Jack mackerel abundance index in the northern zone based on spatiotemporal modelling of acoustic density (NASC). Updated to 2026

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May, 2026

Payá, 2026

BACKGROUND

Acoustic biomass estimates primarily depend on:

- Sampling design (transects)
- **Acoustic density or Nautical Area Scattering Coefficient (NASC, m^2/nmi^2)**
- Size structures (catches)
- Target Strength relationship
- Estimation model (bootstrap, geostatistical, etc)

BACKGROUND

- Number on hauls to get the biological sampling in the first part of the time series is considered low (about 25).
- The number of hauls has increased (about 35) in the last years.
- What is the trend in an index based on the acoustic density (NASC)?
- How does a NASC-based index compare with acoustic biomass estimates?

OBJECTIVE

Estimate an acoustic density (NASC) index using spatiotemporal models with sdmTMB

METHOD

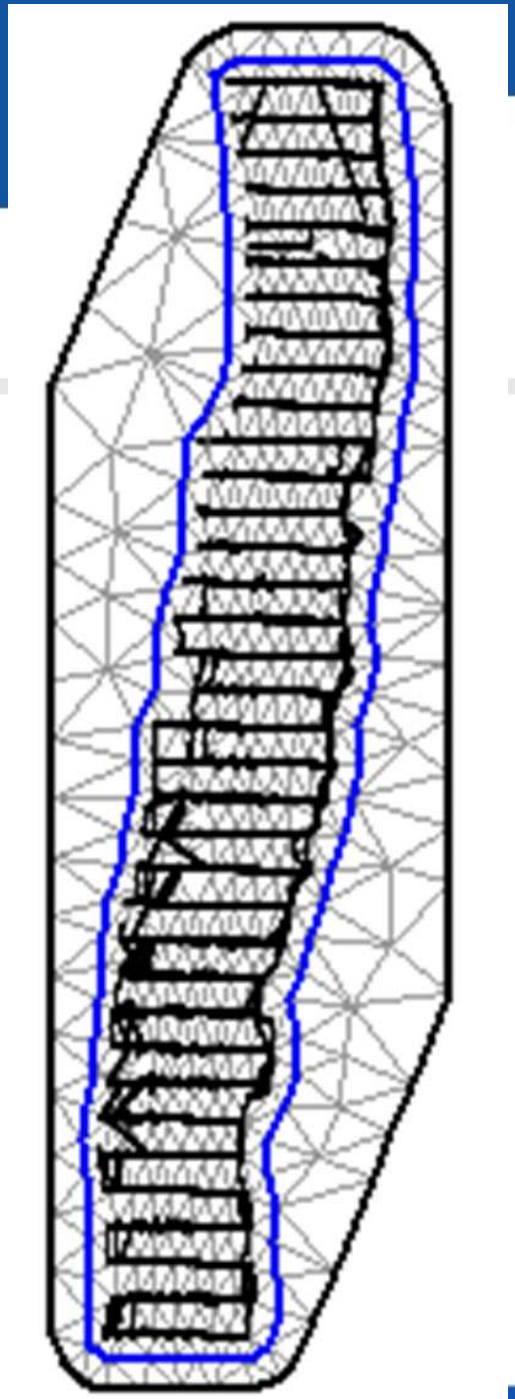
- The sdmTMB package, which allows for the implementation of spatial geostatistics and spatiotemporal generalized linear mixed models (Anderson et al. 2022), **using TMB** to fit the model and **INLA** to establish the SPDE (Stochastic Partial Differential Equation).

METHOD

- Estimation mesh

Mesh used with estimates restricted to the interior of the blue polygon.

Data up to 2024.



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METHOD

Model 1. Effect of temperature (SST) with spatial covariance and isotropy.

```
fit1 <- sdmTMB(  JM_Sa ~ s(ST) ,   data = cjmST,   family = tweedie(link =
          "log"),   mesh = mesh,  spatial = "on")
```

Model 2. Effect of Salinity (Sal) with spatial covariance and anisotropy.

```
fit2 <- sdmTMB(  JM_Sa ~ s(Sal),   data = cjmST,   family = tweedie(link =
          "log"),   mesh = mesh,  spatial = "on",  anisotropy = TRUE)
```

Model 3. Effect of oxygen concentration (Oxg) with spatial covariance and anisotropy.

```
fit3 <- sdmTMB(  JM_Sa ~ s(Oxg),   data = cjmST,   family = tweedie(link =
          "log"),   mesh = mesh,  spatial = "on",  anisotropy = TRUE)
```

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METHOD

Model 4. Effect of oxygen concentration (Oxg) with first-order autoregressive (ar1) spatiotemporal covariance and anisotropy.

```
fit4 <- sdmTMB(  JM_Sa ~ s(Oxg), data = cjmST, mesh = mesh, time = "Year",
                 family = tweedie(link = "log"), spatial = "off", spatiotemporal = "ar1",
                 extra_time = c(2022), anisotropy = TRUE )
```

Model 5. Fixed effect of year and oxygen concentration (Oxg), with first-order autoregressive (ar1) spatiotemporal covariance and anisotropy.

```
fit5 <- sdmTMB( data = cjmST, formula = JM_Sa ~ 0 + as.factor(Year) + s(Oxg),
                time = "Year",   mesh = mesh_6,   family = tweedie(link = "log"),
                spatiotemporal = "ar1",   extra_time = c(2022),   anisotropy = TRUE)
```

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METHOD

Update using data up to 2026

Preliminary Model 5

2026 Acoustic survey

without Oxigen

Model 5. Fixed effect of year ~~and oxygen concentration (Oxg)~~, with first-order autoregressive (ar1) spatiotemporal covariance and anisotropy.

fit5 <- sdmTMB(data = cjmST, formula = JM_Sa ~ 0 + as.factor(Year) **~~+ s(Oxg),~~** time = "Year", mesh = mesh_6, family = tweedie(link = "log"), **spatiotemporal = "ar1",** extra_time = c(2022), anisotropy = TRUE)

METHOD

2026 Acoustic Biomass estimated using NASC index

Step 1: Regression between Acoustic biomass and NASC index using data up to 2025.

Step 2: Acoustic Biomass 2026 estimated from regression and the 2026 NASC index

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RESULTS

BEST MODEL with data up to 2024

Model 5. Fixed effect of year and oxygen concentration (Oxg), with first-order autoregressive (ar1) spatiotemporal covariance and anisotropy.

