

## Introduction

- Purse-seine fisheries targeting small pelagic species are highly important in Portugal.
- The target are sardine (*Sardina pilchardus*) and chub-mackerel (*Scomber colias*), but also anchovy (*Engraulis encrasicolus*), and horse-mackerel (*Trachurus trachurus*).
- Catch  $\neq$  landings due to slipping (release of unwanted live fish at sea) and discards.
- Slipping creates uncertainty in total removals, often ignored in stock assessments.
- Understanding slipping rates and survival is essential for accurate and sustainable fisheries management.

## Objectives

- Quantify slipping rates for sardine and chub-mackerel
- Estimate post-release survival of slipped fish
- Evaluate implications for stock assessment and fisheries management



## Material and Methods

### Observer-based dataset

- 454 fishing trips
- 556 fishing sets
- Period: 2005-2019
- Portugal mainland coast in 3 different areas - NW, SW and South
- Data collected included:
  - species composition of landings and slipping (number and weight)

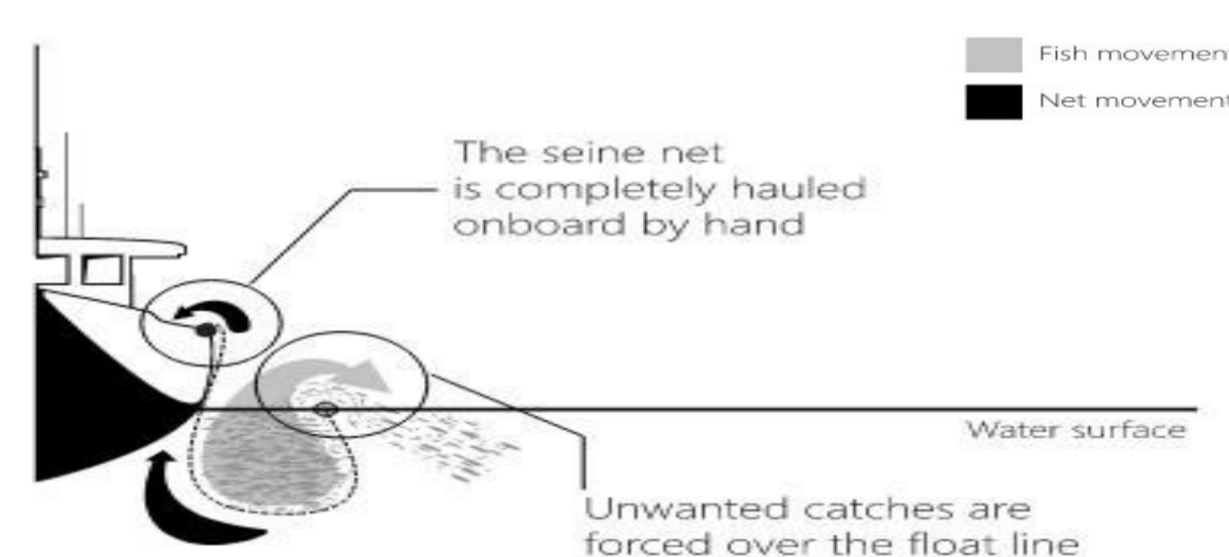


Diagram 1: illustrating the slipping method (Marçalo et al. 2018).

