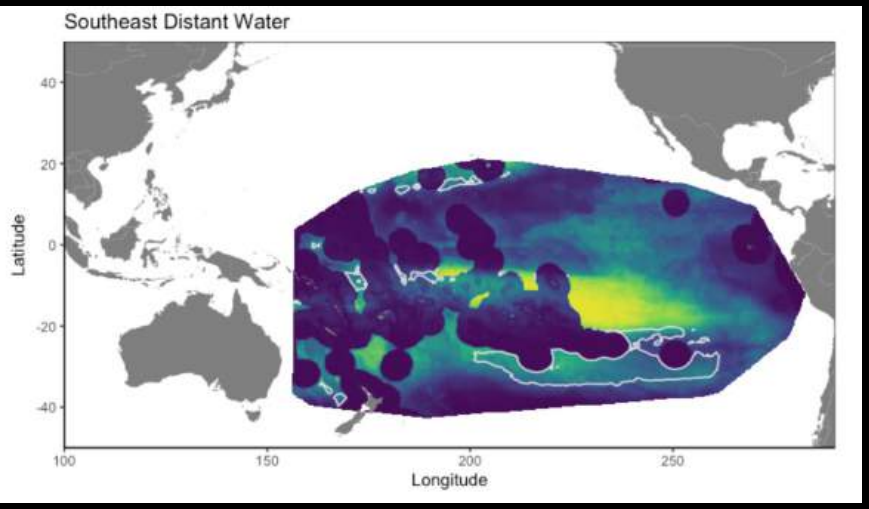
Modeling Approach

- Boosted Regression Tree (BRT)
- 12 variables: daily, 0.25^{o} resolution
- 3 years of training data (2017-2019)
- N = 14,000 – 184,000 records per fleet

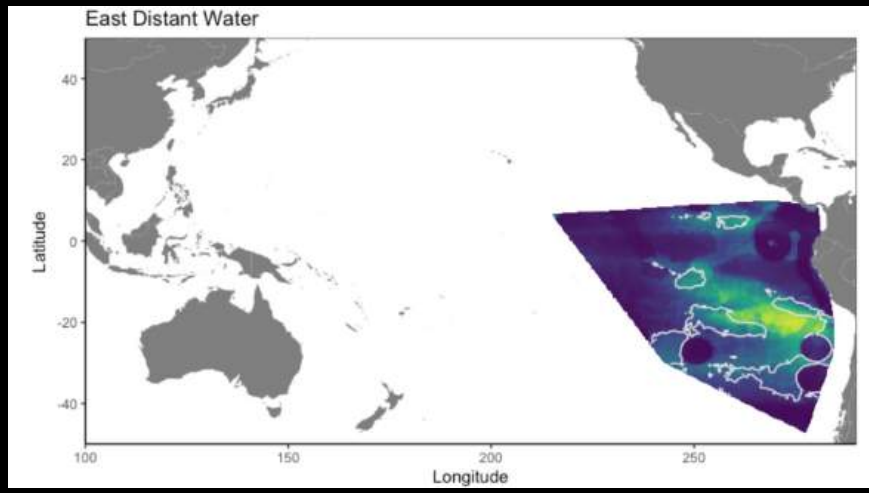
Distant Water Fleets



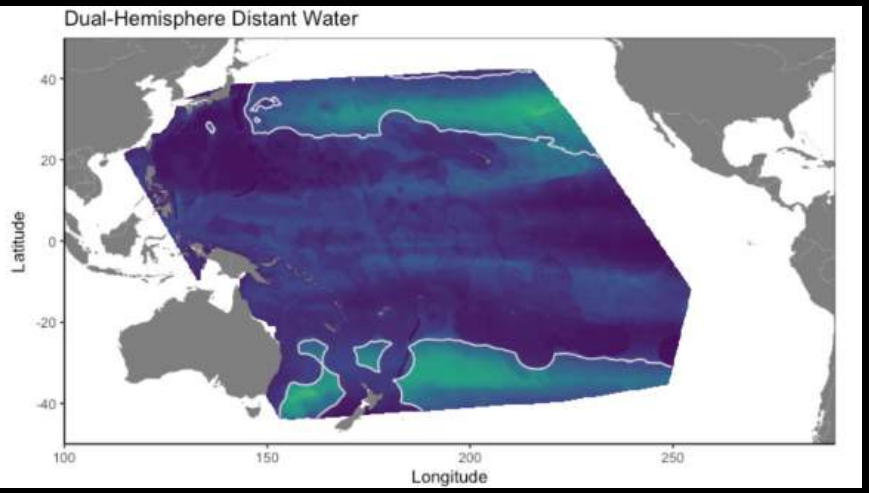
R^2 = 0.53, AUC = 0.93, TSS = 0.74
Vars: Dist (31%), DO (23%), NPPV (13%)



R^2 = 0.50, AUC = 0.92, TSS = 0.69
Vars: Dist (30%), DO (22%), ADT (14%)