Modelo	Código	df	AIC
Modelo 1	fit1	7	117209.2
Modelo 2	fit2	9	117195.1
Modelo 3	fit3	9	116995.2
Modelo 4	fit4	10	109135.0
Modelo 5	**fit5**	**24**	**109107.6**

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RESULTS

Model 5. Fixed effect of year and oxygen concentration (Oxg), with first-order autoregressive (ar1) spatiotemporal covariance and anisotropy.

fit5 <- sdmTMB(data = cjmST, formula = JM_Sa ~ 0 + as.factor(Year) + **s(Oxg),** time = "Year", mesh = mesh_6, family = tweedie(link = "log"), spatiotemporal = "ar1", extra_time = c(2022), anisotropy = TRUE)

$$g(\mu_{s,t)}) = \mathrm{X}_{s,\mathrm{t}}^{\mathrm{main}}\beta + S(Oxg) + \delta_{s,t}$$

$$\delta_{t=1} \sim MVNormal(0, \Sigma_\epsilon),$$

$$\delta_{t>1} \sim \rho\delta_{t-1} + \sqrt{1-\rho^2}\epsilon_t,$$

$$\epsilon \sim MVNormal(0, \Sigma_\epsilon)$$

Donde: $\mathrm{X}_{s,\mathrm{t}}^{\mathrm{main}}$ corresponde a la matriz de diseño del efecto principal fijo año, β es el vector de los coeficientes del efecto fijo; $\epsilon_{s,t}$ son campos aleatorios espaciotemporales

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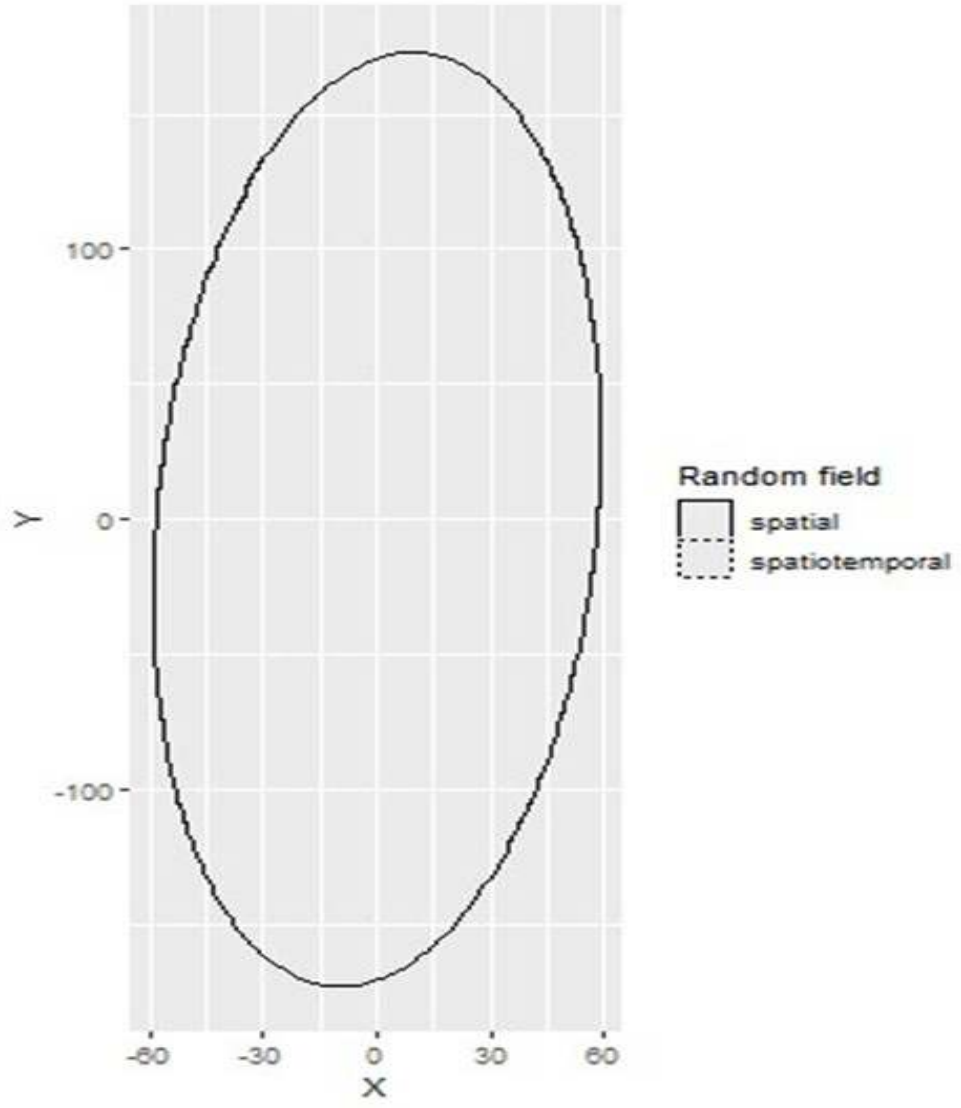
RESULTS

Anisotropy of model 5.



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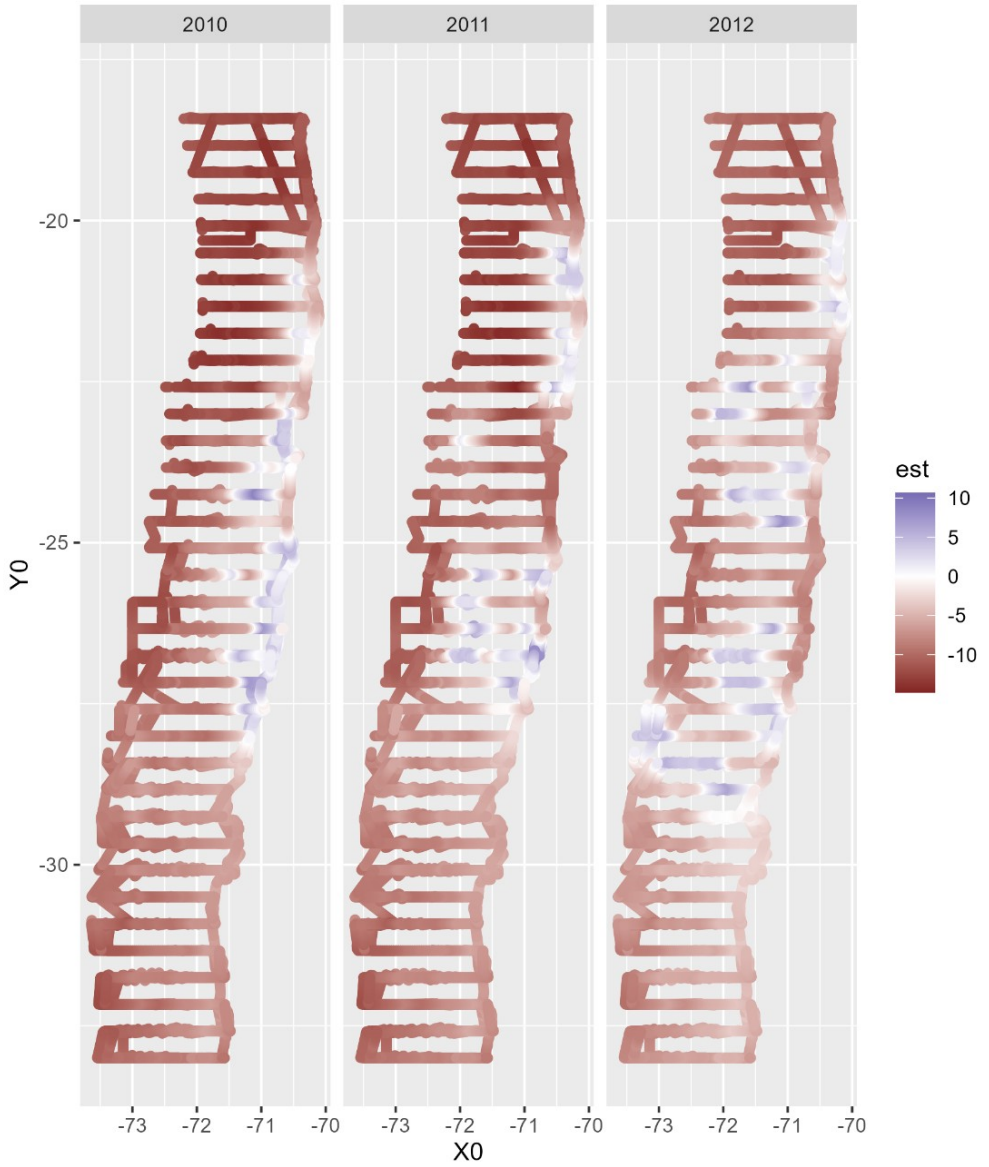
RESULTS



