Species Distribution Modelling in the Southern Ocean in the context of marine spatial and conservation planning

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Background

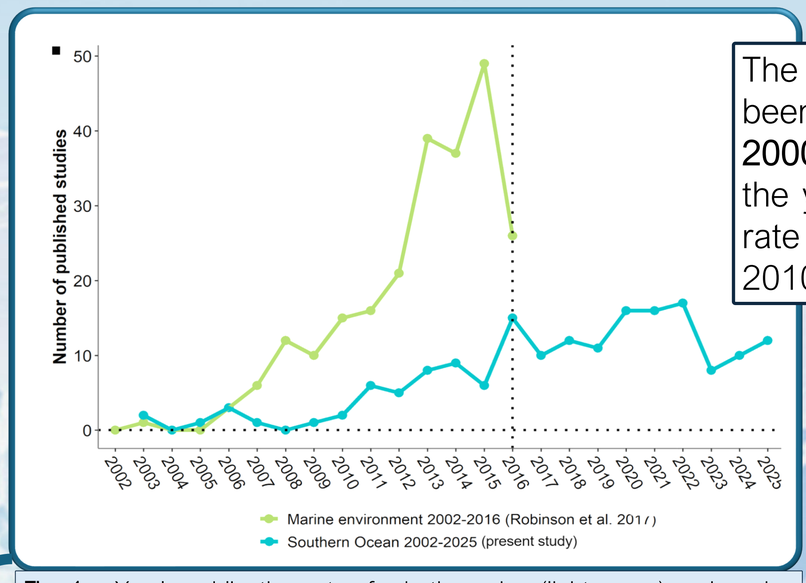
The **Southern Ocean** (SO) hosts **unique** and **vulnerable** ecosystems that play a **crucial role** in **global marine food webs**. Over the last **few decades**, this region has been under growing attention due to **increased pressures** from **climate change** and **fisheries**. **Species Distribution Models** (SDMs) have become **central tools** for ecological researchers, especially in the SO where **biodiversity data** is **sparse** in both space and time.

This work provides an **in-depth review of 25 years** of Southern Ocean SDMs (SO-SDM) research on **species' current and future distributions** and aims to act as a **keystone resource** to address the need for **evidence-based decision making** in the **Antarctic region**.

From a curated list of **171 research articles**, we evaluate **research trends** regarding modelling frameworks, algorithms and **taxonomic priorities**. We further review whether and how authors have **integrated climate change projections** and evaluate **how human uses** of the ocean and **protected areas** are **incorporated into SDM** analyses and subsequent discussions.

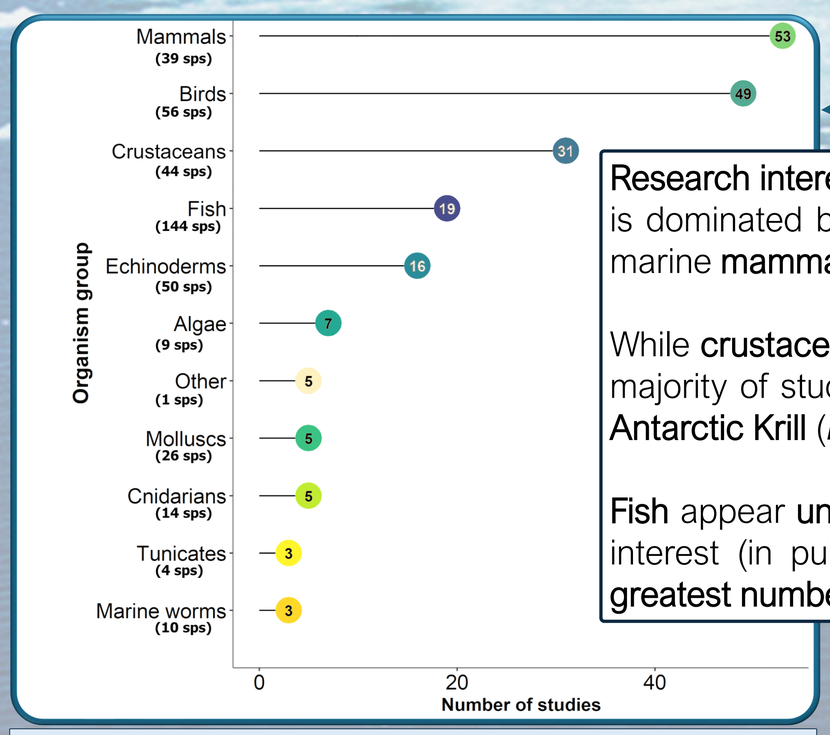
Based on this systematic review, we aim to **highlight critical opportunities** to **strengthen the utility of SDMs** in **delivering sound, readily available information** to support decision-making and to contribute to **sustainably managing both biodiversity and human activities** in a rapidly **changing Southern Ocean**.