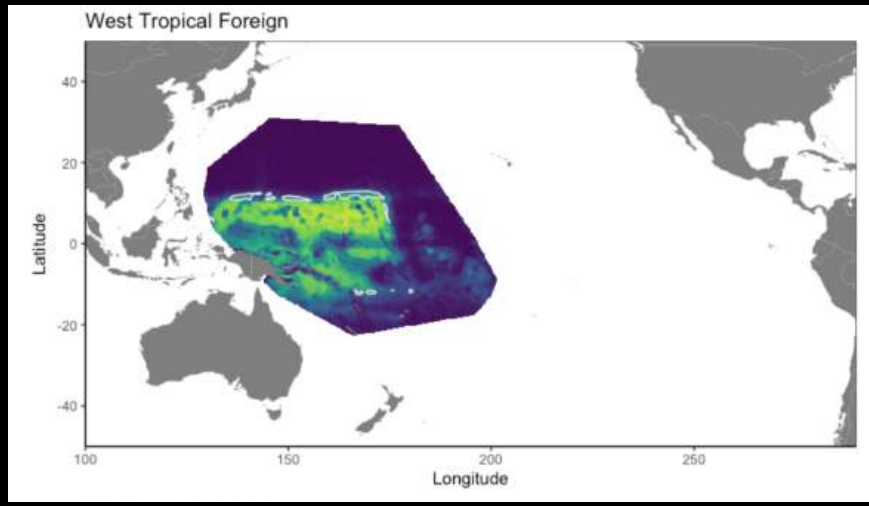


R^2 = 0.53, AUC = 0.93, TSS = 0.72
Vars: NPPV (20%), Bathy (16%), SST (15%)

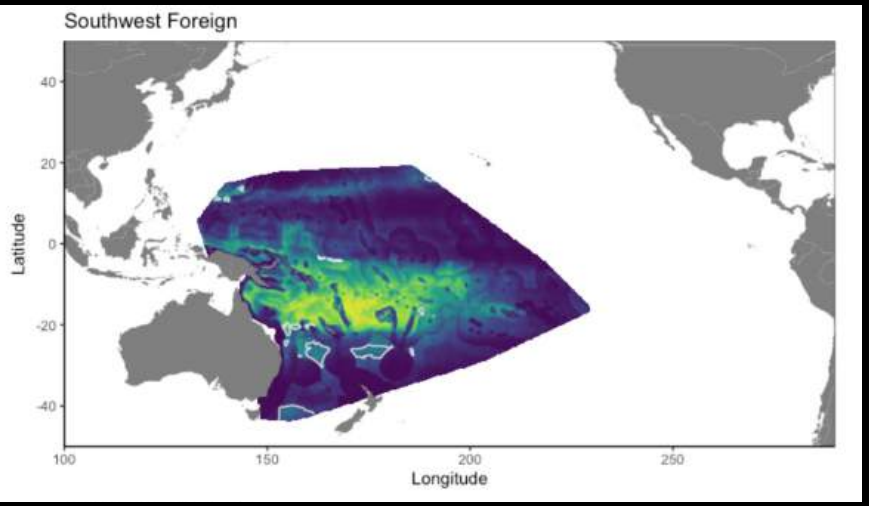


R^2 = 0.53, AUC = 0.94, TSS = 0.75
Vars: SST (58%), MLD (20%), Dist (7%)

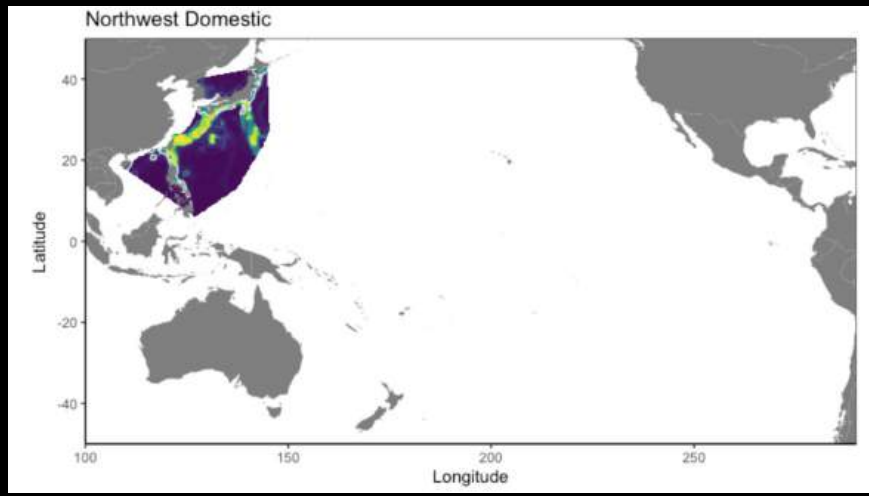
Foreign & Domestic Fleets



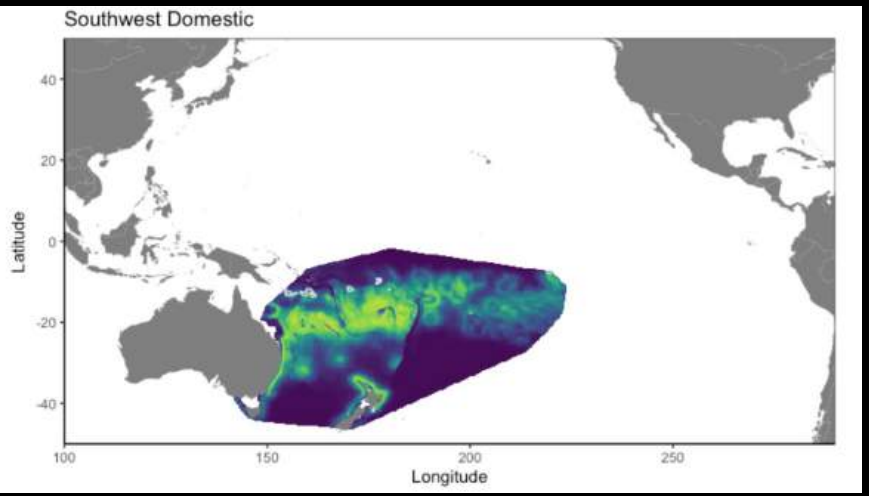
R^2 = 0.47, AUC = 0.91, TSS = 0.67
Vars: DO (53%), Dist (21%), Bathy (11%)



