Species Listing Eligibility and Conservation Actions for *Squalus chloroculus* (greeneye spurdog), *Squatina albipunctata* (eastern angelshark) and *Cephaloscyllium albipinnum* (whitefin swellshark): Data from the South East Australian Marine Ecosystem Survey (SEA-MES) Voyages 1-4.

The Southeast Australian Marine Ecosystem Survey (SEA-MES) is revisiting previous bio-physical and ecosystem surveys of the Australian SE continental shelf using the CSIRO research vessel (RV) *Investigator* to document changes in the ecosystem over 30 years. It is attempting to untangle the effect of different human activities on the ecosystem, including climate change and fisheries.

SEA-MES consists of four voyages using *RV Investigator*, Australia's multi-purpose blue-water marine research vessel. Voyages 1-4 have been conducted in May 2023, July 2024, November 2024 and June 2025. Through a range of biological sampling techniques, it has captured an understanding of the ecosystem and foodweb structures from primary production of phytoplankton and benthic algae, through to secondary production of zooplankton, and the diets of fishes from stomach content analysis. It has also undertaken water column sampling to measure the physical and chemical properties of the ocean, towed a video system over the ocean bed to describe the benthic habitat, tested new ways of measuring and monitoring the ecosystem using DNA from tissue and free-floating in the marine environment and counted seabirds using AI techniques.

Background

SEA-MES data collection has employed a range of techniques. The primary method of collection for fish and demersal fauna is demersal trawl using a semi-V-wing demersal trawl. The gear and equipment used by SEA-MES is replicated from the Southeast Fisheries Ecosystem Survey (SEFES) survey of Bax and Williams (2000) in the 1990s. Trawl operations were limited to daylight hours for voyages 1-3, and then paired locations were sampled day and night in SEA-MES 4.

Preliminary SEA-MES Results

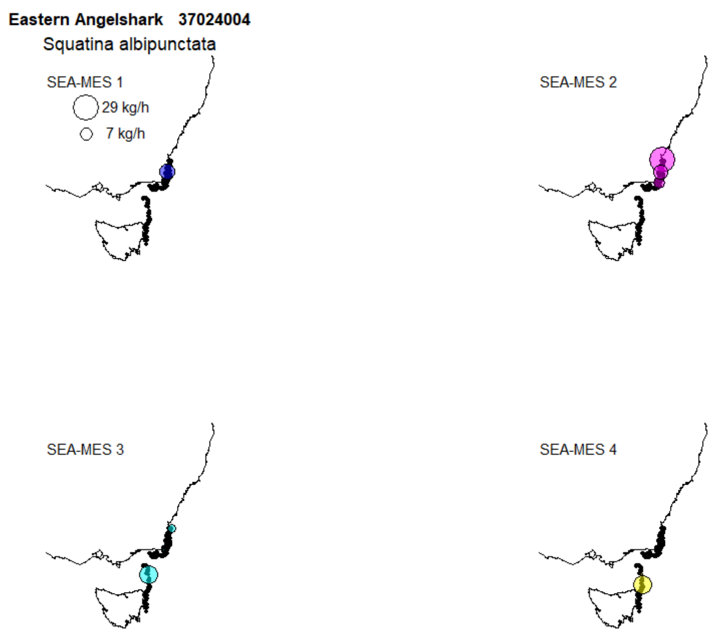
No catches of *Squalus chloroculus* (greeneye spurdog) were seen on the SEA-MES voyages. Catch rates of eastern angel shark were 10.94 (±8.77) kg/h, and whitefin swellshark were 25.04 (± 40.58) kg/h. This was 0.81 and 2.29 times the catch rates of the species from the SEFES voyages.

Species	SEFES CPUE (kg/h)	Shots with species	SEA-MES 1 CPUE (kg/h)	Shots with species	SEA-MES 2 CPUE (kg/h)	Shots with species	SEA-MES 3 CPUE (kg/h)	Shots with species	SEA-MES 4 CPUE (kg/h)	Shots with species	SEA-MES: SEFES ratio
Squalus chloroculus	-	-	-	-	-	-	-	-	-	-	-

***Squatina albipunctata* (eastern angelshark)**	13.20	17	12.56	1	15.87	3	7.21	3	8.28	2	0.81
***Cephaloscyllium albipinnum* (whitefin swellshark)**	11.05	12	22.98	10	11.25	3	43.8	9	15.71	11	2.29

Abundance measurements (CPUE) over four SEA-MES voyages differed across the four SEA-Mes voyages (Figure 1) ranging between 7-29 kg/h for eastern angelshark and 55-219 kg/h for whitefin swellshark.

