# Analysis of Mean Weight by Age for Commercial Fleet and Acoustic Surveys with Linear Mixed-Effects Models: Observations and Estimations from 1989 to 2024

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Fish body weight is essential for converting modeled numbers-at-age into metrics such as total catch biomass or a biomass-based abundance index (Methot and Wetzel, 2013). Stock Synthesis (SS3) uses a file called "wtatage.ss" to incorporate empirical weight-at-age observations (SS3, Methot *et al.*, 2024). For anchovy in the Gulf of Cádiz, mean weight by age data is available from the commercial fleet (*SEINE*, Figure ) and three acoustic surveys (*PELAGO*, *ECOCADIZ*, and *ECOCADIZ-RECLUTAS*, Figure ). Out-of-range values were removed based on specific criteria:

* Weights below 15 grams for ages 2 and 3.
* Age 0 individuals were removed in quarters 1 and 2.
* Weights less than or equal to 2 grams across all quarters.
* Weights above 40 grams were discarded.
* Weights below 20 grams for age 3 in quarter 4.

This procedure was applied to each dataset prior to merging them into a single unified dataset (Taylor *et al.*, 2014). Missing values were removed, and weight was transformed using the natural logarithm. For each quarter and each subset, a linear mixed model was fitted, with log-transformed weight as the dependent variable and age as the fixed effect. A random effect for year was incorporated to capture interannual variability. Estimated datasets were generated for combinations of year (1989–2024) and age (0–3), and log-transformed weight estimates were calculated accordingly. Figure presents a comparison between observed and predicted values for each quarter. These mixed models account for both fixed and random variability in the data. Nonlinear mixed-effects models were implemented using the nlme R package, version 3.1-164 (Lindstrom and Bates, 1990; Pinheiro and Bates, 1996; Pinheiro and Bates, 2002).

The mean weights estimate from the linear mixed-effects model were used to populate the "wtatage.ss" file, which requires mean weight data for ages 0 to 3, covering the period 1989-2023. These weights were specified for both the beginning and mid-point of each quarter and are used for all data sets included in the model.