Estimates including fixed effects and all random errors.

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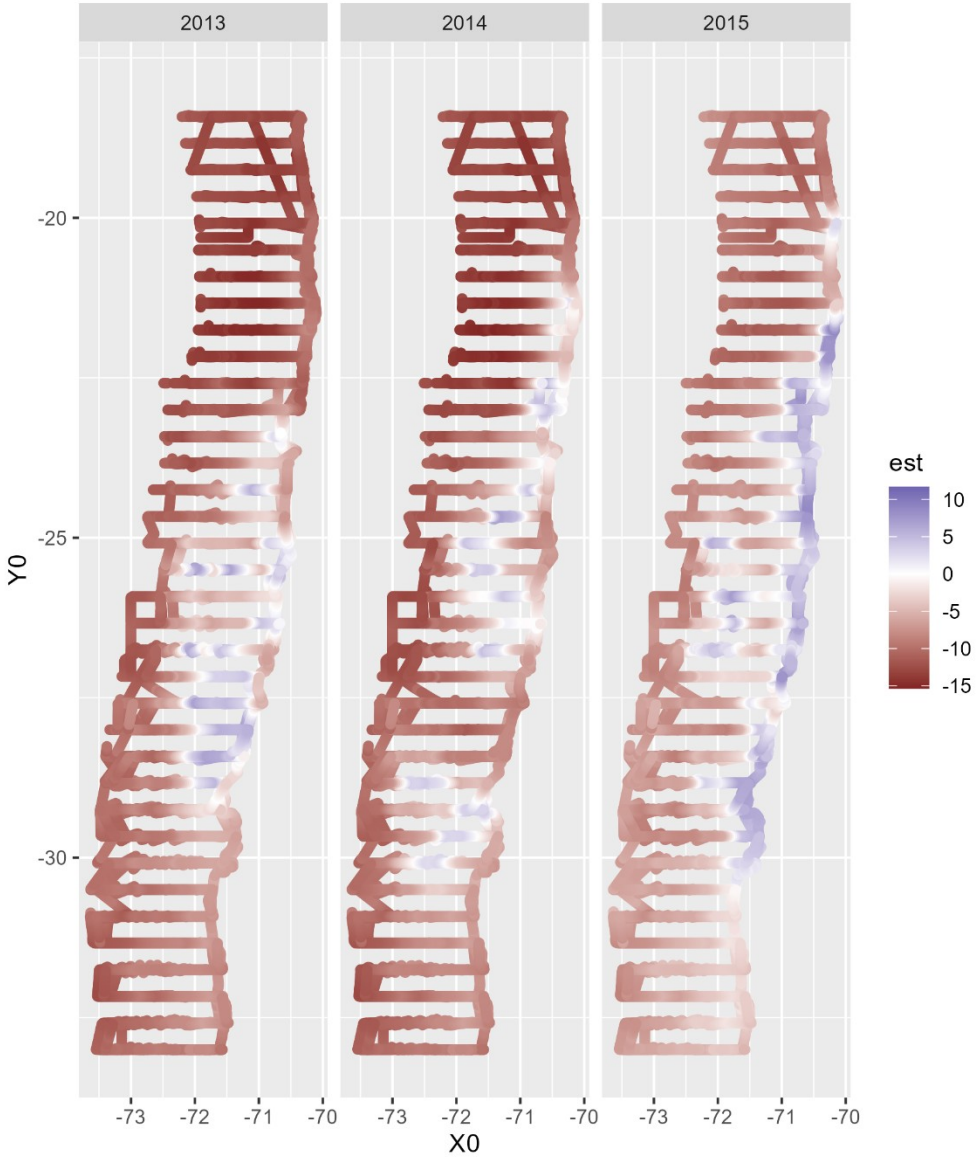
RESULTS



Estimates including fixed effects and all random errors.