(a)



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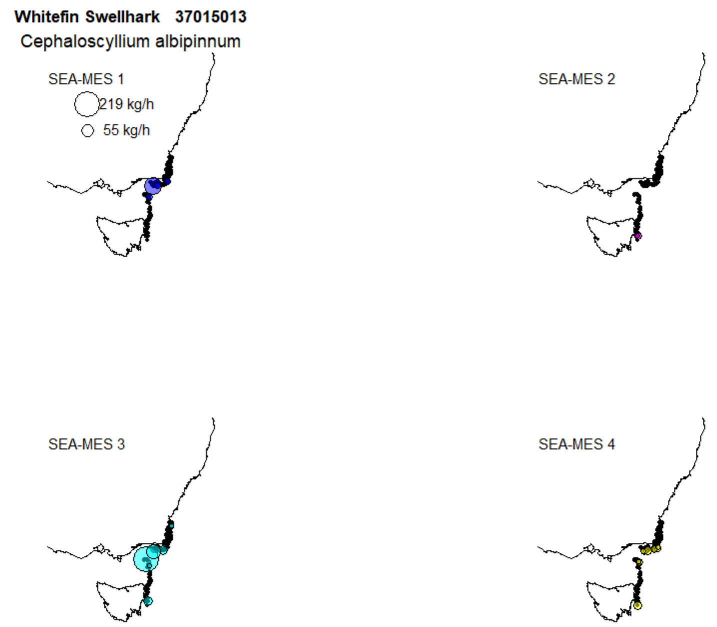
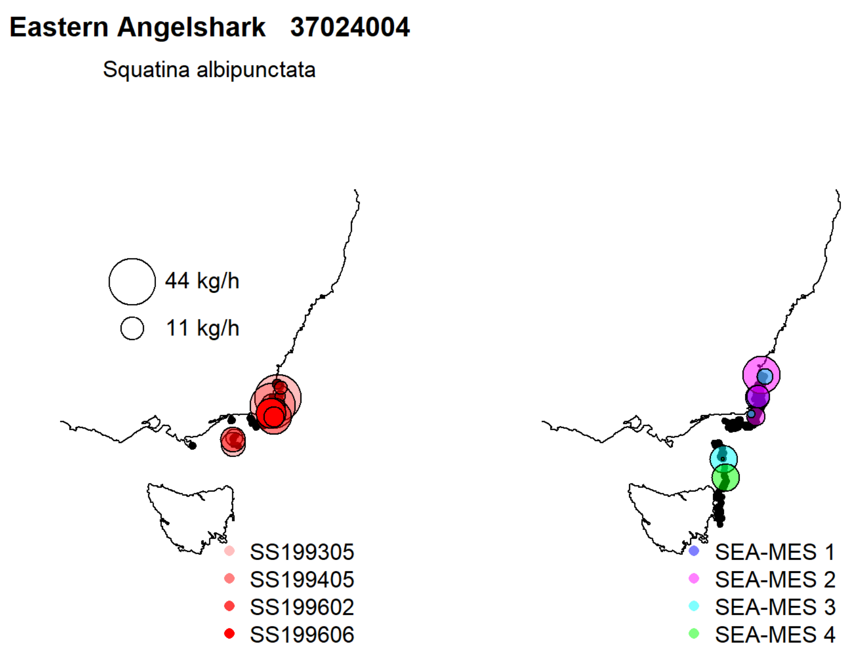


Figure 1. Catch-per-unit-effort (CPUE as kg/h) of (a) Eastern Angelshark and (b) Whitefin Swellshark across four SEA-MES voyages. CPUE is shown as graduated coloured circle, zero catches as black dots.

(a)



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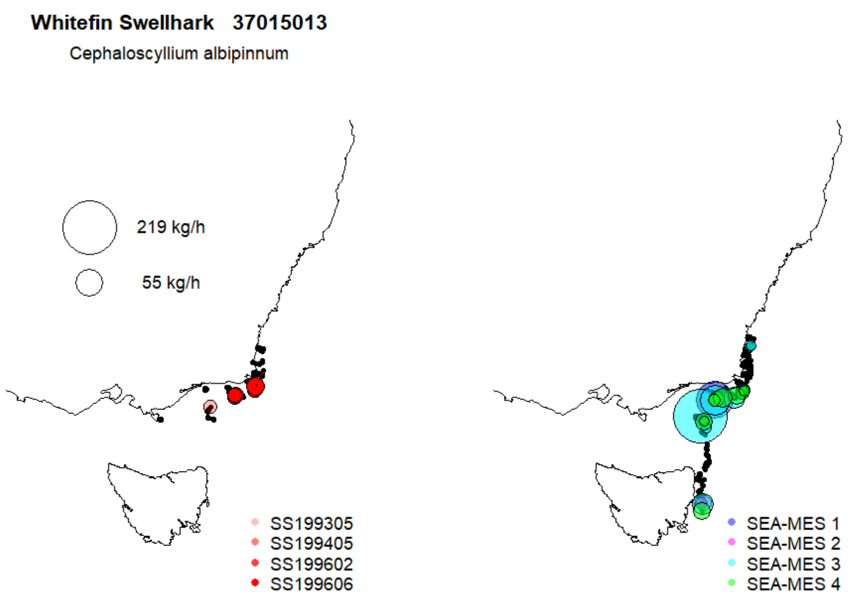


