Departamento de Economía
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Adaptation in Fisheries: Evidence from Behavioral Models and Global Case Studies

Evidence from global case studies and an empirical discrete choice model

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Why Small Pelagic Fish Matter

25%

of global fish catch
by volume

Forage base

Critical for tuna,
seabirds & marine mammals

Boom-bust

Highly volatile — driven
by oceanographic regimes

The management challenge

- Volatile populations
- Key forage for tuna
- Livelihood dependence
- Climate change amplifies all

→ *Directly relevant to IATTC: impacts on tuna habitat & catchability*

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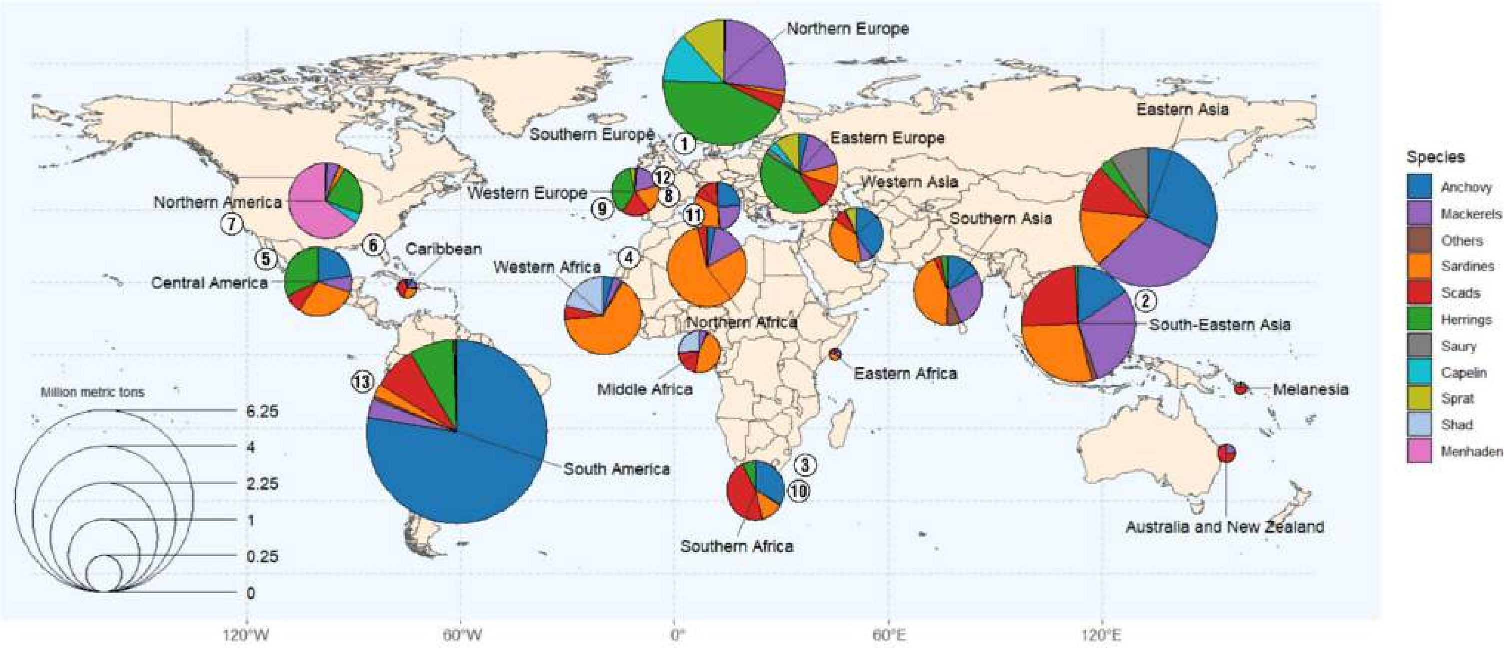
13 Case Studies Across 11 Regions



1. Transboundary issues in the North East Atlantic: The "mackerel war"
2. Shifting SPF distribution outside Japanese EEZ
3. Restructuring of the South African sardine fishery due to an eastward expansion of biomass
4. The case of round Sardinella fisheries in North-West Africa
5. Changes in the distribution of Pacific sardine in Northwestern Mexico
6. Hypoxic events and the Gulf of Mexico menhaden fishery
7. The collapse of the Pacific sardine on the U.S. West Coast in the late 1940s
8. The collapse of the anchovy fishery in the Bay of Biscay
9. Declining trend of the stock of Atlantic Iberian sardine
10. Booms and busts in the South African sardine population
11. Lower anchovy average size in the Tyrrhenian Sea
12. Decline in anchovy sizes in the Bay of Biscay
13. Increasing probability of catching small-size anchoveta in Peru under compression of the habitat and fishing grounds