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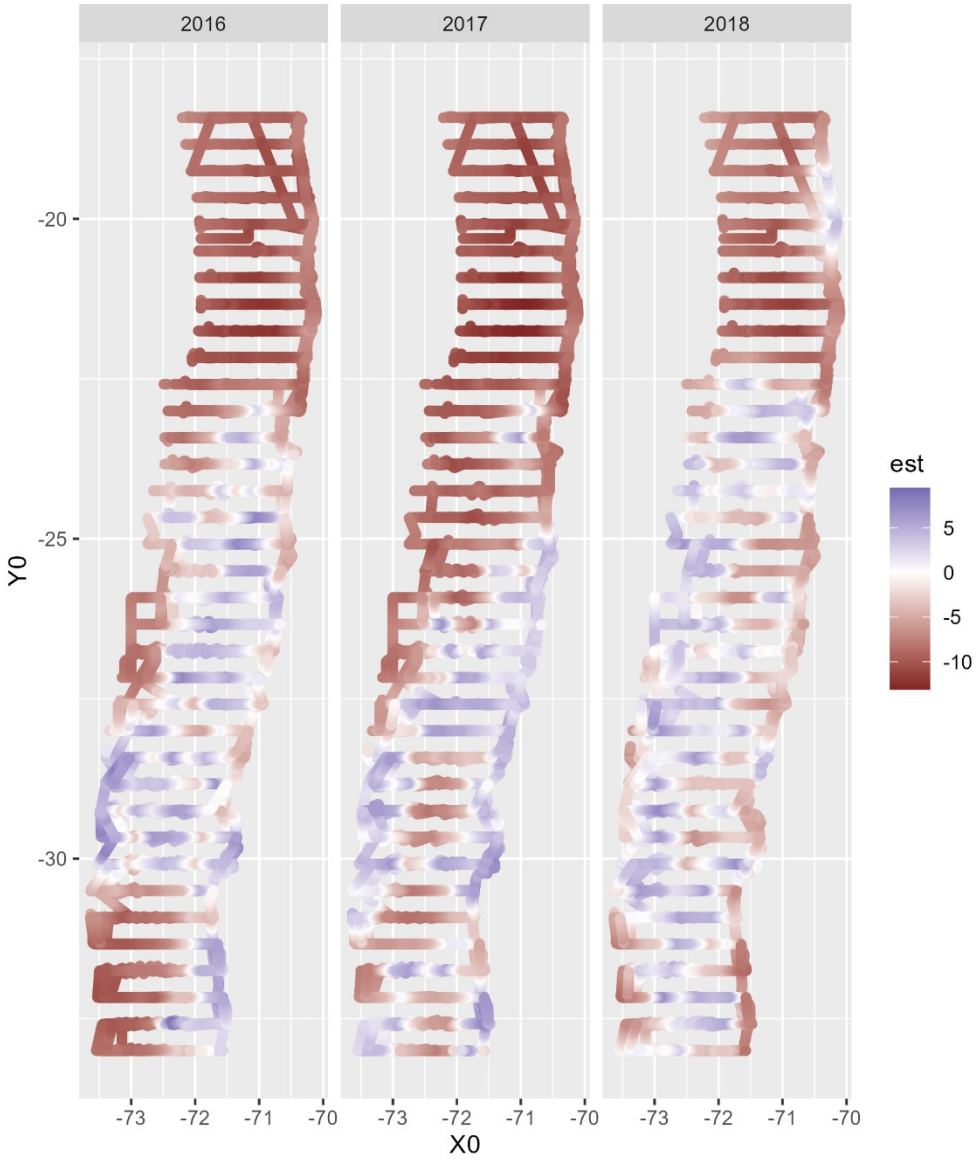
RESULTS



Estimates including fixed effects and all random errors.

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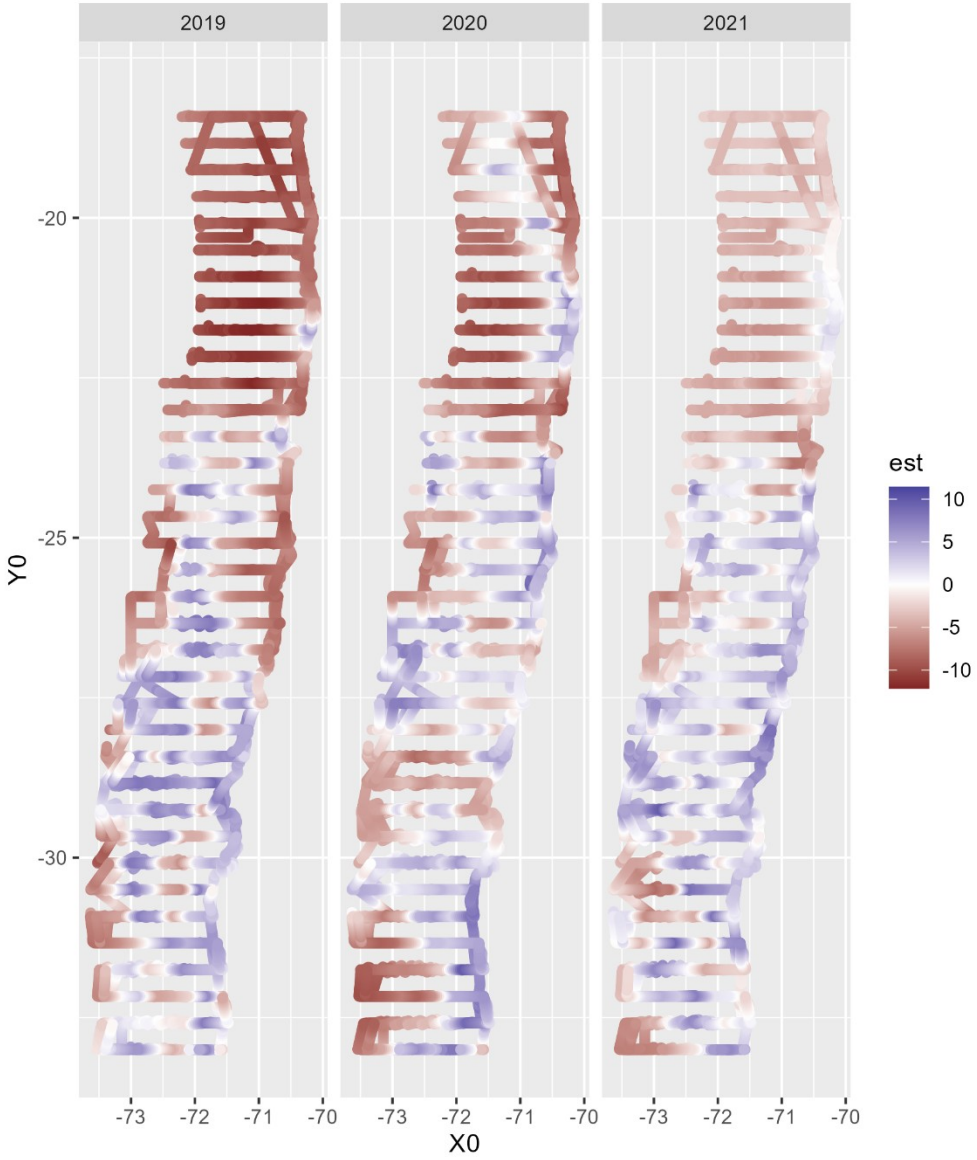
RESULTS



Estimates including fixed effects and all random errors.