Figure 2. Catch-per-unit-effort (CPUE as kg/h) of (a) Eastern Angelshark and (b) Whitefin Swellshark (bottom) by survey. Left: SEFES survey (Bax and Williams 2000) and right: SEA-MES voyages. CPUE is shown as graduated coloured circle, zero catches as black dots.

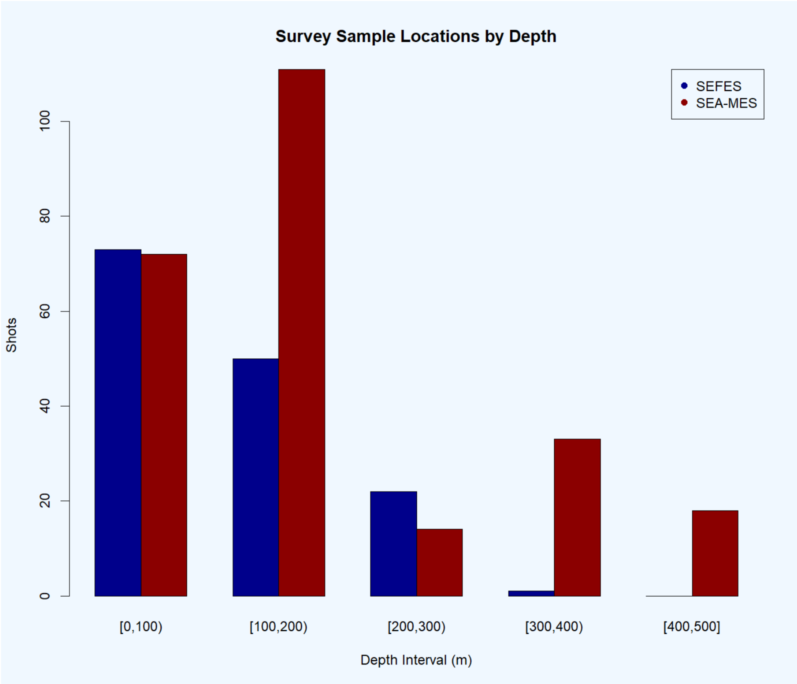


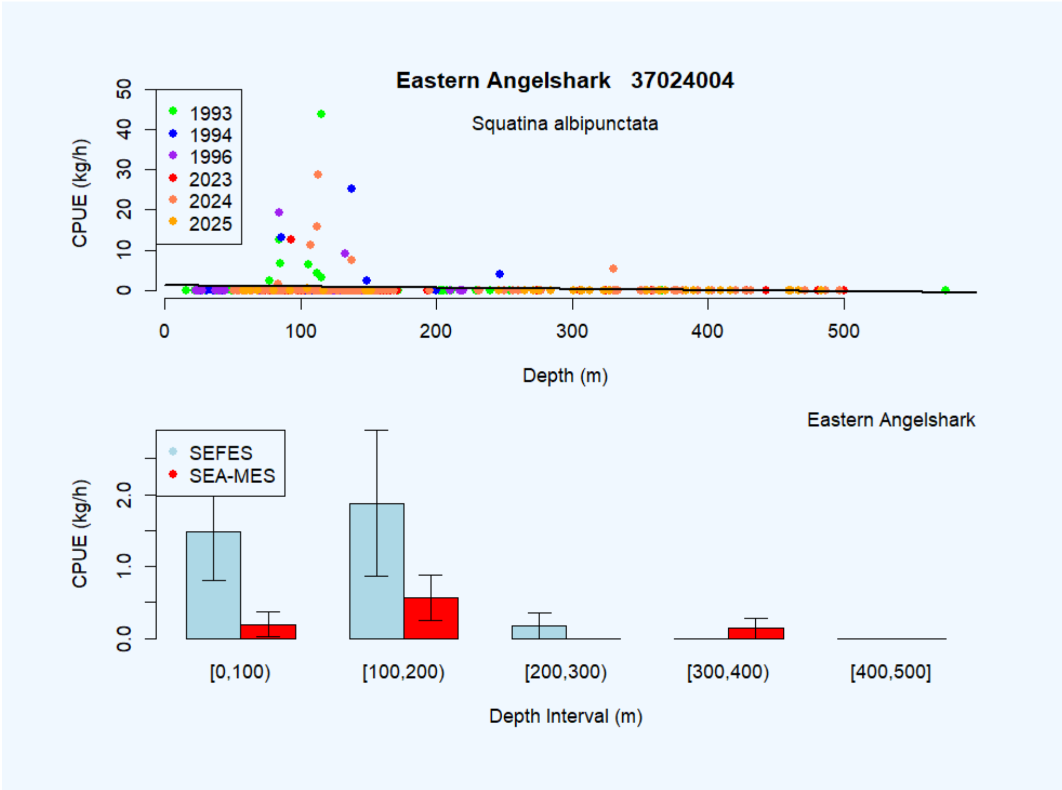
Figure 3. SEFES and SEA-MES sampling effort by depth range.

