Revisiting the use of species distribution modelling in the Southern Ocean to support sustainable ocean planning and conservation

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Marine Protected Areas | Marine Spatial Planning

Background

The **Southern Ocean** (SO) hosts key species assemblages and ecosystems that are **relevant globally,** both for the **biosphere** and **climate** systems.

The SO is under great risk from changing environmental conditions, associated with **human-induced climate change**, and under **severe and rising pressure** from human uses (e.g., fisheries, tourism).

Sustainable management of human uses in the SO requires knowledge about species' current and future distributions, which can be estimated using **Species Distribution Models** (SDM)

The present systematic revision, developed under ERC project PLAnT, assesses how SDMs have been employed across the SO, focusing on **how many** studies pertaining to marine species have been published so far, **what taxa** and organism groups have been the most studied, and where do they stand in terms of extinction risk.

Methodological approaches and projection across future **timeframes** and **scenarios** are quantified.

Finally, how (and if) studies have incorporated considerations on **marine protected area (MPA)** planning and **marine spatial planning (MSP)** is briefly explored.

Methods

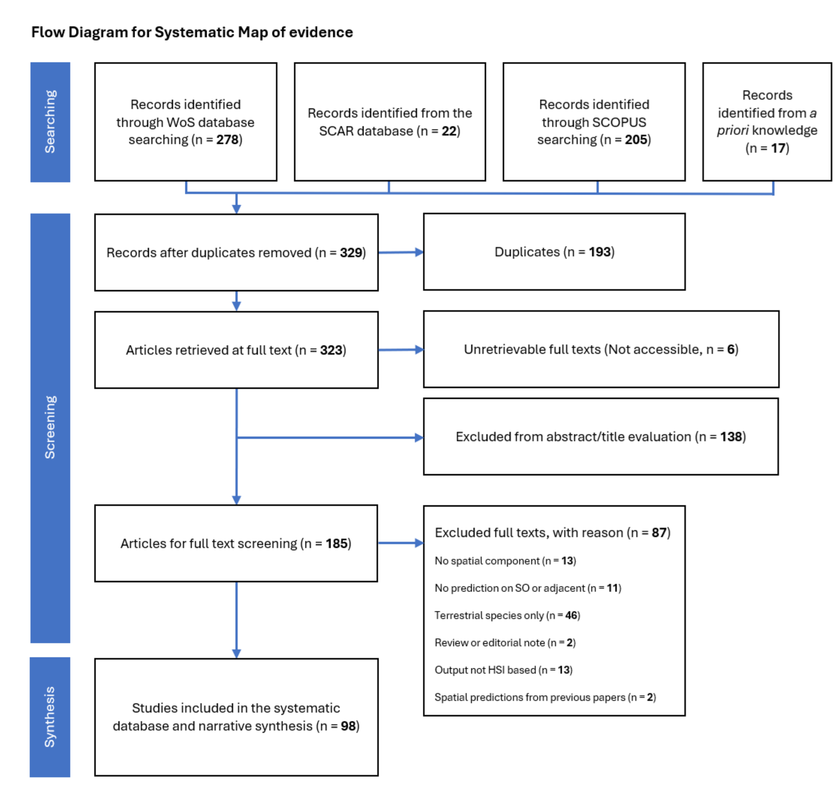
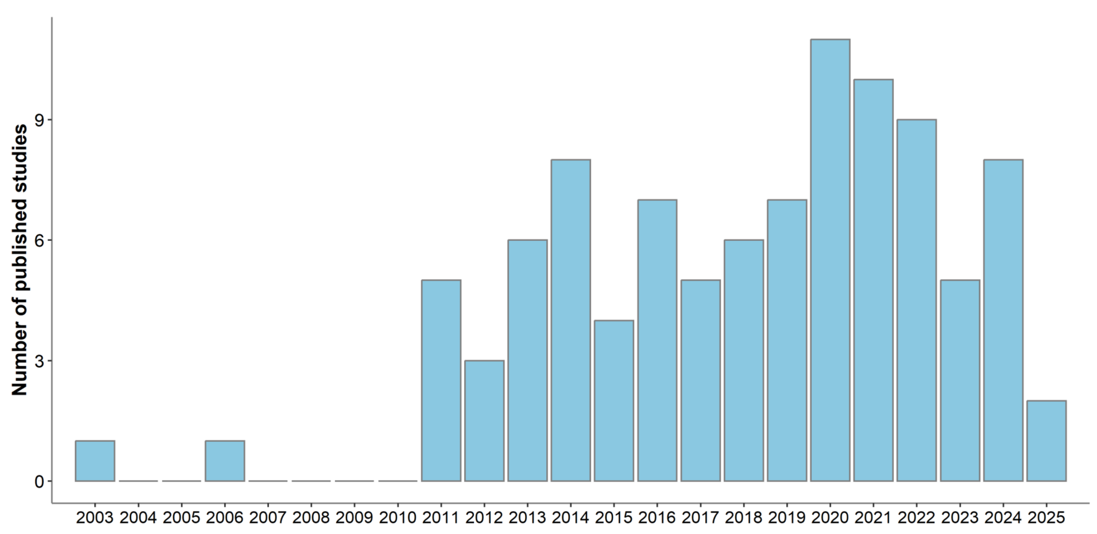