R^2 = 0.48, AUC = 0.92, TSS = 0.69
Vars: DO (28%), ADT (27%), Bathy (18%)

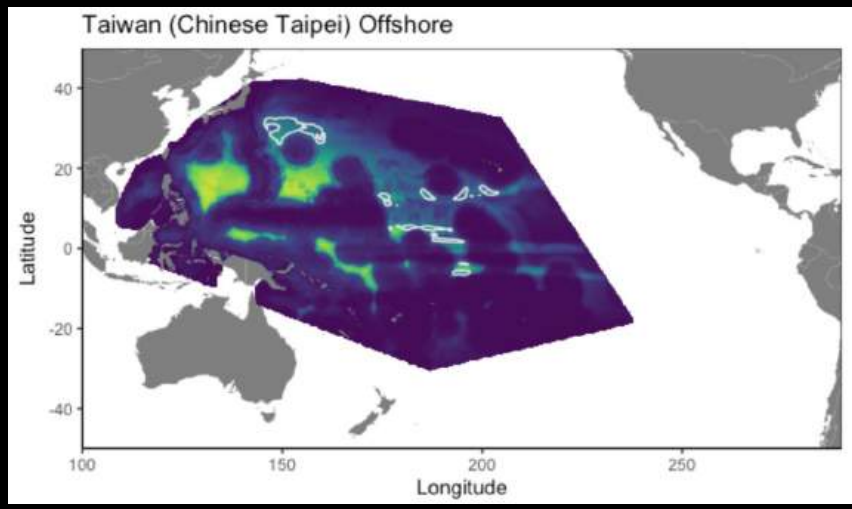


R^2 = 0.35, AUC = 0.87, TSS = 0.58
Vars: Dist (55%), DO (20%), Bathy (13%)

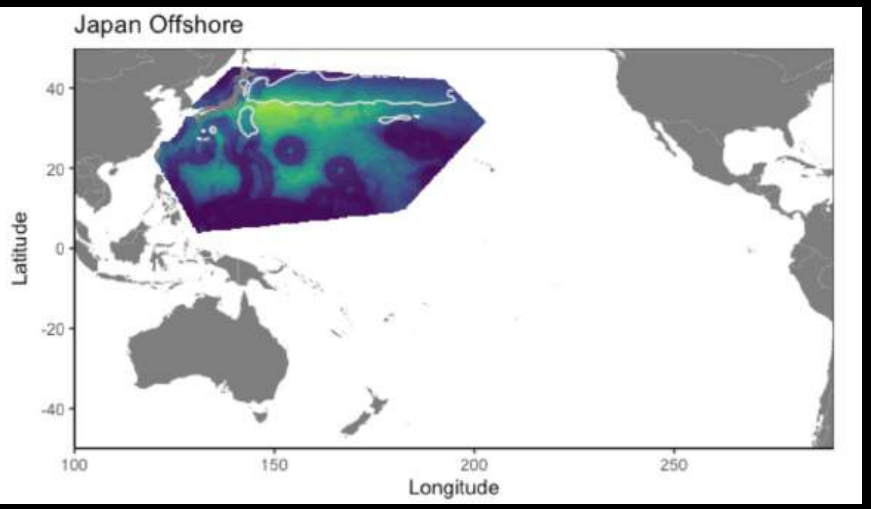


R^2 = 0.43, AUC = 0.89, TSS = 0.64
Vars: DO (28%), Dist (24%), Bathy (22%)

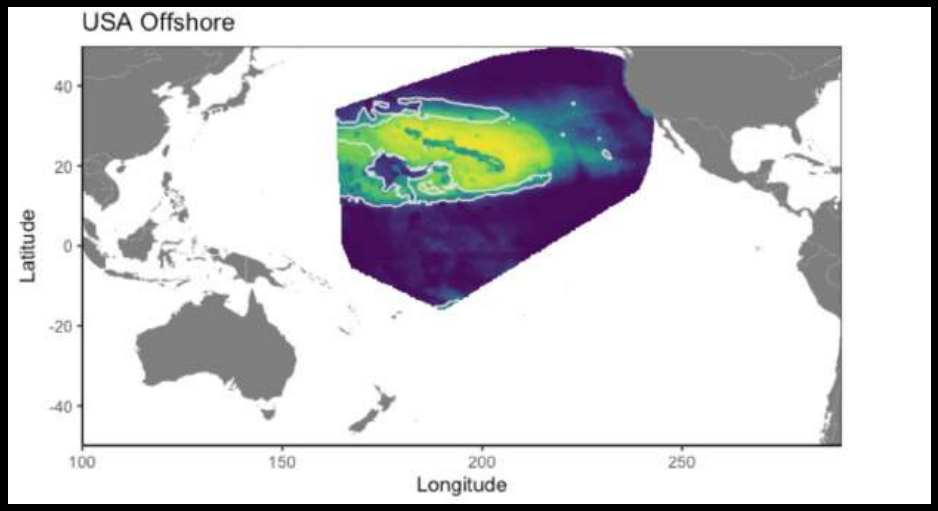
Primarily Single-Nation Fleets



R^2 = 0.51, AUC = 0.93, TSS = 0.74
Vars: Dist (31%), DO (23%), NPPV (13%)