Both species were seen across the latitude range from NSW to Tasmania (Figure 1, 2). Eastern Angelshark ranged as far south as NE Tasmania, whereas Whitefin Swellshark was found farther south off eastern Tasmania.

The sampling effort of the SEFES survey (Bax and Williams 2000) and SEA-MES were comparable for depths <300 m (Figure 3). Eastern Angelshark was found typically on the continental shelf at less than 250m (Figure 4), and consistently at levels below the baseline survey of the 1990's (i.e. SEFES). Whitefin Swellshark was seen in deeper waters (Figure 4), which were not sampled by the SEFES survey to the same degree as SEA-MES.

The SEA-MES survey sites were partitioned into northern and southern sites, where the northern sites were specified by the SEFES latitudes of the SEFES survey (Figure 6 top panel). A comparison of the northern and southern SEA-MES demersal fish community composition with the baseline SEFES composition (Figure 6) indicated the southern sites were more like the earlier SEFES species composition than the northern sites, suggesting the ecosystem structure has shifted south in 30 years. The reasons are still unclear but could potentially be due to a range of factors, including oceanographic factors.

(a)



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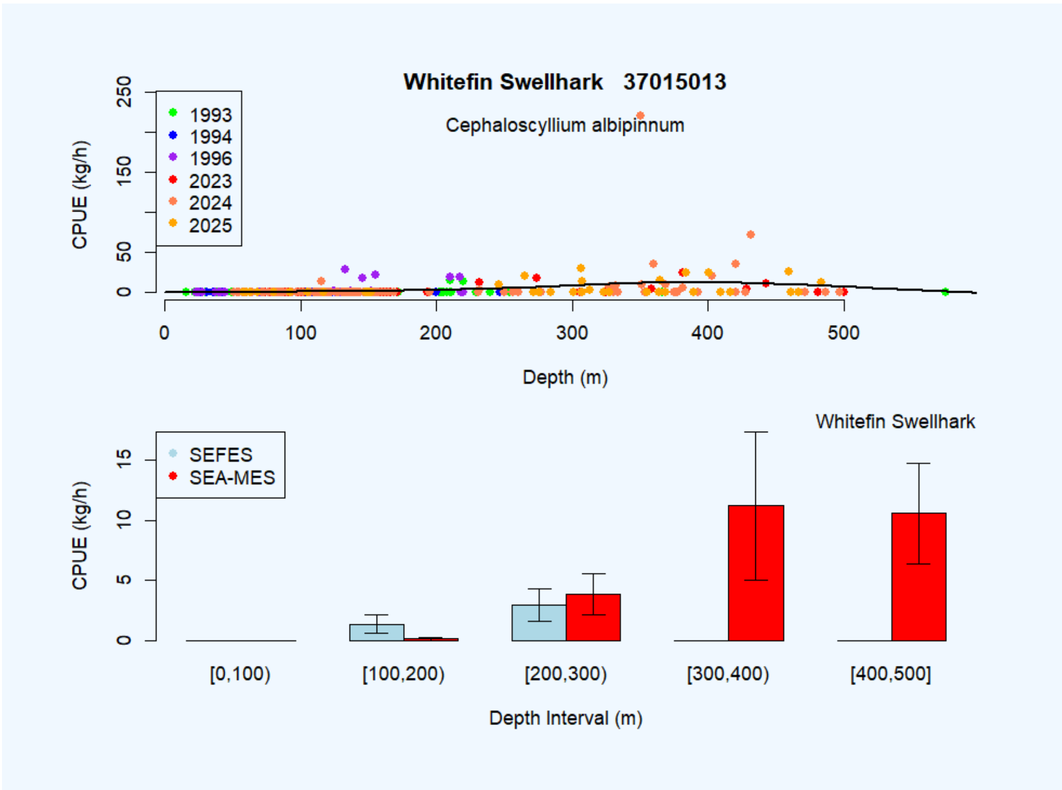