Diagram for systematic **map of evidence** for the literature survey and database curation. Briefly, **SDM studies on the SO** published between **1990** and February **2025** were collected.

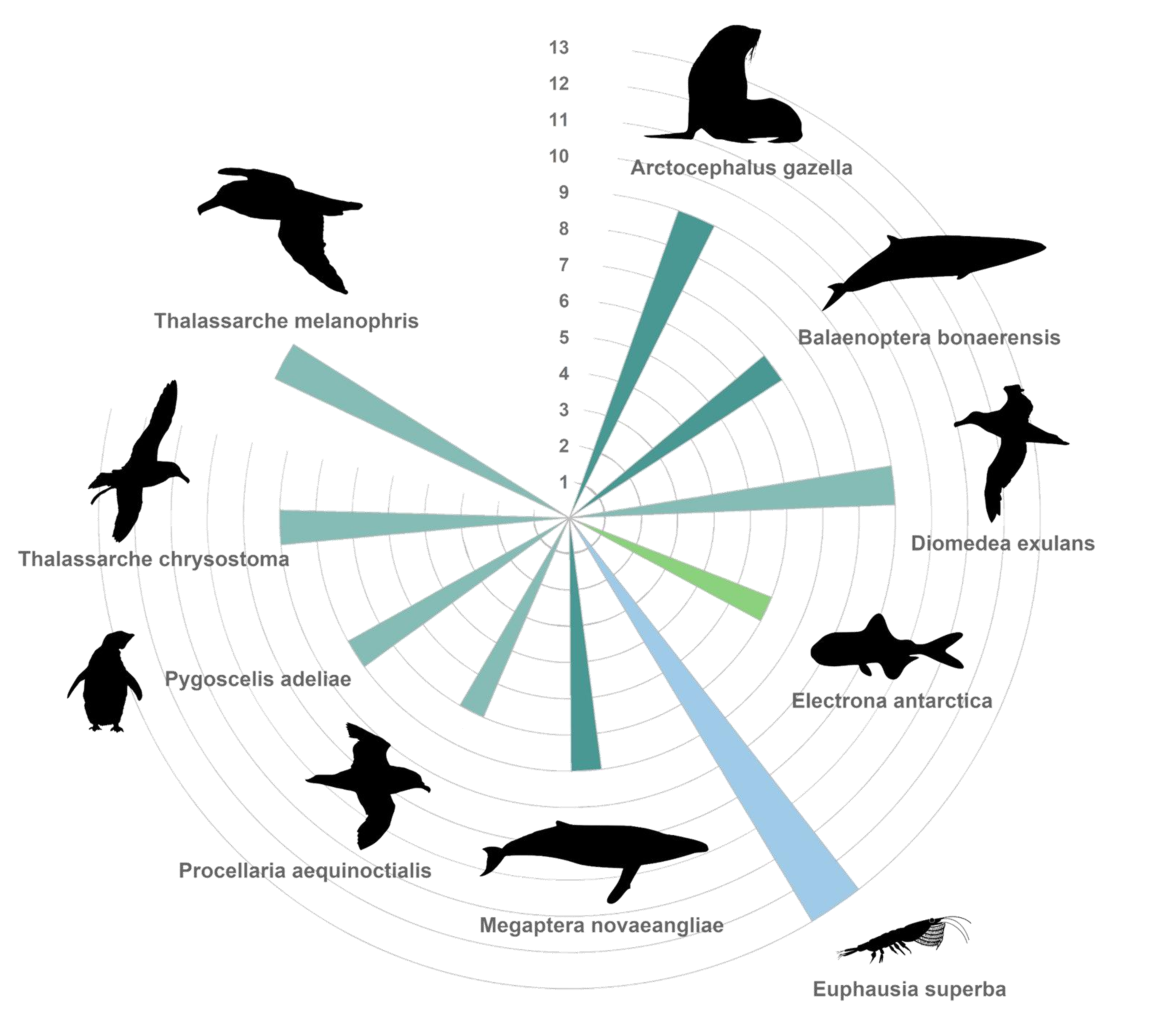
Publication trends for Species Distribution Models (SDMs) performed on the Southern Ocean (SO)

