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

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THE FOLLOWING SECTION OF MATERIAL AND METHODS REFERS TO A MANUSCRIPT CURRENTLY IN PREPARATION AND TO THE POSTER PRESENTED IN MPAinMSP Europe (Bodo, Norway, July 2025).

MATERIAL AND METHODS

The published scientific literature available on the Web of Science (WoS) and the SCOPUS database was surveyed on the 1st of November 2024. Briefly, both databases were queried for articles or proceeding papers published between the 1st of January 1990 and the 1st of November 2024, which included one or more relevant keyword combinations (see **Table 1**). These keywords aimed to retrieve the available literature for articles featuring species distribution model (SDM) or ecological niche modelling (ENM) approaches in marine species, with spatial predictions and/or projections in the region of the Southern Ocean. The resulting list of articles was complemented with references available on the Scientific Committee on Antarctic Research (SCAR) Distant Ecological Model Output Repository (Plasman et al., 2024) and which were not collected by the WoS and SCOPUS queries. This database was accessed on the 10th of February 2025. Lastly, additional relevant articles were included from *a priori* knowledge of this study's authors, to ensure a comprehensive overview of the available scientific literature on Southern Ocean SDMs.

Table 1. Keyword combinations used for the literature search in the Web of Science (WoS) and SCOPUS databases. SDM – Species Distribution Model; ENM – Ecological Niche Model.

x	**KEYWORD 1**	**x**	**KEYWORD 2**
	Southern Ocean	OR	Antarctic
OR	Antarctica	AND	niche model
OR	habitat suitability model	OR	species distribution model
OR	Habitat suitability	OR	SDM
OR	ENM	OR	distribution model

Figure 1 summarizes the systematic literature search and non-systematic database completion according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA), which was used for assistance with this systematic review process (Page et al., 2021). The different databases retrieved a total of 505 journal entries (specifically 278 from WoS, 205 from SCOPUS, and 22 from SCAR DistAnt). Additionally, 17 other articles were pooled across previous knowledge from the co-authors. After duplicate removal (n = 193), a total of 329 articles were left for curation across a set of eligibility criteria, to address suitability for the final database inclusion. This set of eligibility criteria was adapted from Pasanini et al. (2024) and Guisan et al. (2017). In short, the remaining articles were evaluated across 3 main criteria: i) population, ii) intervention, and iii) comparators. Population is a criteria which addresses the type of point data used – e.g., locations and occurrences – and defined that a study was included if at-sea spatial occurrence and/or abundance data for one or more species is collected (either from databases, from the field, or other sources), from within the

scope of the present analysis (i.e., the Southern Ocean and its adjacent areas, and the coastal areas of the Antarctic continent).