Figure 4. CPUE (kg/h) of (a) Eastern Angelshark and (b) Whitefin Swellshark, each showing: top panel containing individual sample CPUE by depth and year (Cool colours 1993-1996: SEFES voyages; Warm colours 2023-2025: SEA-MES voyages; and bottom panels showing mean (±SE) CPUE across samples by depth interval.

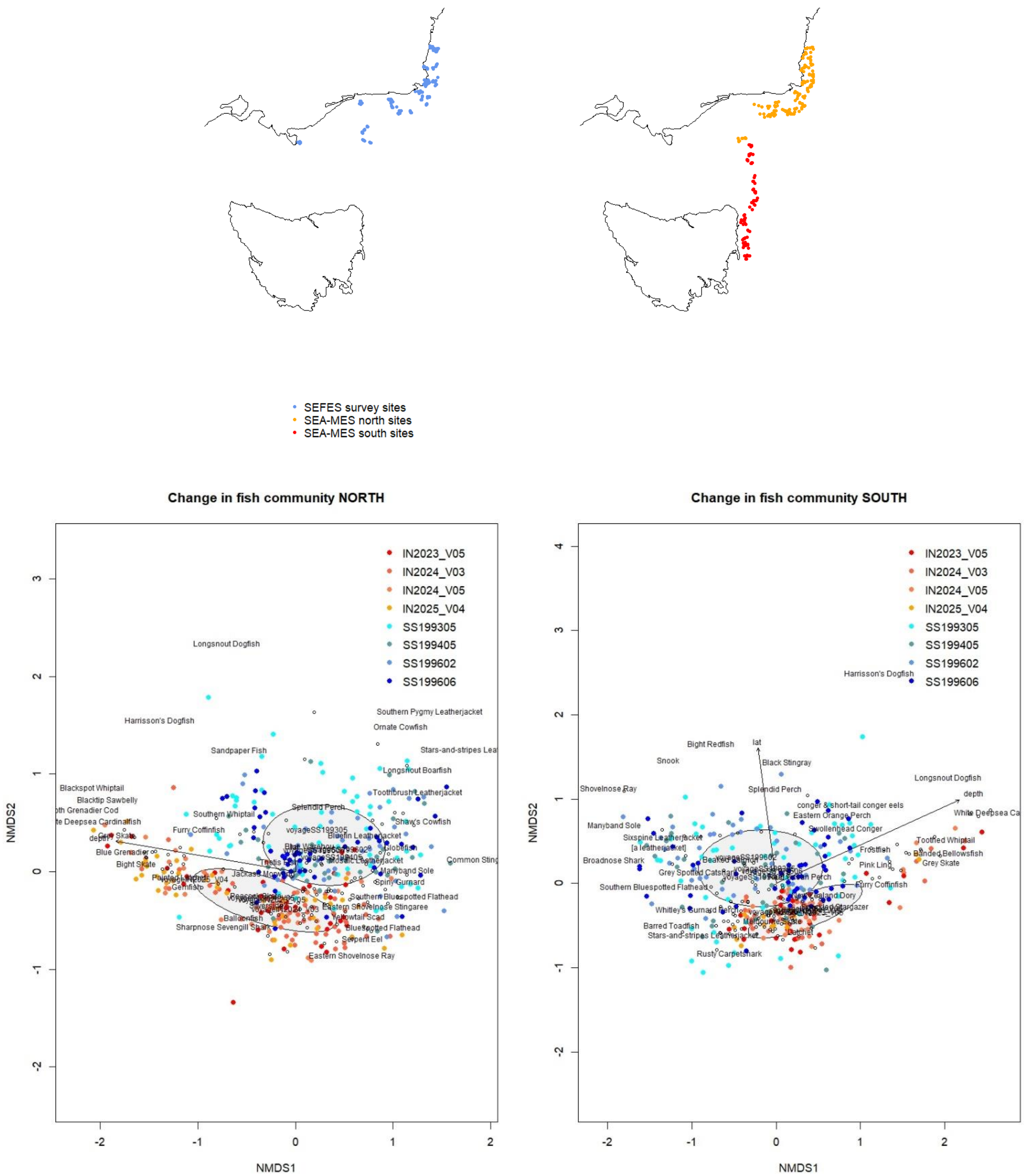

Figure 6. Top panel left: SEFES survey sites - orange; blue: SEA-MES survey sites: NORTH same latitude at SEFES sites - orange; SEA-MES sites SOUTH of SEFES sites: red. Bottom panel: Ordination using non-metric multi-dimensional scaling. Left: species composition of SEFES sites compared to SEA-MES sites NORTH; right: species composition of SEFES sites compared to SEA-MES sites SOUTH. Environmental factors (depth) are shown as vectors. Ellipses are 95% confidence representation of survey voyages.