R^2 = 0.35, AUC = 0.87, TSS = 0.58
Vars: Dist (19%), SST (18%), DO (16%)



R^2 = 0.61, AUC = 0.95, TSS = 0.79
Vars: NPPV (36%), Dist (29%), ADT (14%)

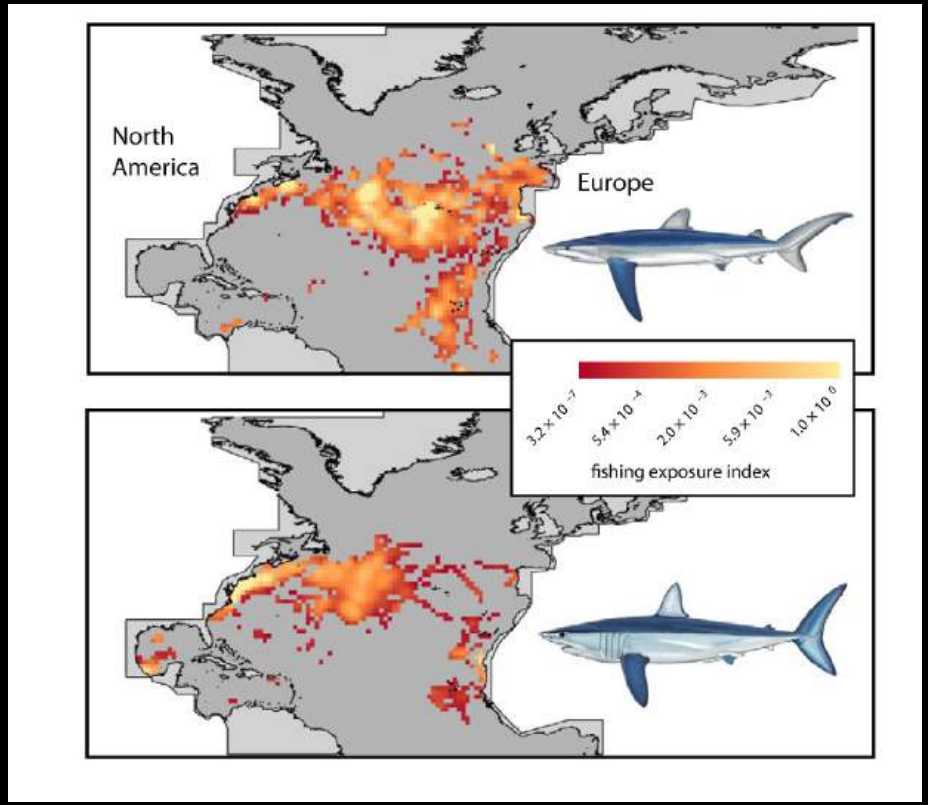
Quantifying Risk & Persistence

Risk

- Fleet-specific scaling
  - Overall effort (vessel days)
  - Intra-annual effort variation (monthly proportion of vessel days)
- Summed across fleets
- Hotspot: > 90th risk quantile