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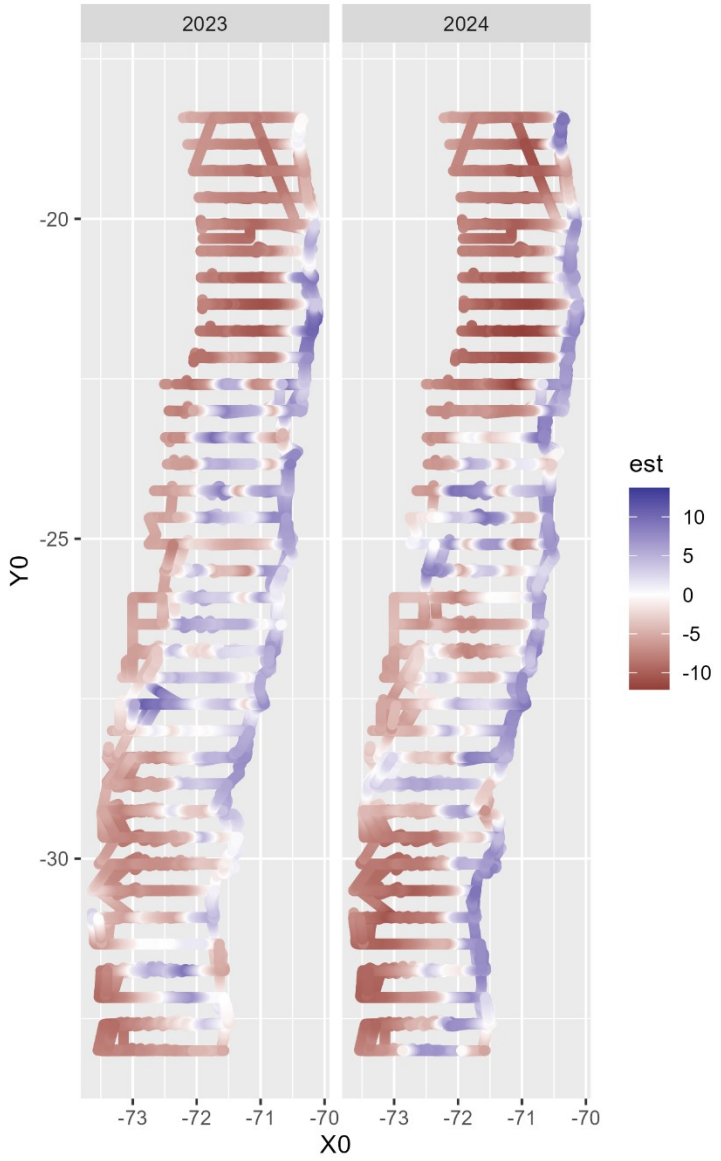
RESULTS



Estimates including fixed effects and all random errors.

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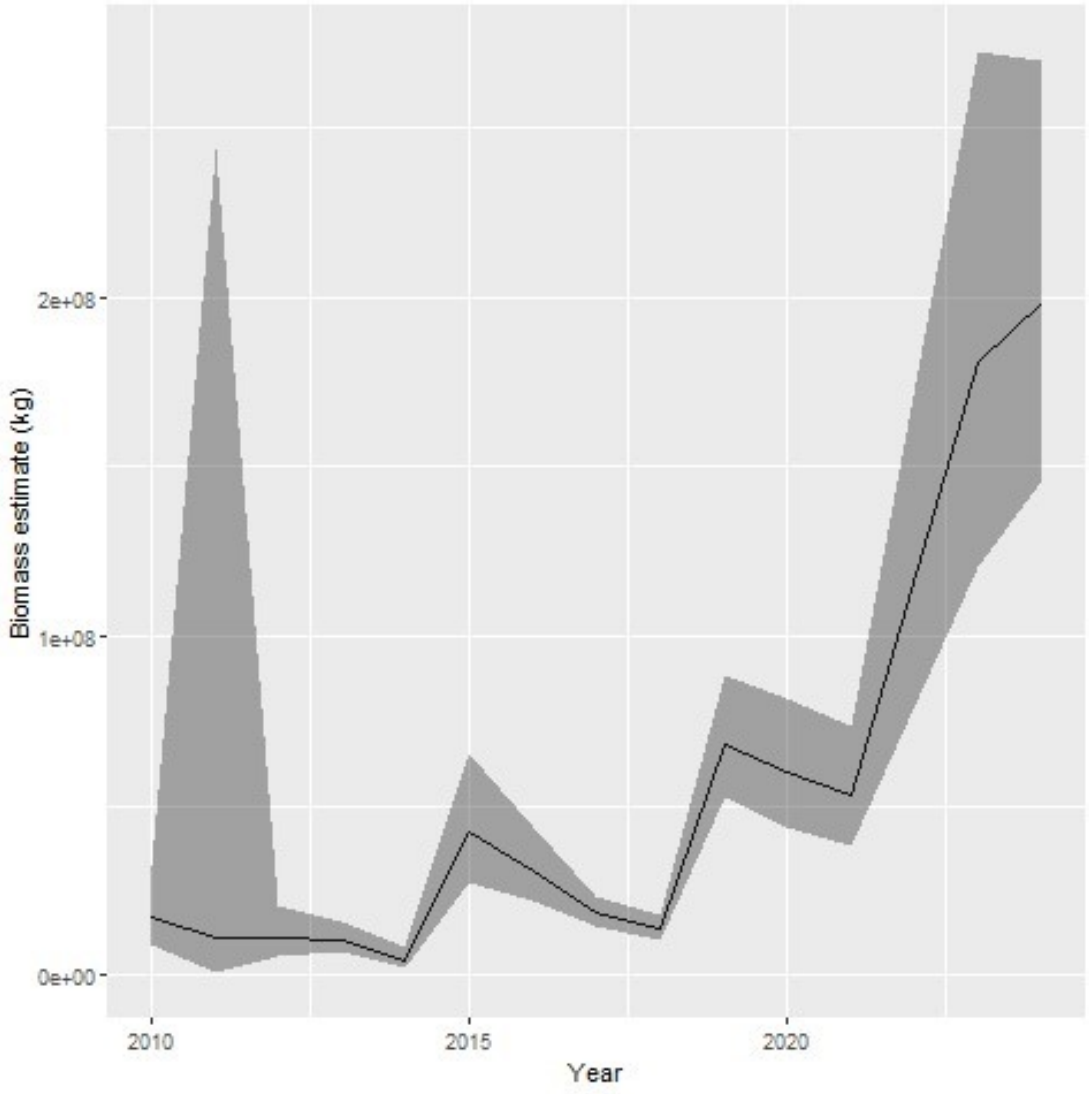
RESULTS



Abundance index based on NASC only.