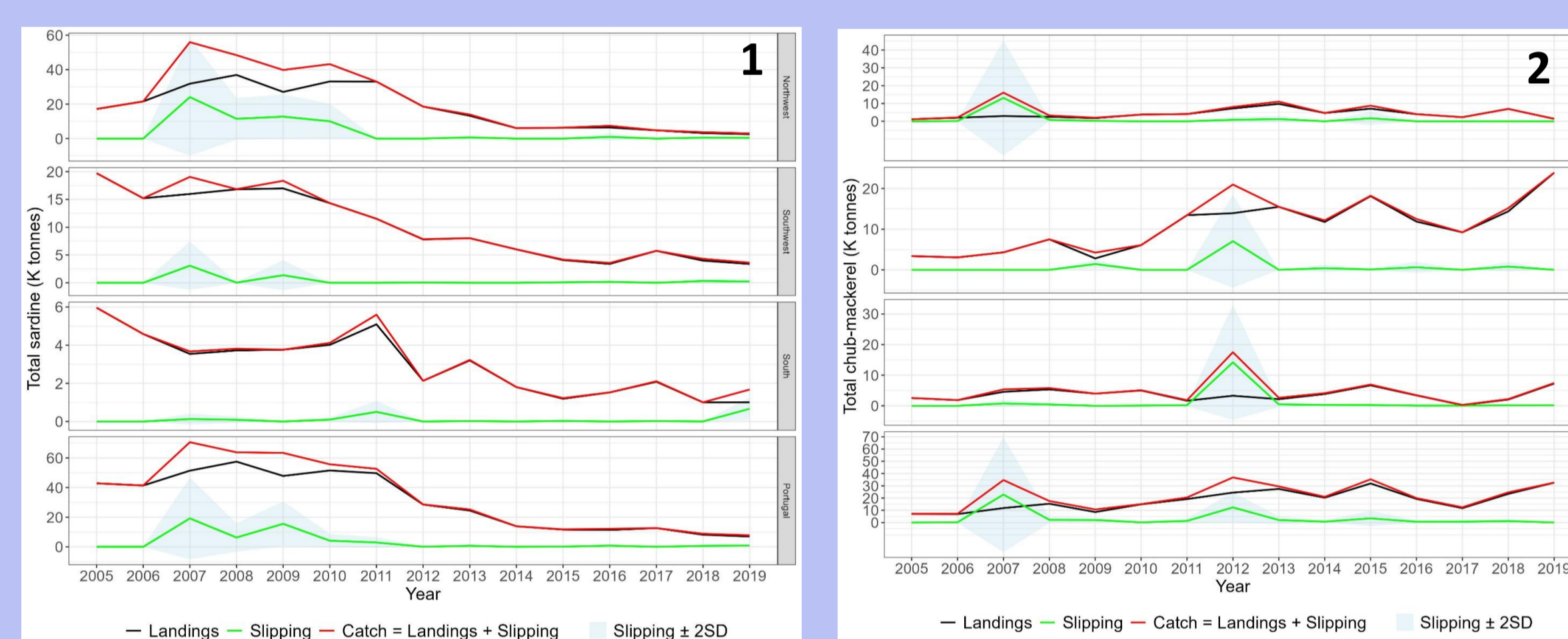
### Data analysis

- Slipping estimation for sardine and chub-mackerel:
  - Cochran's ratio estimator (1977)
  - Zero-inflated process
- Survival rates derived from several experimental studies in Portugal (Dias et al. 2022; Feijó et al. in press; Marçalo et al., 2008, 2010, 2013, 2018, 2019):
  - average, minimum and maximum (100%)