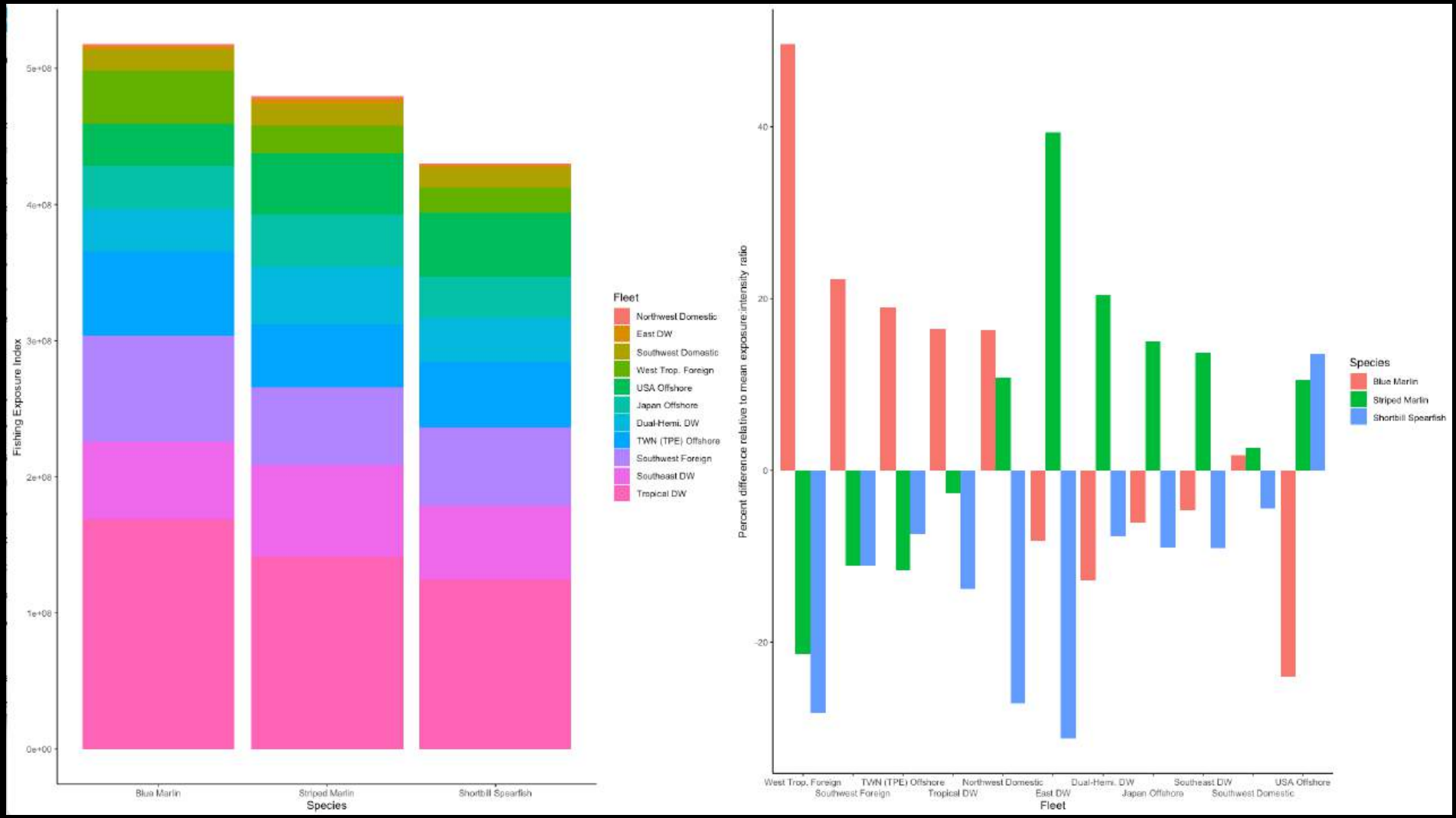
Persistence

- Persistent: ≥ 50% of days
- Ephemeral: > 0 but < 50%
- 10-year, seasonal, interannual, ENSO, PDO