Model 5 fitted using data up to 2024

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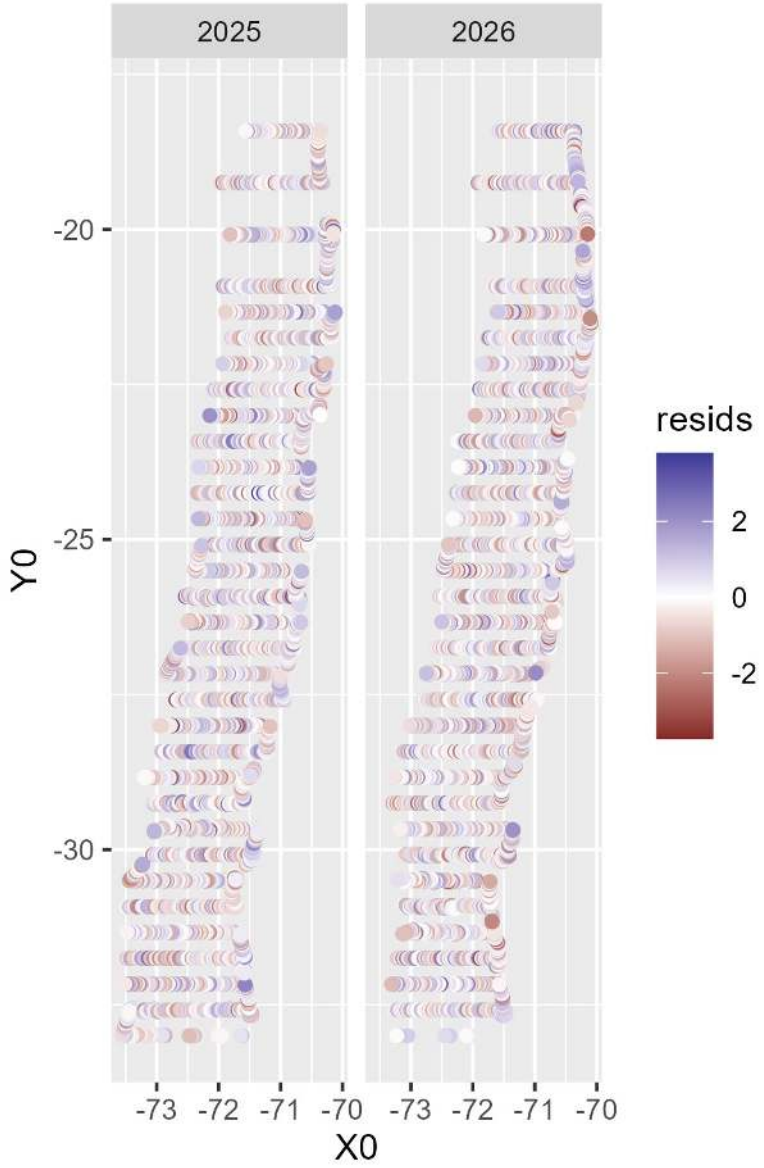
RESULTS



UPDATED with data up to 2026

RESIDS

Abundance index based on NASC only.

Preliminary Model 5 fitted to data up to 2026, excluding oxygen

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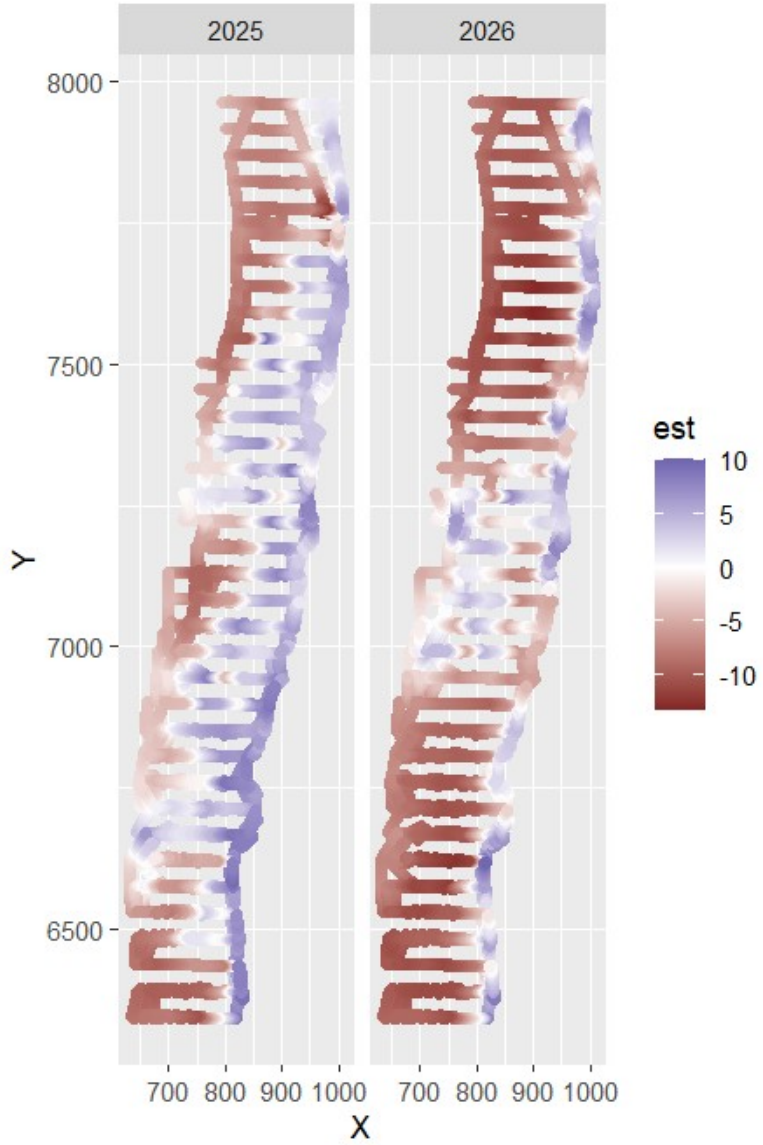
RESULTS



Update up to 2026

Estimates including fixed effects and all random errors.