Three categories

Shifting distribution	Boom-bust dynamics	Fish size & quality
NE Atlantic mackerel (transboundary)	U.S. West Coast sardine (1940s)	Tyrrhenian Sea anchovy
Japan SPF outside EEZ	Bay of Biscay anchovy	Bay of Biscay anchovy
South Africa sardine	Atlantic Iberian sardine	Peru anchoveta (juvenile risk)
NW Africa sardinella	South Africa sardine	
Mexico Pacific sardine	Gulf of Mexico menhaden (hypoxia)	

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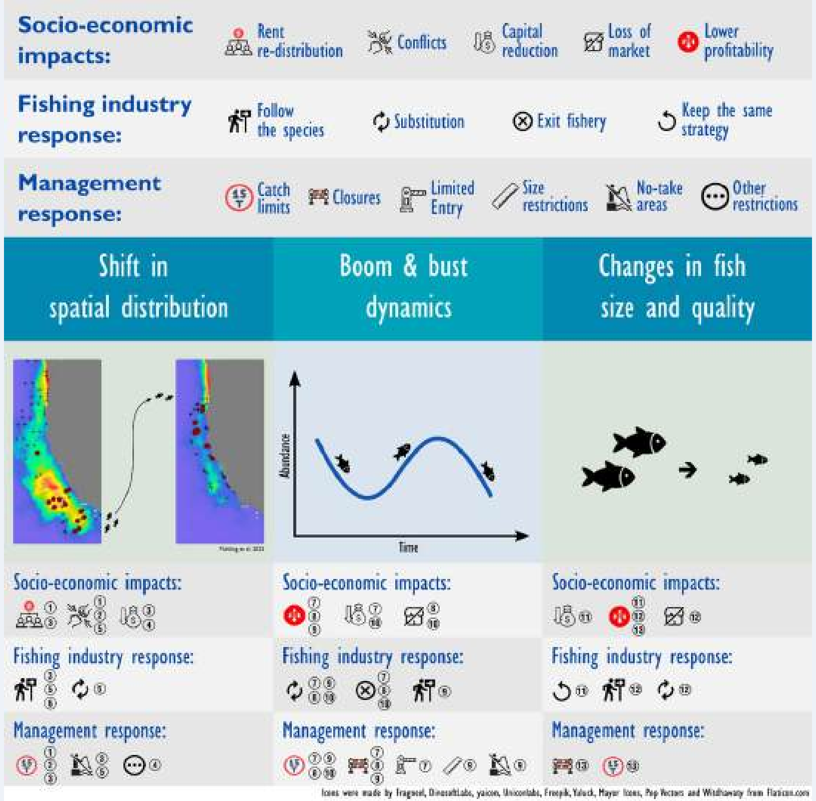
How Does the Fishing Industry Respond?



Case studies:

① Transboundary issues in the North East Atlantic: The "mackerel war"
② Shifting SPF distribution outside Japanese EEZ
③ Restructuring of the South African sardine fishery due to an eastward expansion of biomass
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Fisherman behavioral strategies

🏃 Adapt on the move

Follow the species to new areas. Requires port flexibility, gear adaptability, and capital. Constrained by distance (SPF spoilage, cost).

Example:

South Africa sardine eastward shift; Iberian sardine in Portugal

🔄 Adapt in place

Switch to alternative species in the same area. Requires broad permits and flexible gear. Reduces income risk through portfolio diversification.

Example:

U.S. West Coast: squid, crab, anchovy; South Africa: anchovy

🚪 Exit the fishery

Sell vessel/gear. Observed when collapse is severe and long-lasting. Leads to capital loss and community impacts.

Example:

1940s sardine collapse (U.S.); Bay of Biscay anchovy moratorium

Key insight: Portfolio diversification is the most common resilient strategy — requires access to multiple species, flexible permits, and market demand (sensu Samhouri et al. 2024)

From Case Studies to Empirical Modeling

From Patterns to Behavior

- Case studies → identify adaptation strategies
- BUT: lack of quantification

How exactly do individual fishing vessels respond to changes?

- Discrete choice model for trip-level decisions

→ U.S. West Coast Coastal Pelagic Species (CPS) fleet
→ Nested logit discrete choice model (PacFIN fish tickets 2013–2017)
→ Four distinct fleet segments — heterogeneous behavioral responses

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Empirical Model: Fishermen as Decision-Makers

Nested Logit Model

Data: PacFIN fish tickets 2013–2017 (~41,000 trips)

Three decision levels:

1. Participate vs. stay ashore
2. Which species to target
3. Where to land (port choice)

Key covariates: species availability (from SDMs), price, wind, distance to fishing ground, fishery closures

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Four Fleet Segments (CPS)

C4 — **Southern CCS Industrial Squid**
Squid specialist, Southern California | 29,160 trips

C5 — **Roving Squid-Sardine Generalist**
Multi-species, high mobility | 6,806 trips

C6 — **PNW Sardine Specialist**
Pacific Northwest, sardine-focused | 2,581 trips

C7 — **Southern CCS Forage Diverse**
Diverse forage fish portfolio | 2,481 trips

Two Modes of Adaptation: Evidence from the Model

Nesting structure and elasticities reveal which fleet segments follow species vs. switch within a port (sensu Samhouri et al. 2024)