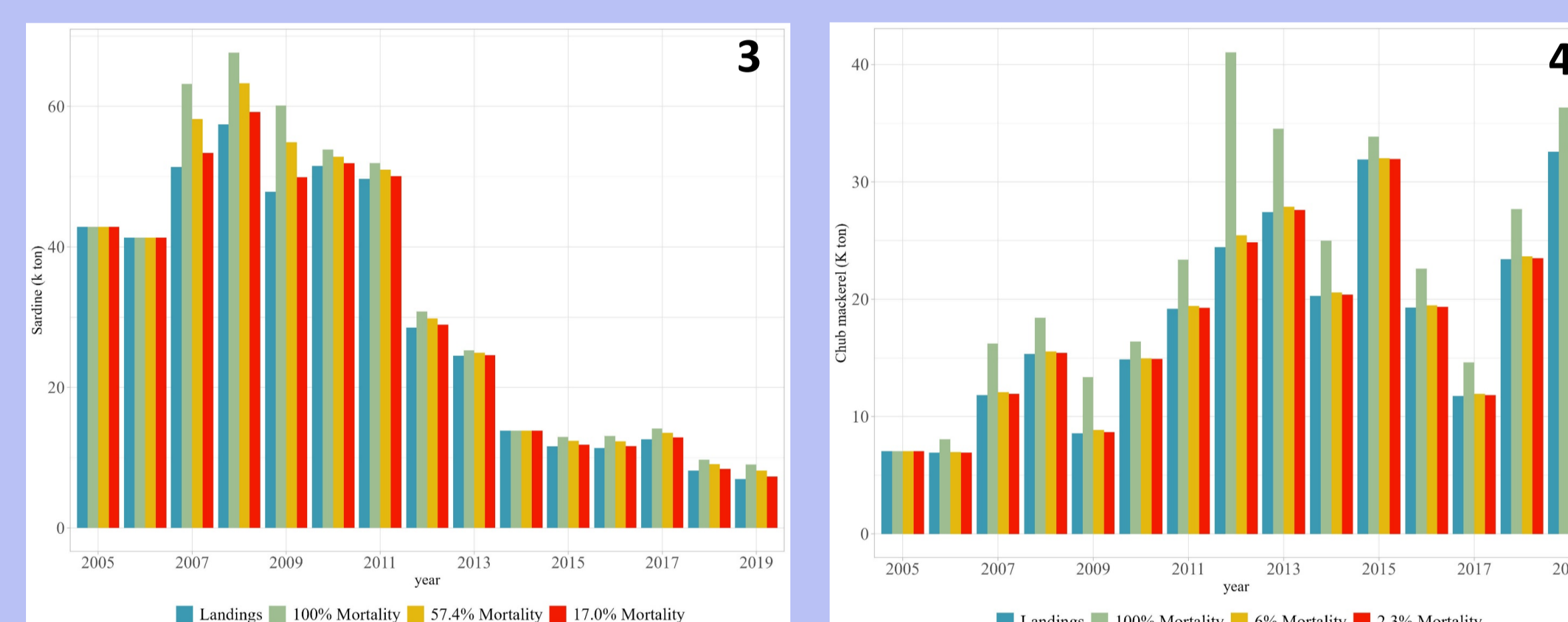
All calculations were performed using R version 4.5.2 (2025).

## Results

Slipping occurred in approximately 20% of fishing trips, indicating a zero-inflated process.



Figures 1 and 2: Sardine (1) and chub-mackerel (2) annual landings and Cochran's estimated total slipping (thousand ton), with associated uncertainty ( $\pm$  2SD), by area over the period 2005–2019.



Figures 3 and 4: Sardine (3) and chub-mackerel (4) landings (blue bars) and estimated total catches under different mortality scenarios for slipped fish for maximum (green bars), mean (yellow bars) and minimum (red bars) values (literature-based).

Post-release survival significantly alters estimates of total catch and fishing mortality.

Slipping rates showed high variability across time and space, with coefficients of variation (CV) up to:

- **Sardine:** 0.43 - 1.48
- **Chub-mackerel:** 0.35 - 1.22

Estimated slipping ranges of total catch:

- **Sardine:** 0.06 - 75%
- **Chub-mackerel:** 0.004 - 444%

Survival differed markedly between species (literature-based):

- **Sardine:** 5 - 88 % survival  $\rightarrow$  generally high mortality (6 studies)
- **Chub-mackerel:** 94 - 98 % survival  $\rightarrow$  low mortality (1 study)

Applying mortality scenarios showed that:

- overestimates fishing mortality, assuming 100% mortality
- Including survival leads to lower and more realistic catch estimates

## Discussion

- **Slipping is a significant, with high uncertainty driven by variability, zero-inflation, and low sampling coverage.**
- **Species-specific survival matters:**
  - sardine = high sensitivity
  - chub-mackerel = high resilience
- **Stock assessments may be biased if slipping is not accounted for.** Including slipping requires avoiding the assumption of 100% mortality of released individuals.

## Management Implications

- Incorporating survival into stock assessments can:
  - Improve estimates of **fishing mortality**
  - Reduce bias in **catch data**
  - Support more accurate **TAC/quota decisions**
- Potential management strategies:
  - Shift from **daily to weekly landing quotas**
  - Improve **shoal identification and selectivity**
  - Promote **better use of catches and reduce unnecessary slipping**

## Conclusions

Slipping creates a significant gap between catch and landings. Ignoring slipping and survival leads to biased stock assessments.

Species-specific survival must be explicitly included in models. More studies and different approaches should be done.

This work provides a framework to integrate slipping into fisheries assessment and management. Particularly important for the Iberian sardine, certified by the Marine Stewardship Council (MSC).