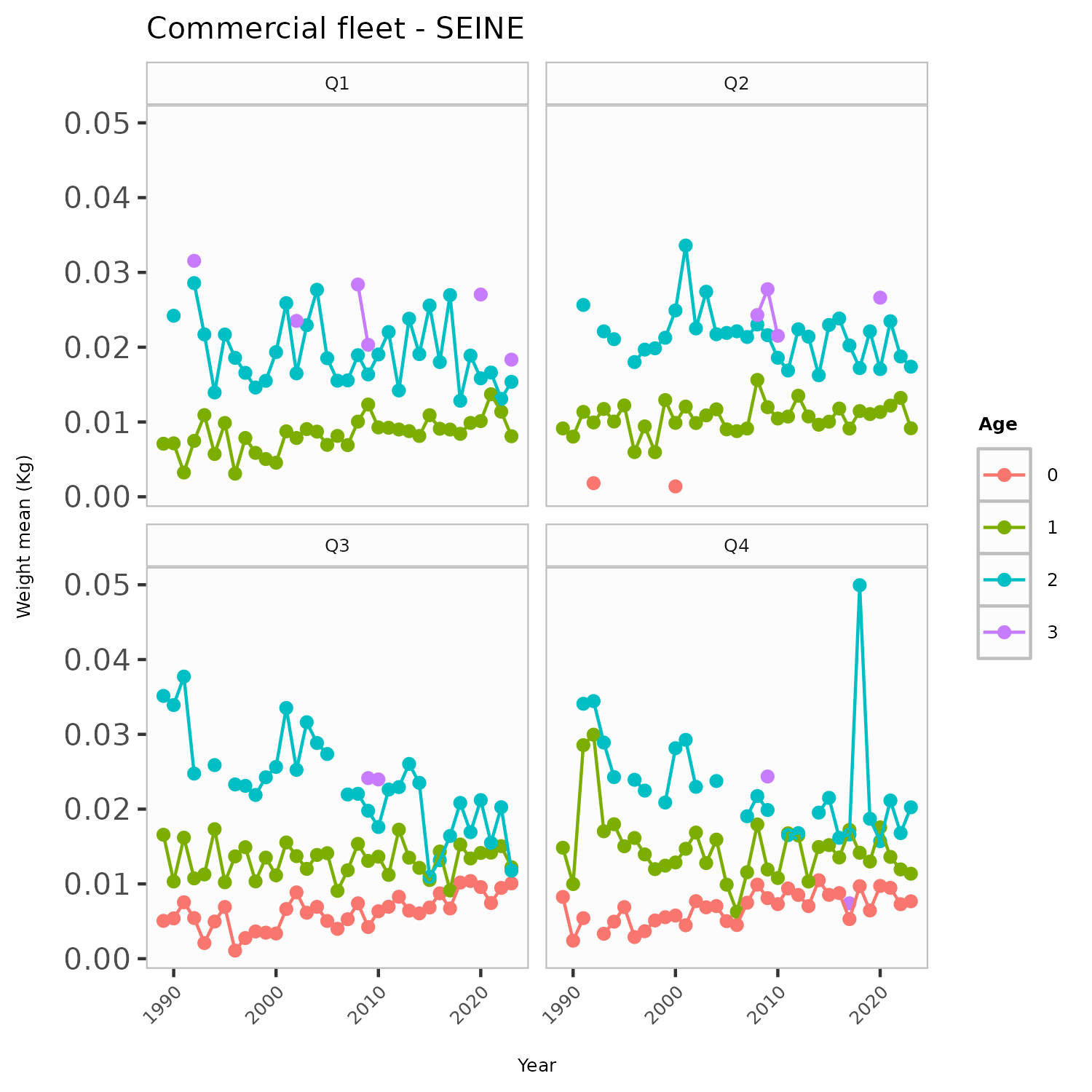


Figure .: ane.27.9a stock. Observed mean weights (in kilograms) for commercial fleet (*SEINE*) by age group (0 to 3 years) for four quarters (Q1, Q2, Q3, Q4) over the period 1989 to 2024.

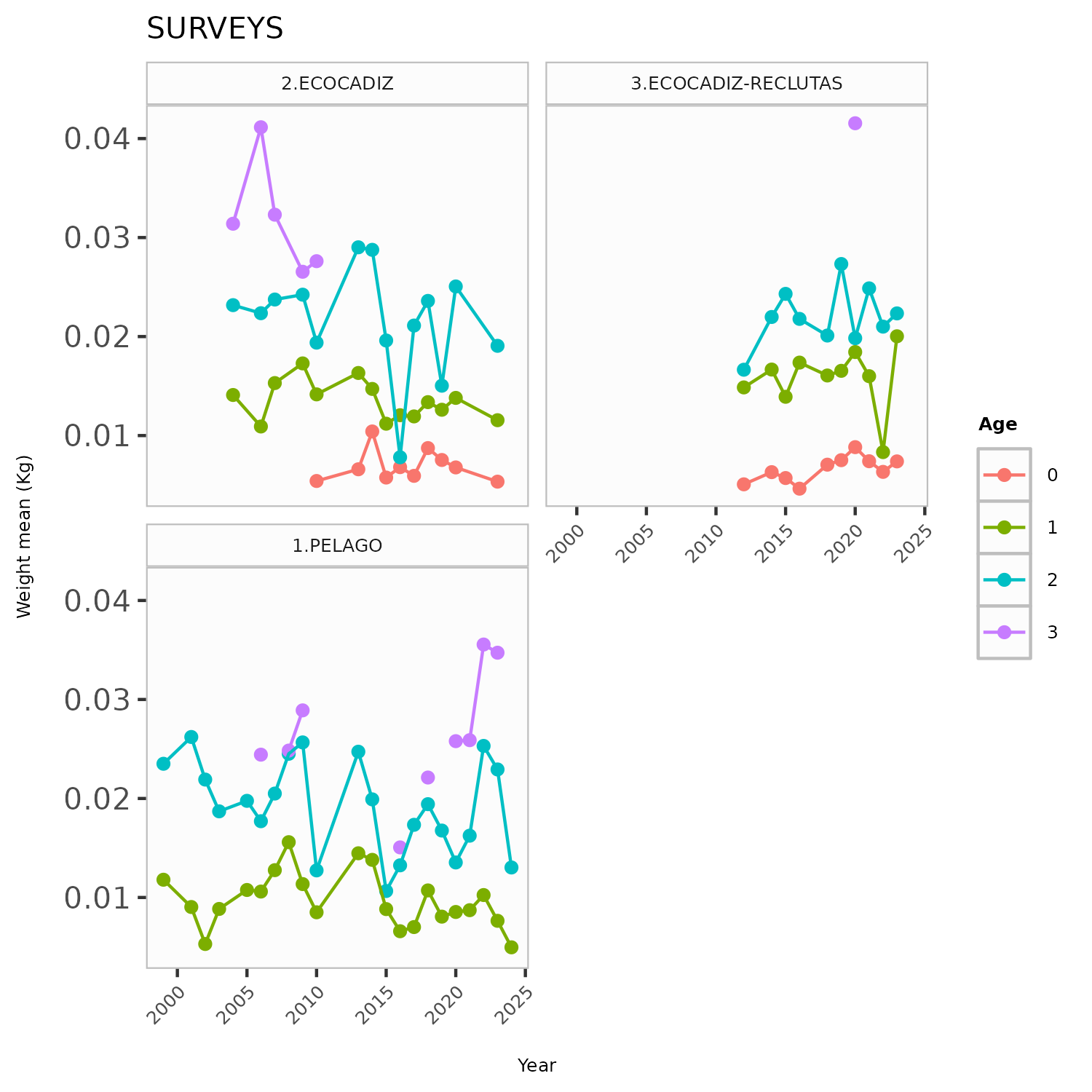


Figure .: ane.27.9a stock. Observed mean weights (in kilograms) for acoustic surveys (*PELAGO*, *ECOCADIZ* and *ECOCADIZ-RECLUTAS*) by age group (0 to 3 years).