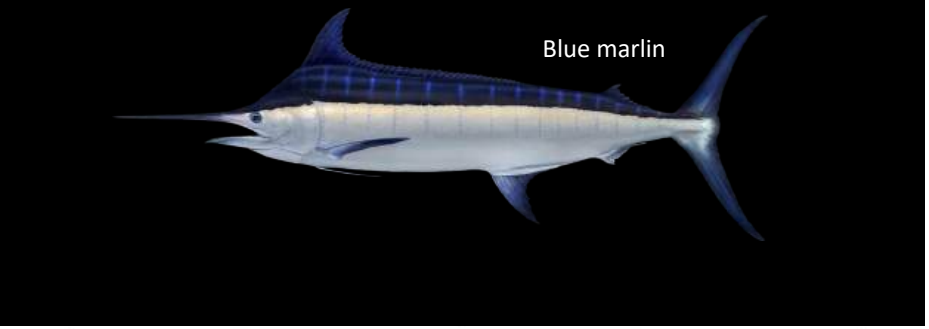


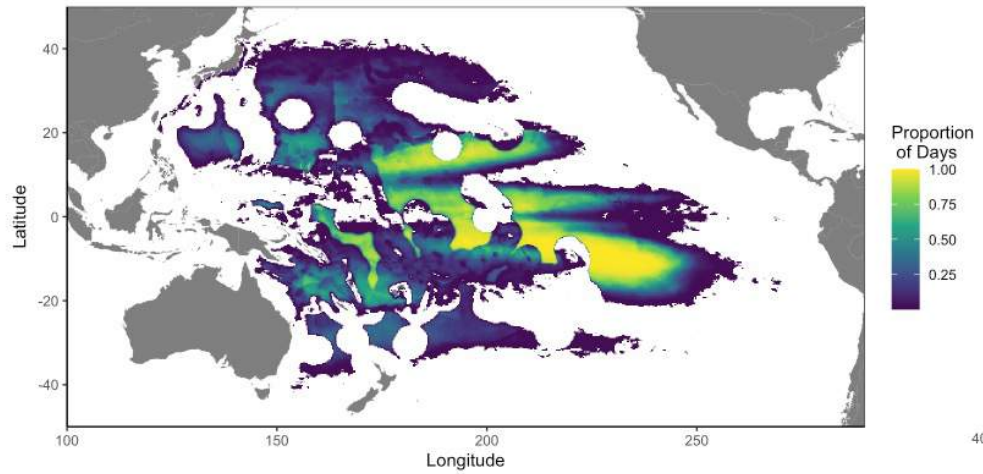
Quieroz et al. 2019
Nature

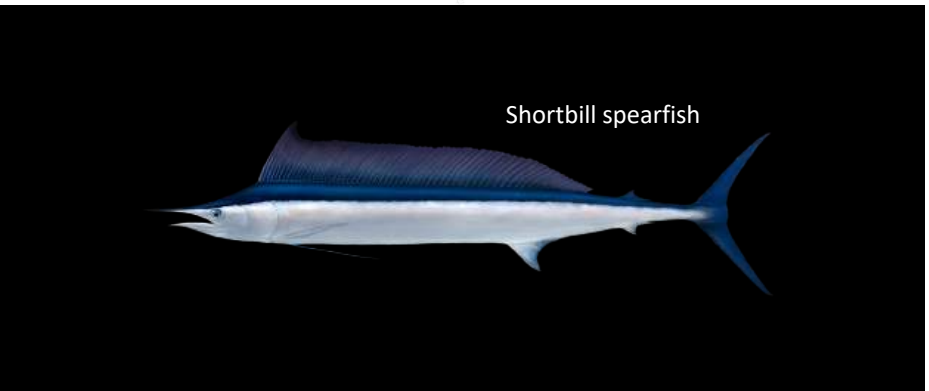
Cumulative and Fleet-Specific Exposure

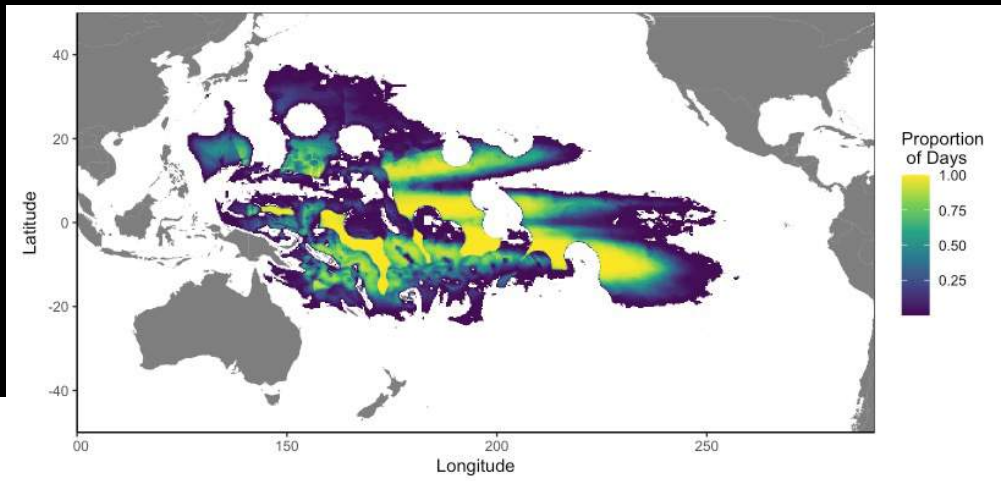


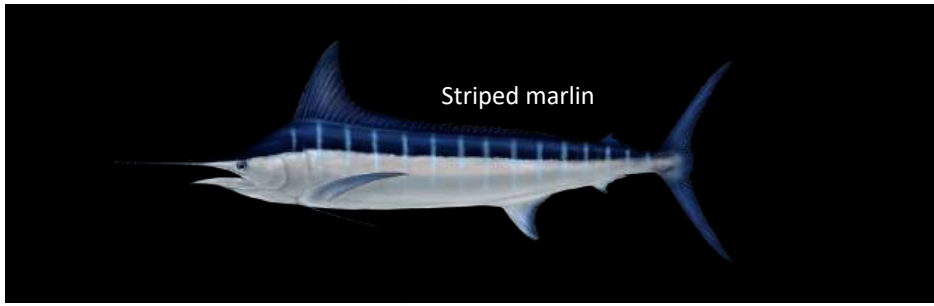
Billfish (By)catch Hotspots

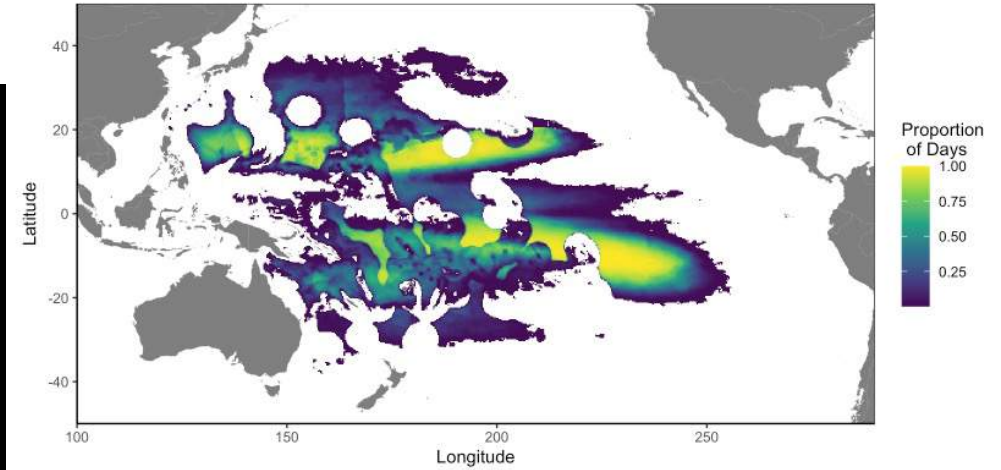