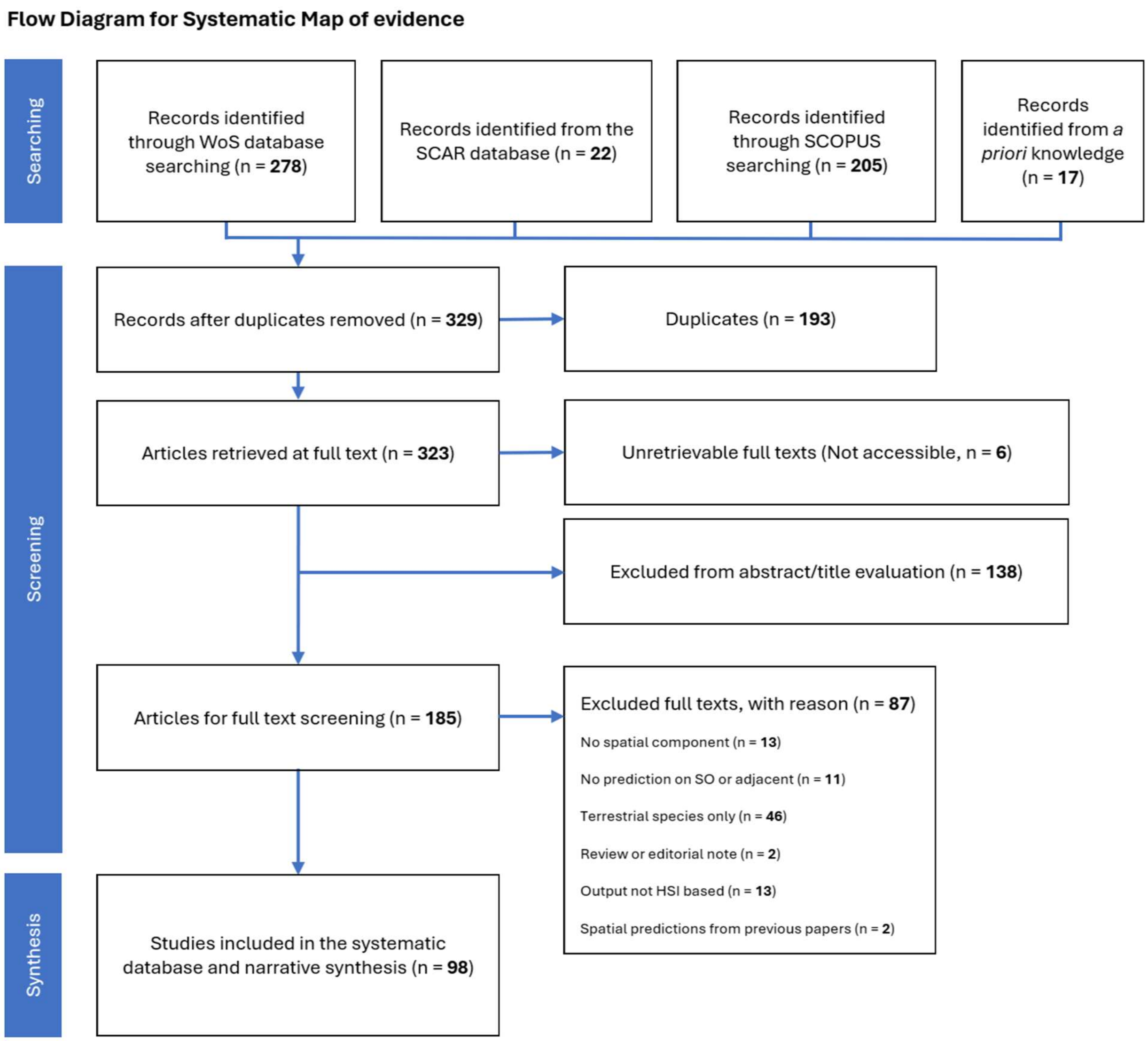

Figure 1. Flow Diagram summarizing the searching, screening and synthesis process performed systematically according to the eligibility criteria of the present study.

The second criteria, Intervention, evaluates if an article presents the application (or not) of correlative and mechanistic SDMs and/or ENMs (the latter only if including a spatial prediction). This application must have been performed through frameworks which associate species occurrence or abundance with either physical-chemical, environmental, topographic, biotic, and/or anthropogenic predictor variables. In the case of the present article, mechanistic models (i.e., expert-knowledge-based, such as Aquamaps) were maintained. Lastly, the Comparator criteria relates to the type of correlative approach implemented and the type of evaluation metrics. Articles that did not implement ecological modelling with a spatial component were removed. The final list featured a total of 98 suitable research articles. From the curated article database, information was retrieved from each paper for a series of topics, namely: i) taxonomic information – i.e., number of species and their taxonomical identification at the Phyllum, Class, Order, Family, and species level, whenever possible; ii) conservation status – i.e., IUCN category, species uses, whenever available; iii) point data information – i.e., number of occurrences, coverage, and occurrence data sources; iv) occurrence category – i.e., telemetry, abundance, visual or acoustic data; v) occurrence data type – i.e., true-absences, pseudo-absences (i.e., background data), or presence-only data; vi) study extent – i.e., latitudinal range, global or localized (e.g., Southern Ocean and adjacent); vii) predictor information – i.e., static and dynamic variables, predictor sources, and spatial resolution; viii) modelling approach – i.e., machine-learning, regression based, or other, ensemble of algorithms, and algorithms used; ix) future projections – i.e., projection made at different time periods into the future, associated coupled modelling intercomparison project (CMIP) and associated scenarios; and x) MPA/MSP integration – i.e., the mentioning of MPA- and/or MSP-related terms in the main body of text, and the inclusion (or not) of MPA/MSP-related layers for either statistical or discussion motives.