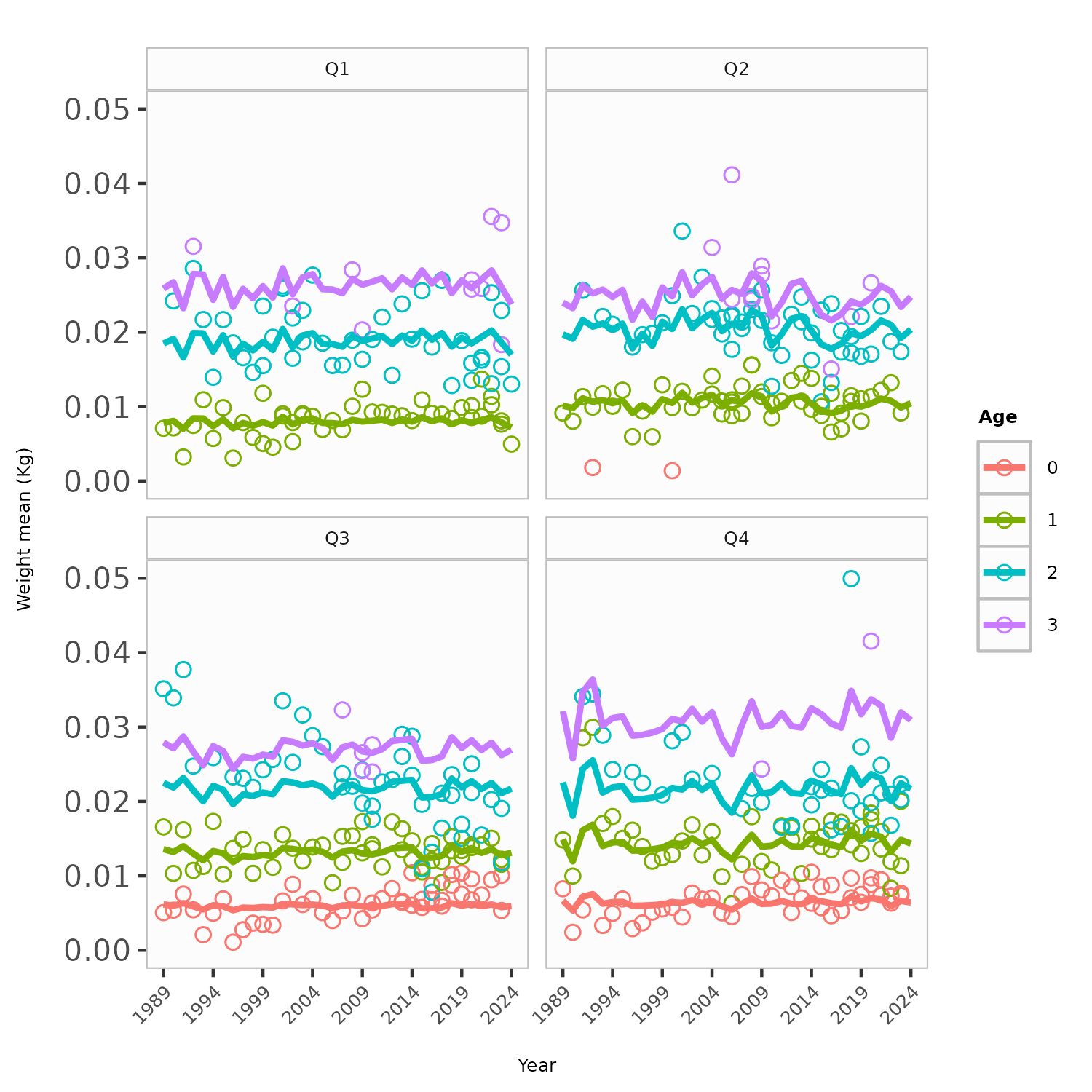


Figure .: ane.27.9a stock. Observed and predicted mean weights (in kilograms) by age group (0 to 3 years) for four quarters (Q1, Q2, Q3, Q4) over the period 1989 to 2024. Circles represent observed data points, while solid lines indicate estimates from the linear mixed-effects model. Each panel corresponds to a specific quarter. Data were obtained from the commercial fleet (SEINE) and acoustic surveys (*PELAGO*, *ECOCADIZ*, and *ECOCADIZ-RECLUTAS*).

# Referencias

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