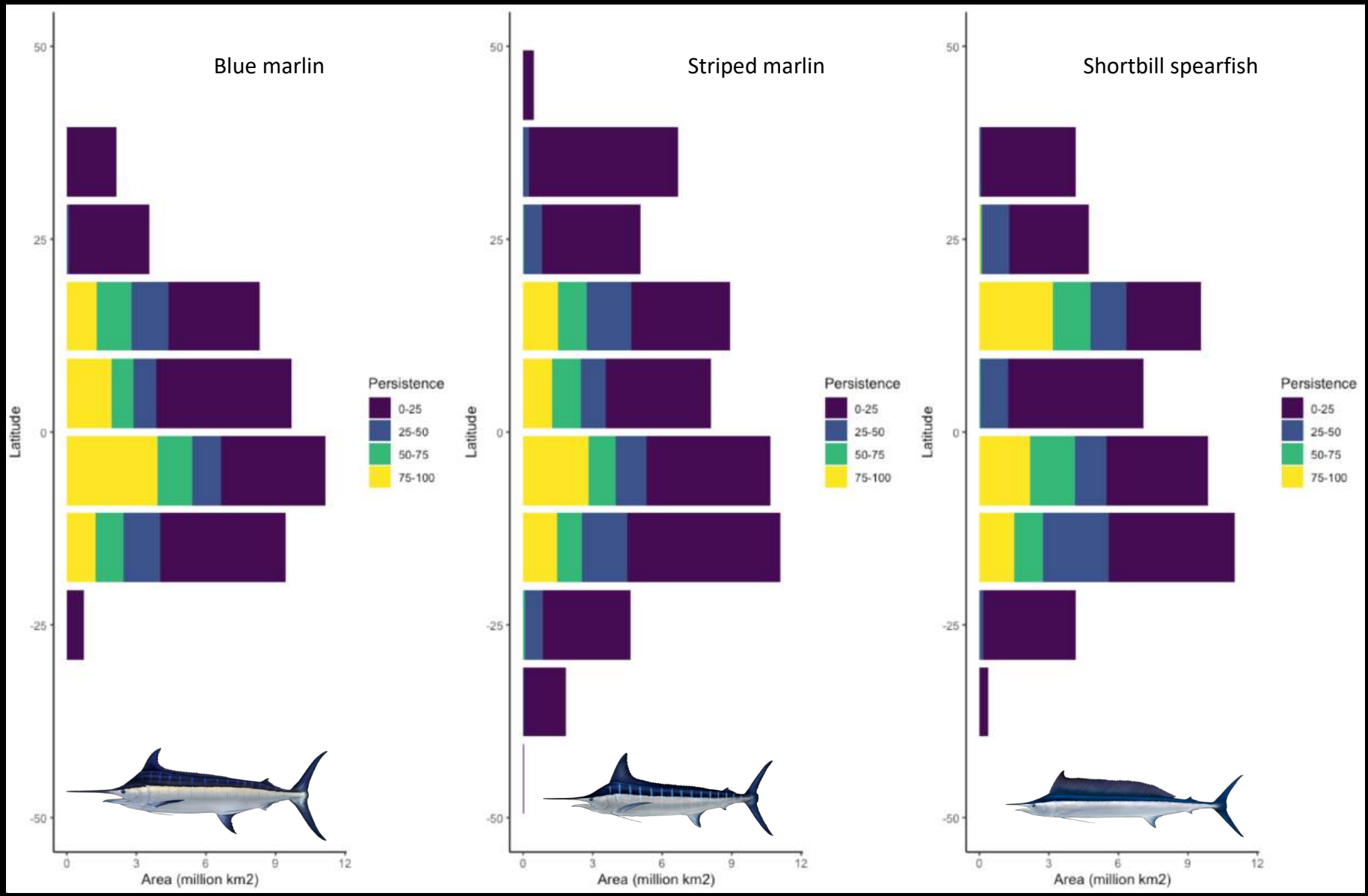




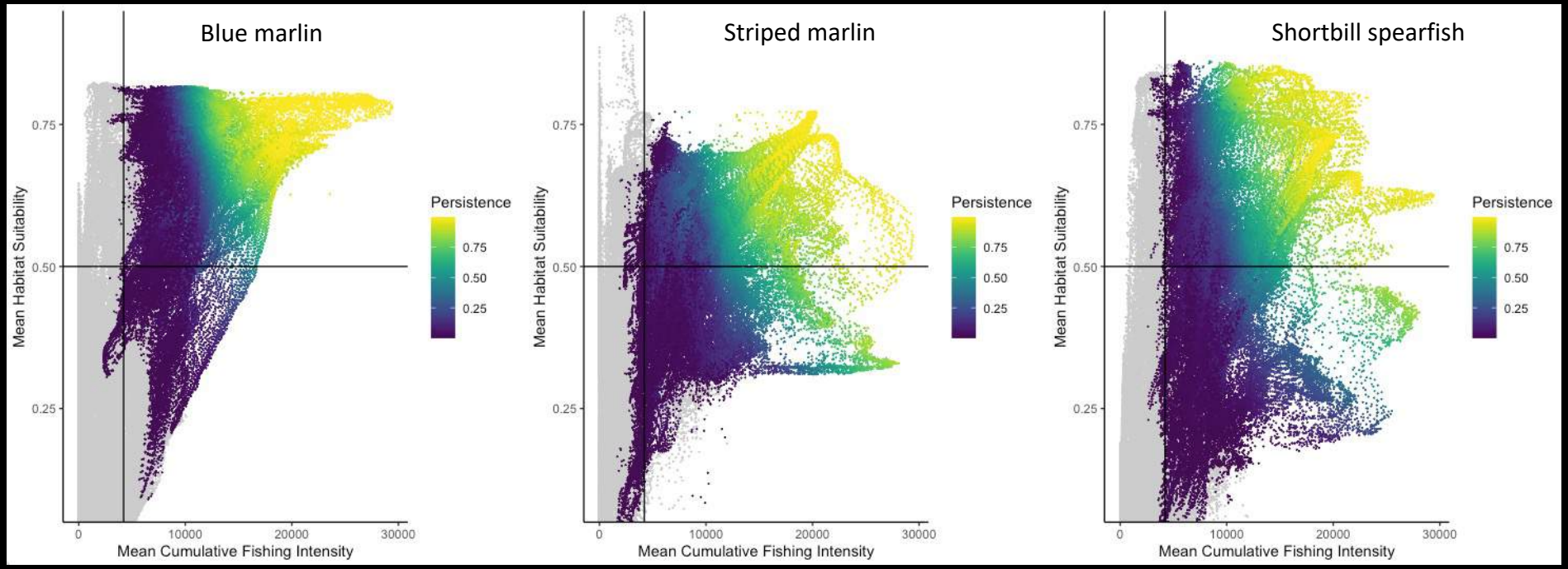


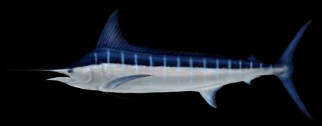


Billfish (By)catch Hotspots



What Makes a Hotspot





WCPFC

IATTC

High Seas

EEZs

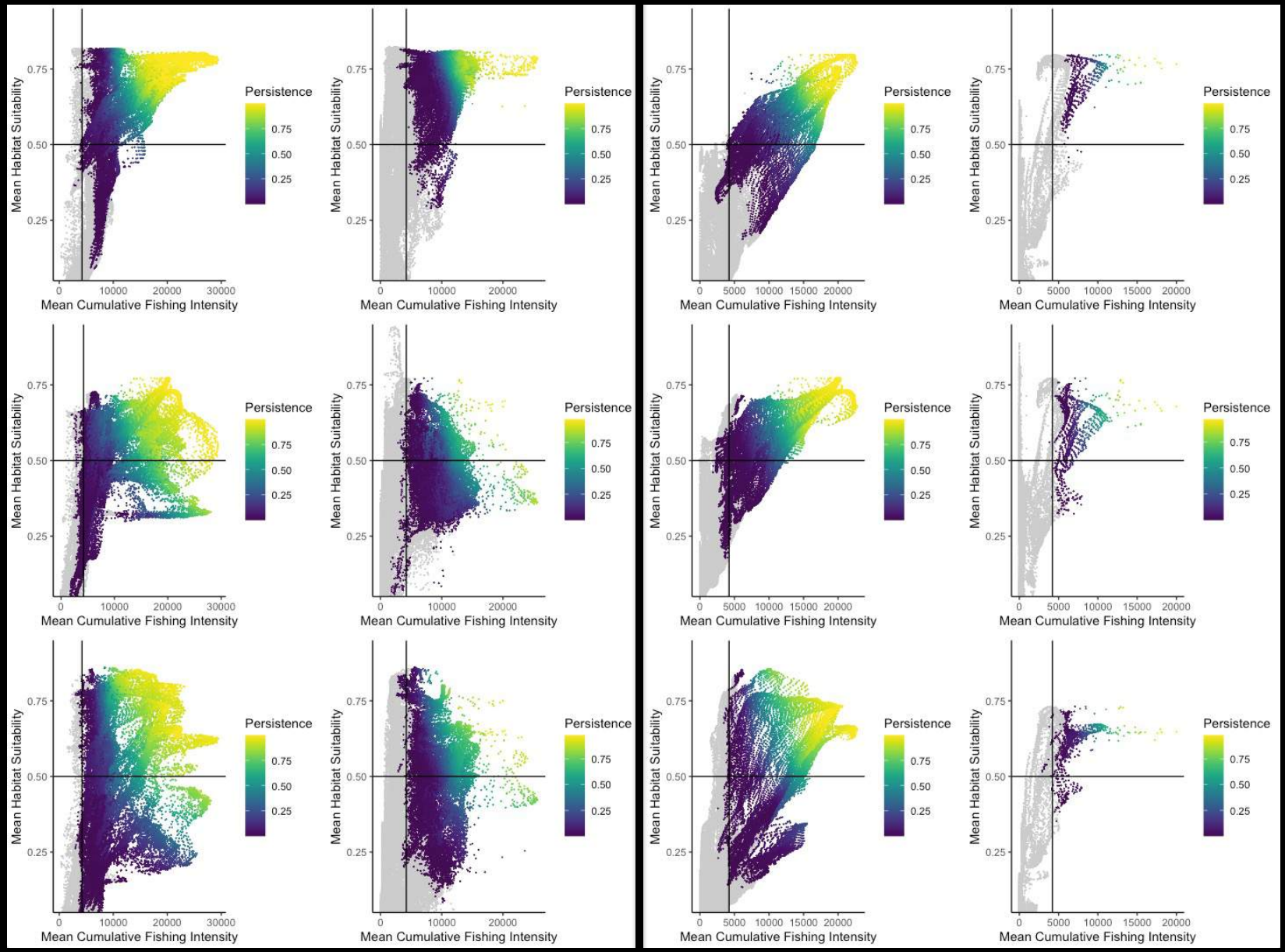
High Seas

EEZs

Blue marlin

Striped marlin

Shortbill spearfish



Feedback For Actionable Insight

- What analyses would be most informative to management Pacific-wide and within your jurisdiction?

- What context might we want to emphasize to better situate these analyses in the broader issues of (by)catch and management across EEZs and ABNJ?

Questions?

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