- SO-SDM production gained momentum in the 2010s.
- Constitute approximately a fifth of the yearly marine-SDM production (~6 per year)



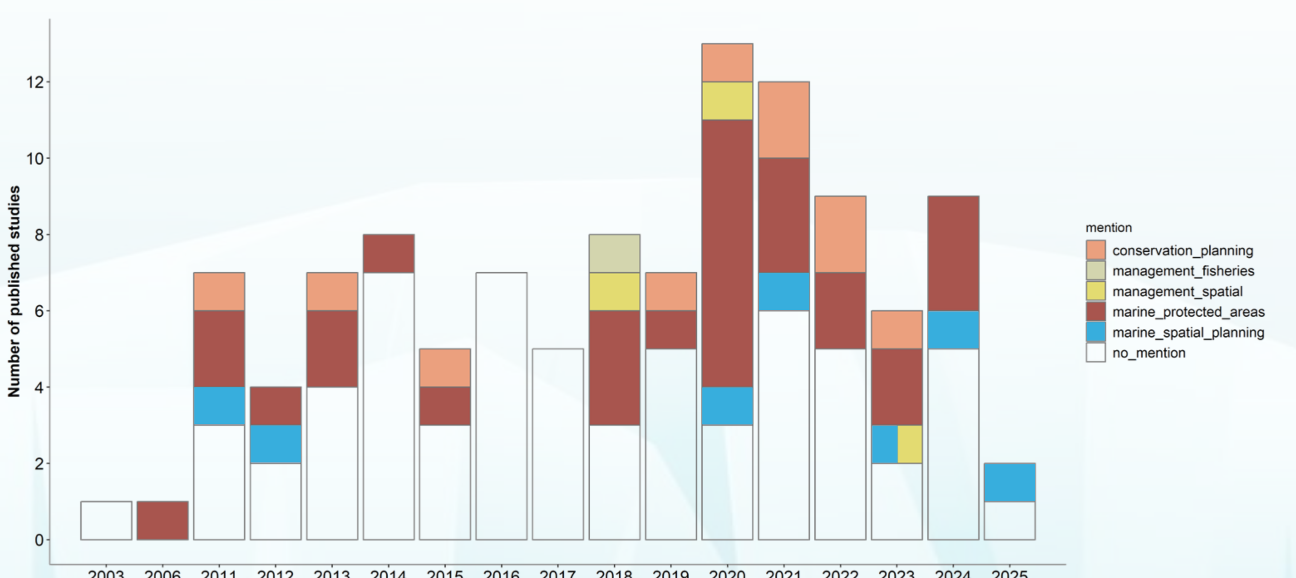
Number of studies featuring the top ten most studied species in SO-SDMs.

- Krill (*Euphausia superba*) is the species with most interest.
- Sea mammals and seabirds dominate research efforts.
- One myctophid (*Electrona antarctica*) is the 10th most studied species.