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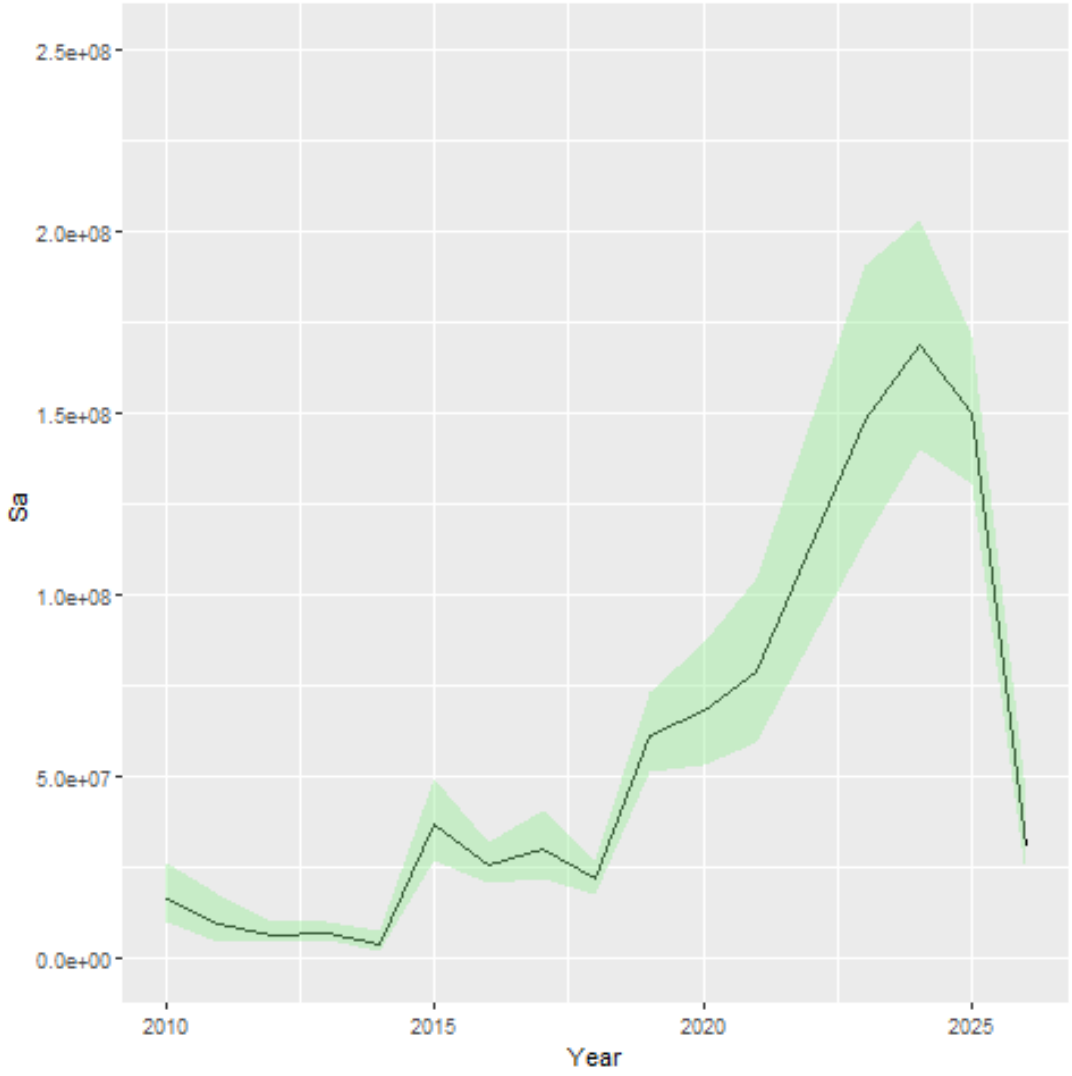
RESULTS



UPDATED with data up to 2026

Abundance index based on NASC only.

Preliminary Model 5 fitted to data up to 2026, excluding oxygen

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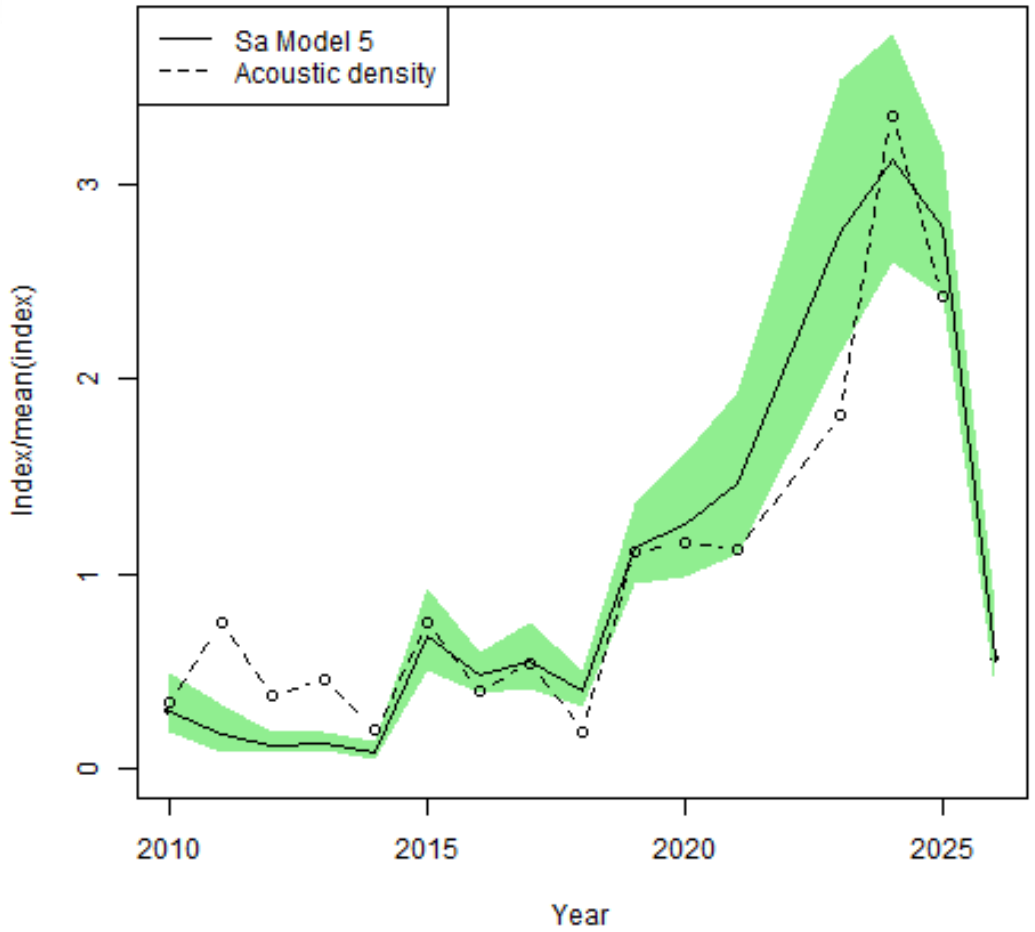
DISCUSSION



NASC index of preliminary model 5 and estimated **density estimated by acoustics.**