Changes in oceanographic conditions

An analysis of ocean conditions from the Bluelink ReANalysis (BRAN2020; Chamberlain et al. 2021) experiment, which uses a 10-km resolution (eddy-resolving) ocean model to simulate oceans conditions from 1993 to 2023 shows that eddy-mixing was higher during 2023 as measured by annual variability in sea surface height (Figure 7). In particular, a stationary a warm core eddy is easily seen in July 1993 (Figure 8). By contrast, July 2023 (Figure 8) has overall higher sea surface height right down the east coast of Tasmania, as a result of eddies moving through the region throughout the month (Figure 9). Sea surface temperature (Figure 10) was also higher during July 2023 compared to July 1993. Bottom temperatures, which are likely to be less variable, have also seen increases (Figure 11). These results are accessible at https://research.csiro.au/sea-mes/how-have-ocean-conditions-changes/. The specific effect of them on the ecosystem are still uncertain.

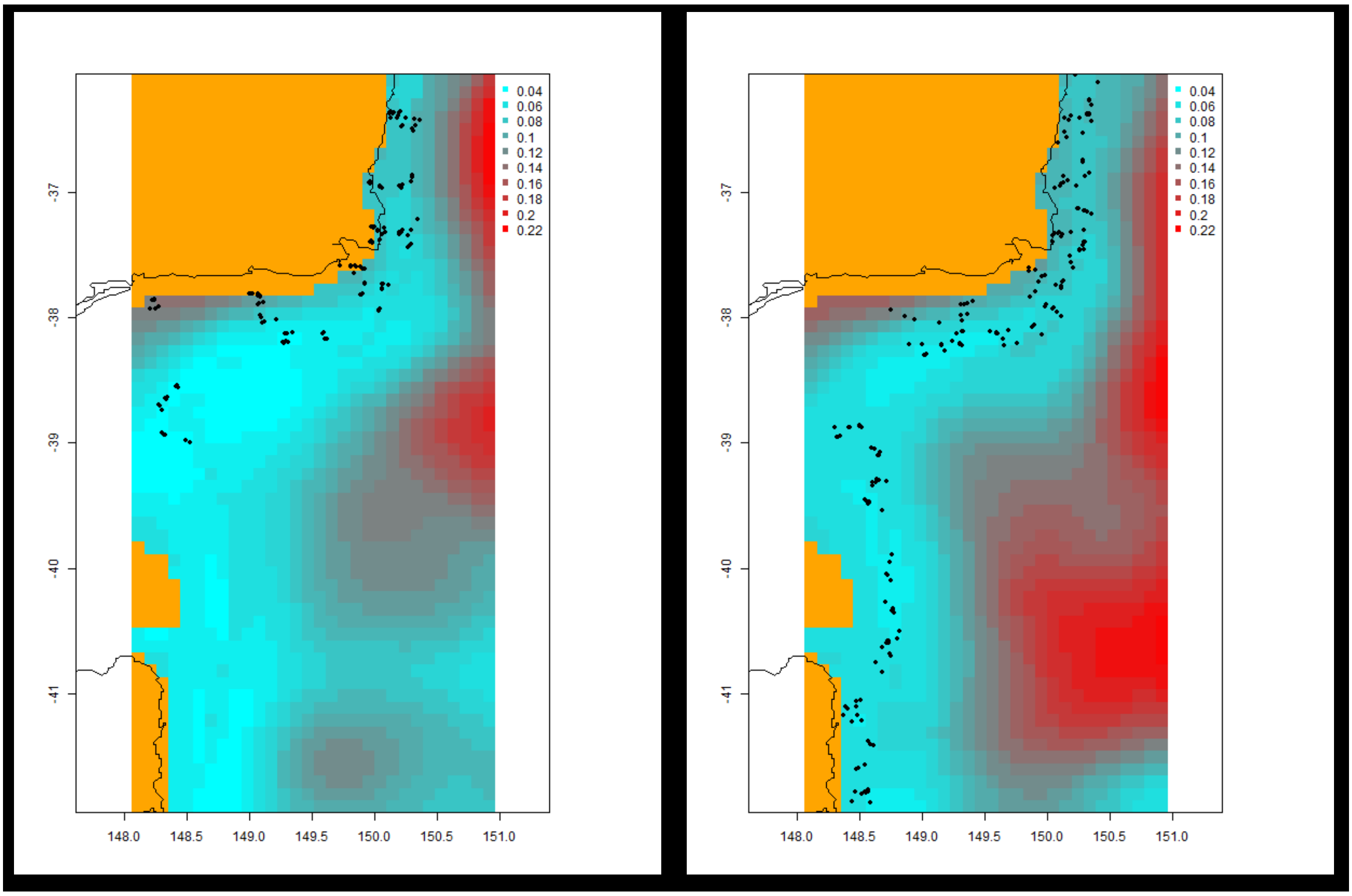

Figure 7. Annual eddy field strength measured as the annual variability (standard deviation) in daily sea surface height in calendar year 1993 (left) and 2023 (right). Dots are survey trawl sample locations: SEFES (left) and SEA-MES (right).

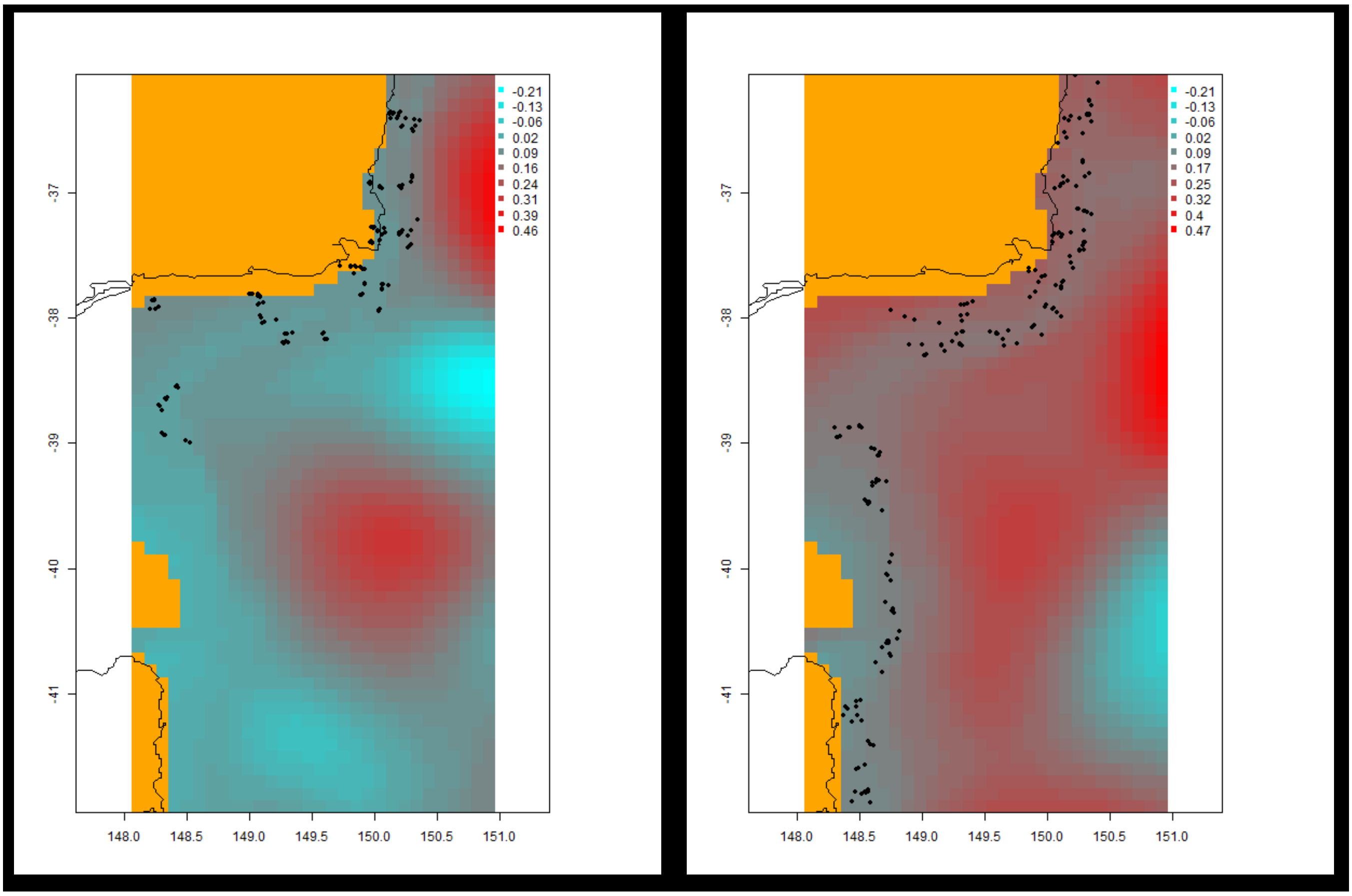

Figure 8. Mean monthly sea surface height during July 1993 (left) and July 2023 (right) showing warm core eddies (red) and cold core eddies (blue). Dots are survey trawl sample locations: SEFES (left) and SEA-MES (right).