Research trends and taxonomic interest



The application of SO-SDMs has been **rising steadily** since the **early 2000s**, constituting up to a **fifth** of the yearly marine SDM publication rate by the second half of the 2010s.

Fig. 1 – Yearly publication rates for both marine (light green) and marine Southern Ocean (light blue) Species Distribution Models, between 2000-2025.



Research interest (number of publications) is dominated by **charismatic groups** (e.g., marine **mammals** and **seabirds**).

While **crustaceans** rank 3rd place, the vast majority of studies (n = 22) are related to **Antarctic Krill** (*Euphausia superba*).

Fish appear **underrepresented** in research interest (in publications) but present the **greatest number of studied species**.

Fig. 2 – Number of SO-SDMs (2000-2025) published across 11 different organism groups (number of studied species within brackets).

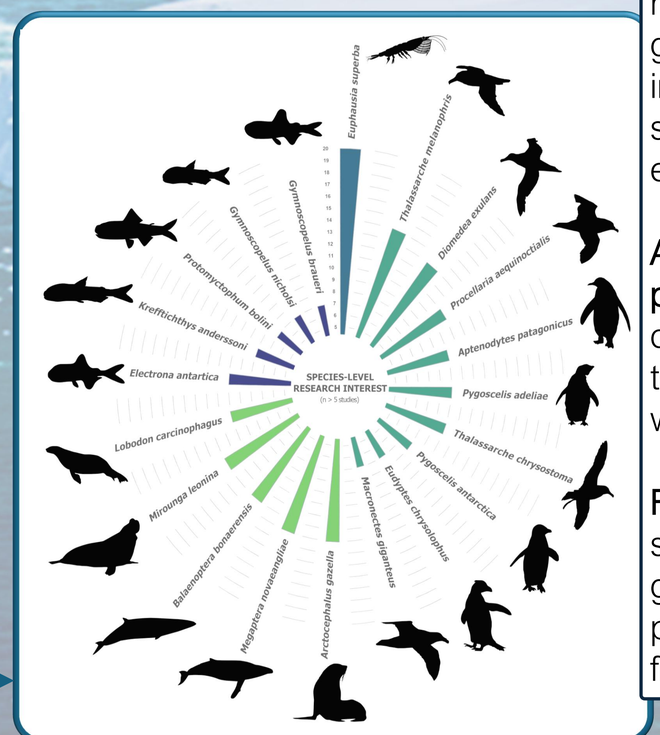


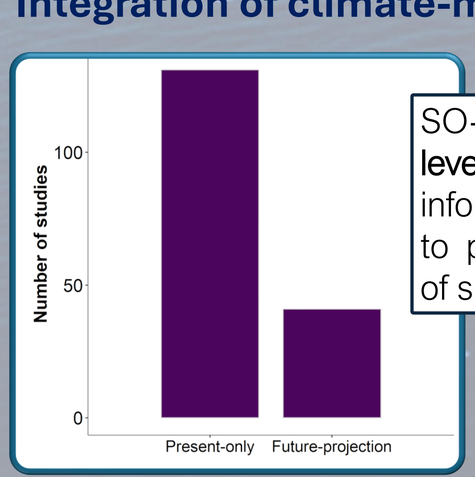
Fig. 3 – Top 20 of the most studied species in SO-SDMs (2000-2025).

Antarctic Krill (*E. superba*) is the most studied species across all groups, highlighting its great importance as a keystone species in Southern Ocean ecosystems.

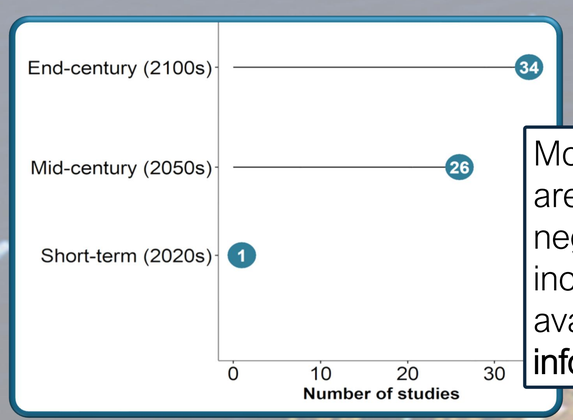
Albatrosses, **penguins**, and **pinnipeds** permeate the ranking – charismatic species with a key top-down role in SO-marine food webs.