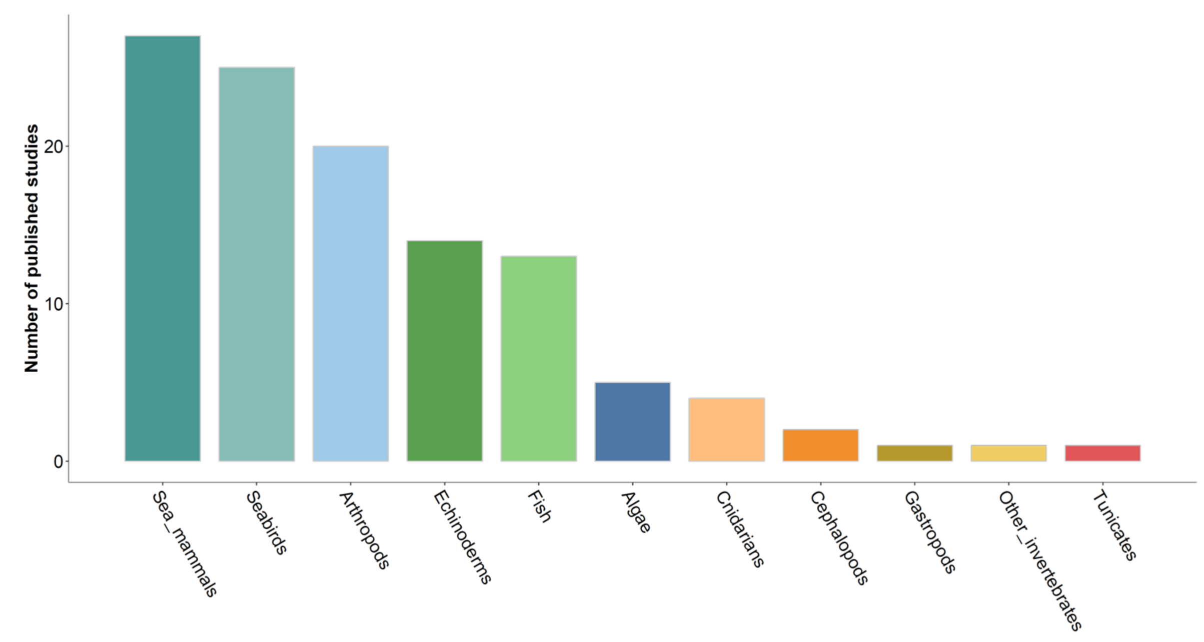
Number of studies per year that mention specific MPA-related and MSP-related keywords, and those that do not.

- MPA and MSP still lack integration (both on study's discussion and in output generation).
- Integrating information on human uses, threats, pressures, and protection areas with SDMs is key to producing useful SDM outputs towards promoting sustainable ocean planning and conservation.



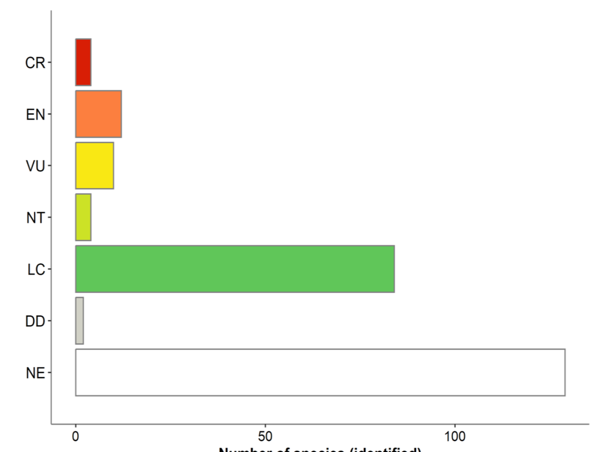
Number of published SDM studies featuring species from each organism group (artificial).

- Large focus on sea-mammals and seabirds
- Arthropods mostly represented by one species (see below)



Number of species (identified) subject of SDM modelling for each category of the Red List of the International Union for the Conservation of Nature (IUCN).