🏃 Adapt on the move

Fleet segments: c4, c5, c6

Nests are species-specific — substitution across ports within same species:

c4 Squid specialist	N. Anchovy	**λ = 0.494**
c5 Roving generalist	Pacific Sardine	**λ = 0.403**
c6 PNW sardine	Pacific Sardine	**λ = 0.404**

Low λ → strong within-species port correlation
→ vessels follow species across ports

Availability elasticities dominate at the intensive margin — availability > price for targeting

🔄 Adapt in place

Fleet segment: c7 (Southern CCS Forage Diverse)

Nests are port-based — switching occurs within a fixed area:

Santa Barbara nest	**λ = 0.490**
Los Angeles nest	**λ = 0.730**
Monterey nest	**λ = 0.730**

Own-price elasticities ~0.45 across all CPS species

Price dominates targeting decisions within port — unique pattern, not seen in other segments

Climate Scenario: SDM-Driven Redistribution of Species Availability

What we do

- Shift squid distribution (SDM-based) -- (42.99°N to 40.66°)
- Keep prices & regulations fixed

What this isolates

- Pure behavioral response to availability

c4 Squid specialist

↑ squid targeting, ↓ mackerel; large participation increase — strong availability elasticity

c5 Roving generalist

↑ squid targeting, ↓ no-participation; modest other changes

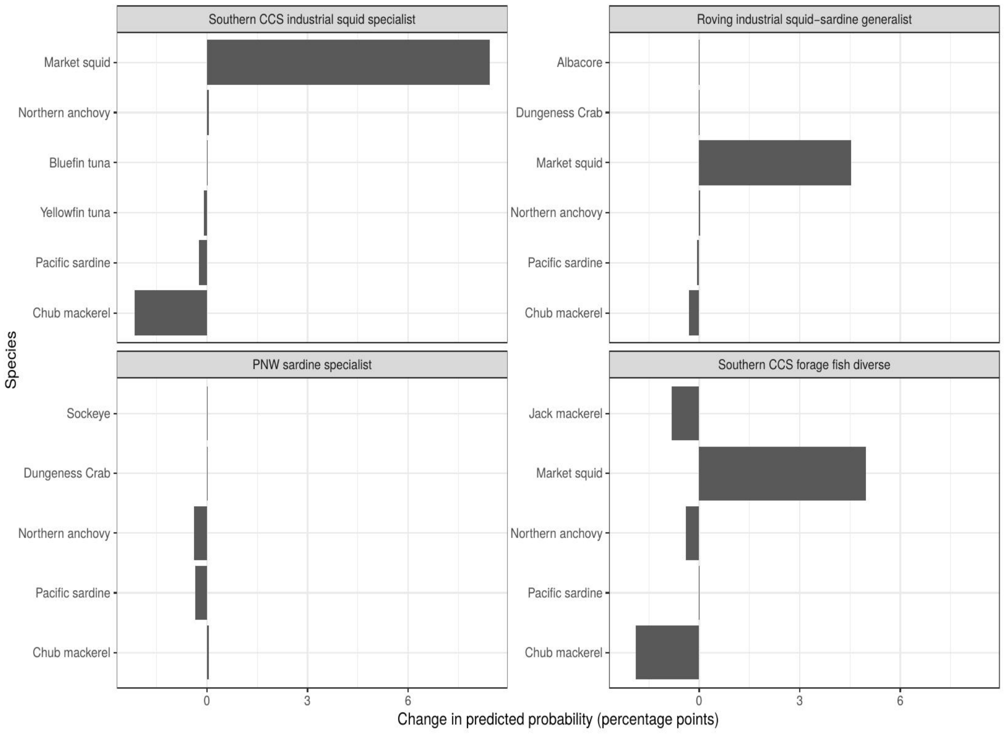
c6 PNW specialist

Small responses — squid not primary target in their area

c7 Forage diverse

Large reallocations: ↑ squid, ↓ chub & jack mackerel

Figure 6: Change in predicted targeting probability (percentage points) under SDM-based species redistribution scenario



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Short vs. long run responses

Short run (this model — 2013–2017)

- Capital fixed: vessels, gear, home ports remain the same
- Vessels adjust target species and port within existing infrastructure
- OOS validation: pseudo-ρ^2 = 0.22–0.44 → robust short-run predictor

Long run (beyond this model)

- All inputs adjustable: ports, gear, processing capacity
- Permanent fleet exits, new home ports, species licensing changes
- Parameters may shift — Lucas critique caveat applies

⚠ *Lucas critique: macro-level changes (e.g. fleet restructuring) could alter estimated parameters — model most reliable for short-to-medium term forecasting*

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Summary

1. Climate change reshapes availability
2. Fishers adapt in two distinct ways
3. Adaptation depends on fleet structure
4. Models can predict short-run responses

Thank you!

Questions?

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