Fish (in general) remain poorly studied, evidencing a knowledge gap regarding this key meso-predator group with important fished-species.

Integration of climate-model information



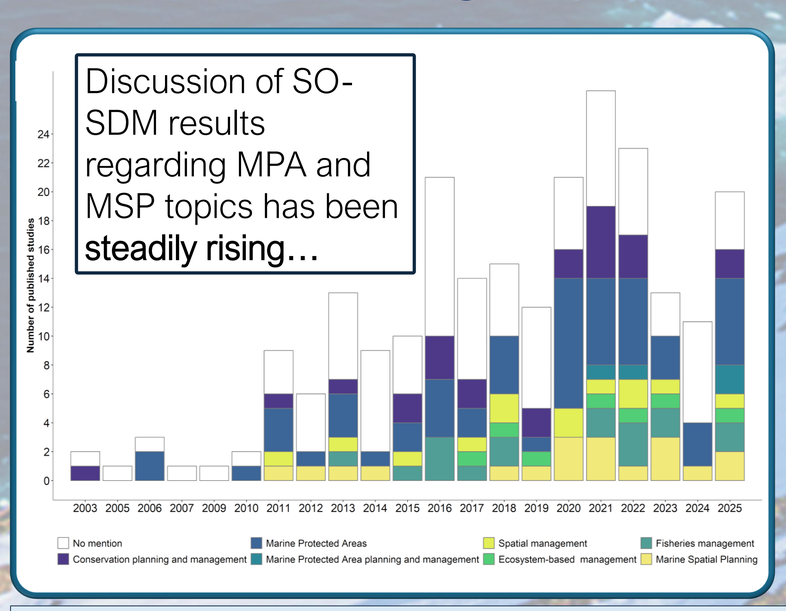
SO-SDMs still **lack adequate levels** of **climate-model** information being integrated to produce **future projections** of species distributions.



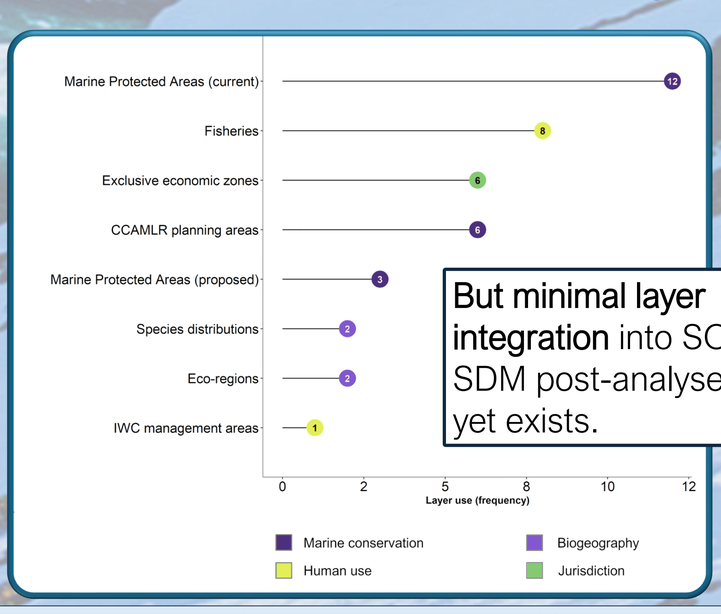
Most future projections are **mid- to end-century**, neglecting the incorporation of already-available **decadal climate information**.

Fig. 4 – (top) Number of studies producing present-day and future-day projections; (bottom) number of studies per future time-frame.

How do SO-SDMs integrate MPA- and MSP-related considerations and layers?



Discussion of SO-SDM results regarding MPA and MSP topics has been **steadily rising…**



But minimal layer **integration** into SO-SDM post-analyses yet exists.

Fig. 5 – (left) MPA- and MSP-related considerations in SO-SDMs (2000-2025); (right) MPA- and MSP-related layers included in SO-SDMs (2000-2025).

Project information

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