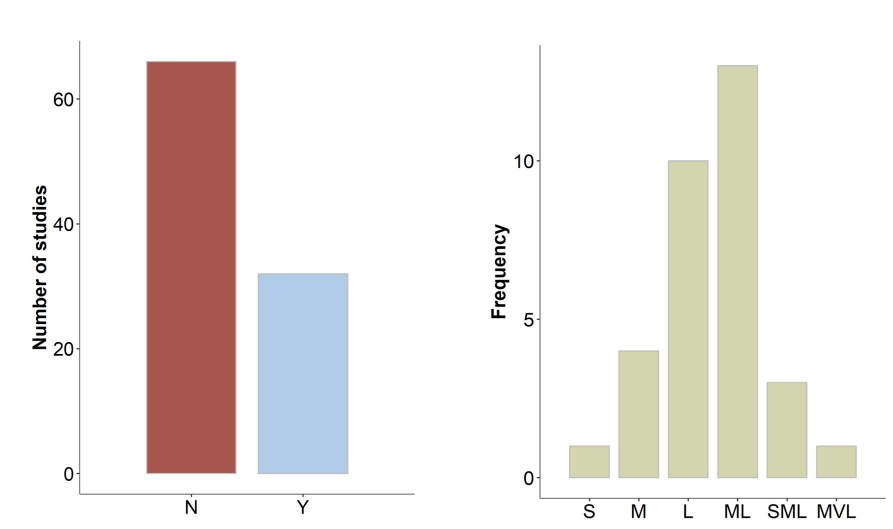
- Most species are classified as Least Concern or have not been evaluated (e.g., echinoderms, arthropods).



ORGANISM GROUP	CR	EN	VU	NT	LC	DD	NE
Algae	-	-	-	-	-	-	3
Arthropods	-	-	-	-	1	-	43
Cephalopods	-	-	-	-	19	-	-
Cnidarians	-	-	-	-	1	-	13
Echinoderms	-	-	-	-	-	-	50
Fish	-	1	2	-	18	1	13
Gastropods	-	-	-	-	-	-	6
Other invertebrates	-	-	-	-	-	-	-
Sea birds	2	4	4	3	26	1	-
Sea mammals	2	7	4	1	19	1	-
Tunicates	-	-	-	-	-	-	1

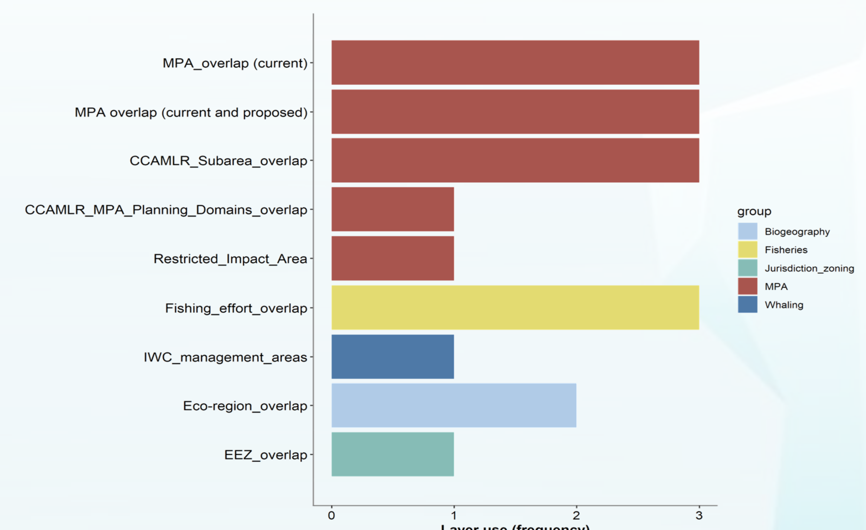
Studies with (Y) and without (N) projections into future timeframes (left). Timeframes of projection (right) – S: short time, same decade; M: mid-century, 2050s; L: end-century, 2100; MVL: next-century, 2150s.

- 32% of articles utilize future-projected predictors to estimate distributions across time.
- Most studies project into the 2050s and 2100s.



Total number of studies which use and/or overlap MPA-reçated or MSP-related layers/shapefiles in their analyses or discussions.

- Reduced number of layers integrated into analyses.
- Majority linked with MPA (current and proposed).



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