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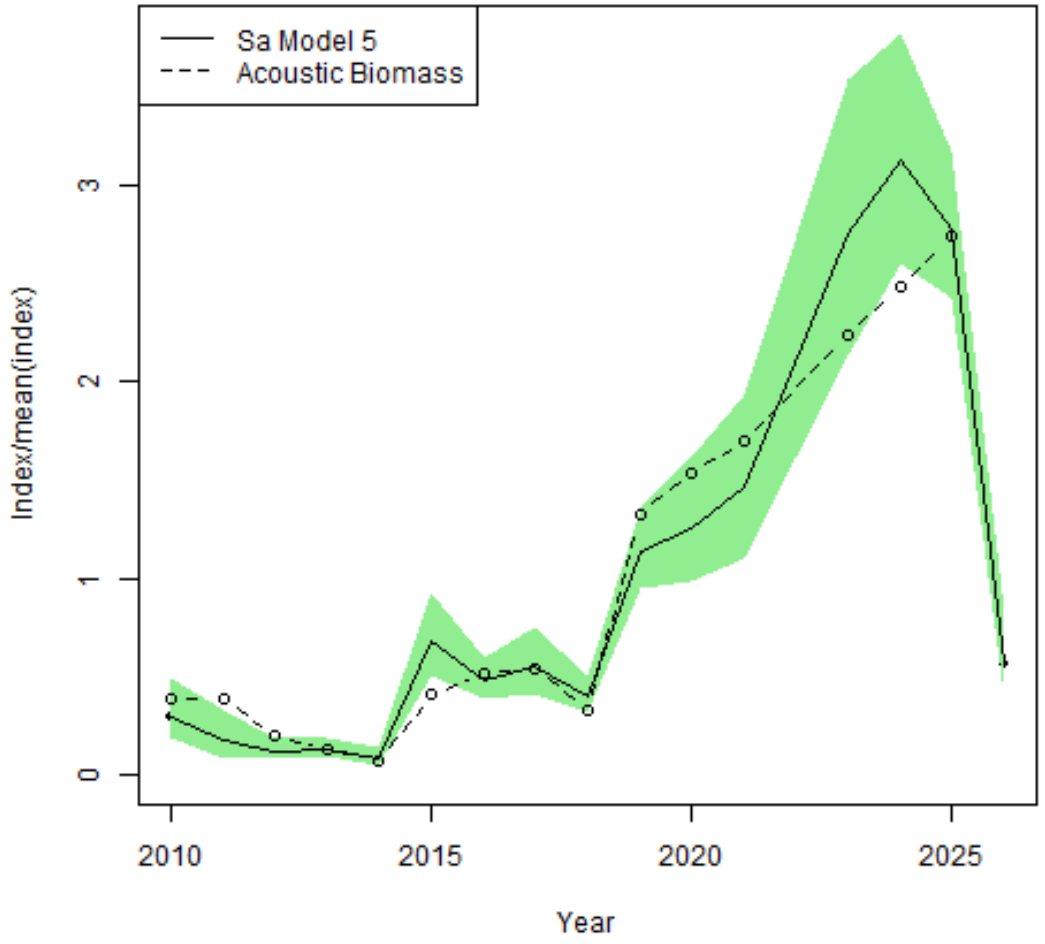
DISCUSSION



- NASC index of preliminary model 5 and Acoustic **biomass estimated by traditional geostatistic.**

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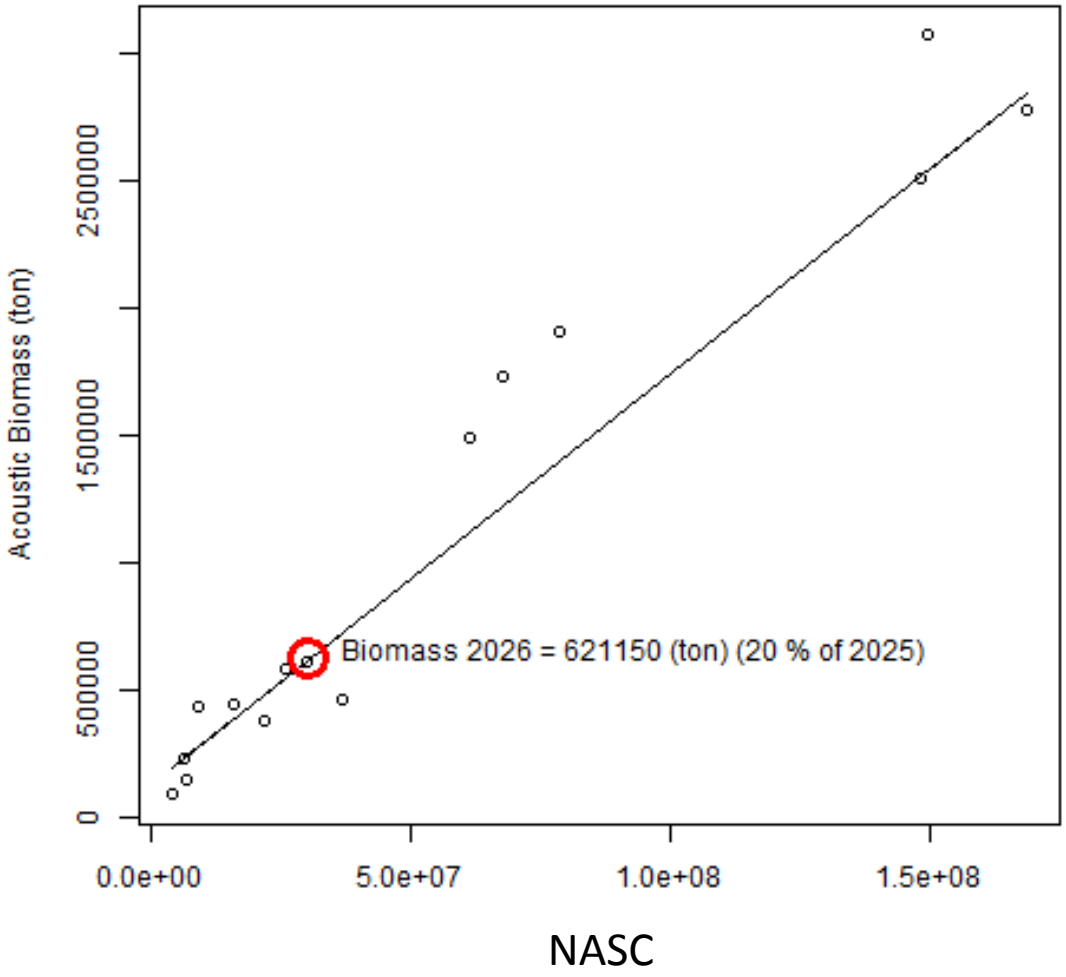
DISCUSSION



Acoustic Biomass 2026 estimated using NASC index and Acoustic biomass linear relationship

621150 t

(20% of 2025)

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CONCLUSIONS

- The NASC index remained low from 2010 to 2018, and then increased sharply until 2024-2025, and finally in decreased in 2026.

- The trend of the NASC index was **similar** to the trend of the **biomass** (ton) estimated by the hydroacoustic method.

- This is noteworthy, as these series are not completely comparable; while the NASC index is the pure acoustic signal, the biomass in tons results from the combination of the NASC, biological information, and the length-target strength relationship.

- From the NASC spatiotemporal model, the acoustic biomass can be estimated for 2026: 621,150 ton

- Acoustic Biomass 2026 estimated from NASC-Biomass Regression (621,150 ton) was very similar to the full updated Acoustic biomass (642,382 ton).

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End

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