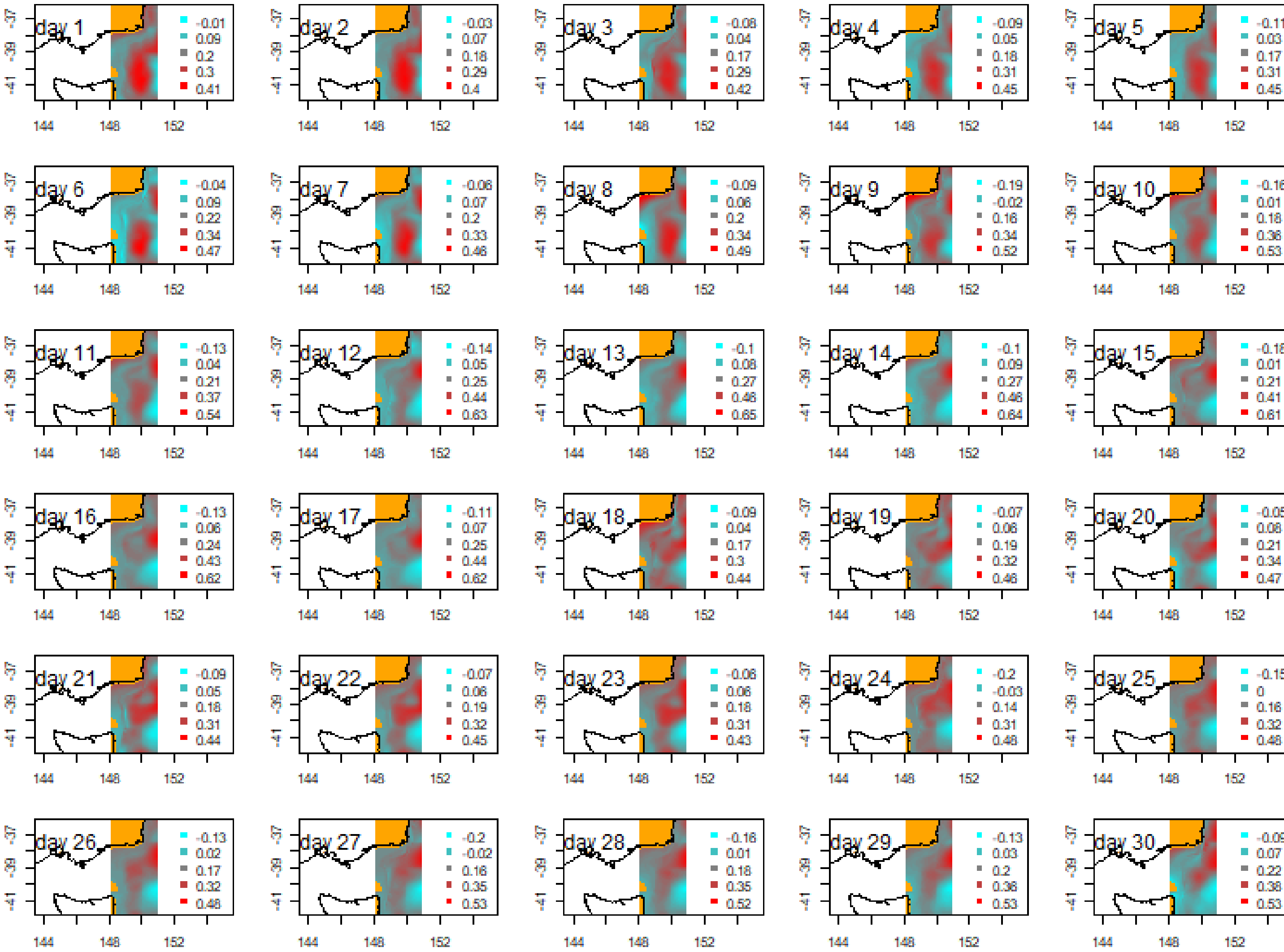

Figure 9. Daily sea surface height (m) during July 2023 showing warm core eddies (red) and cold core eddies (blue).

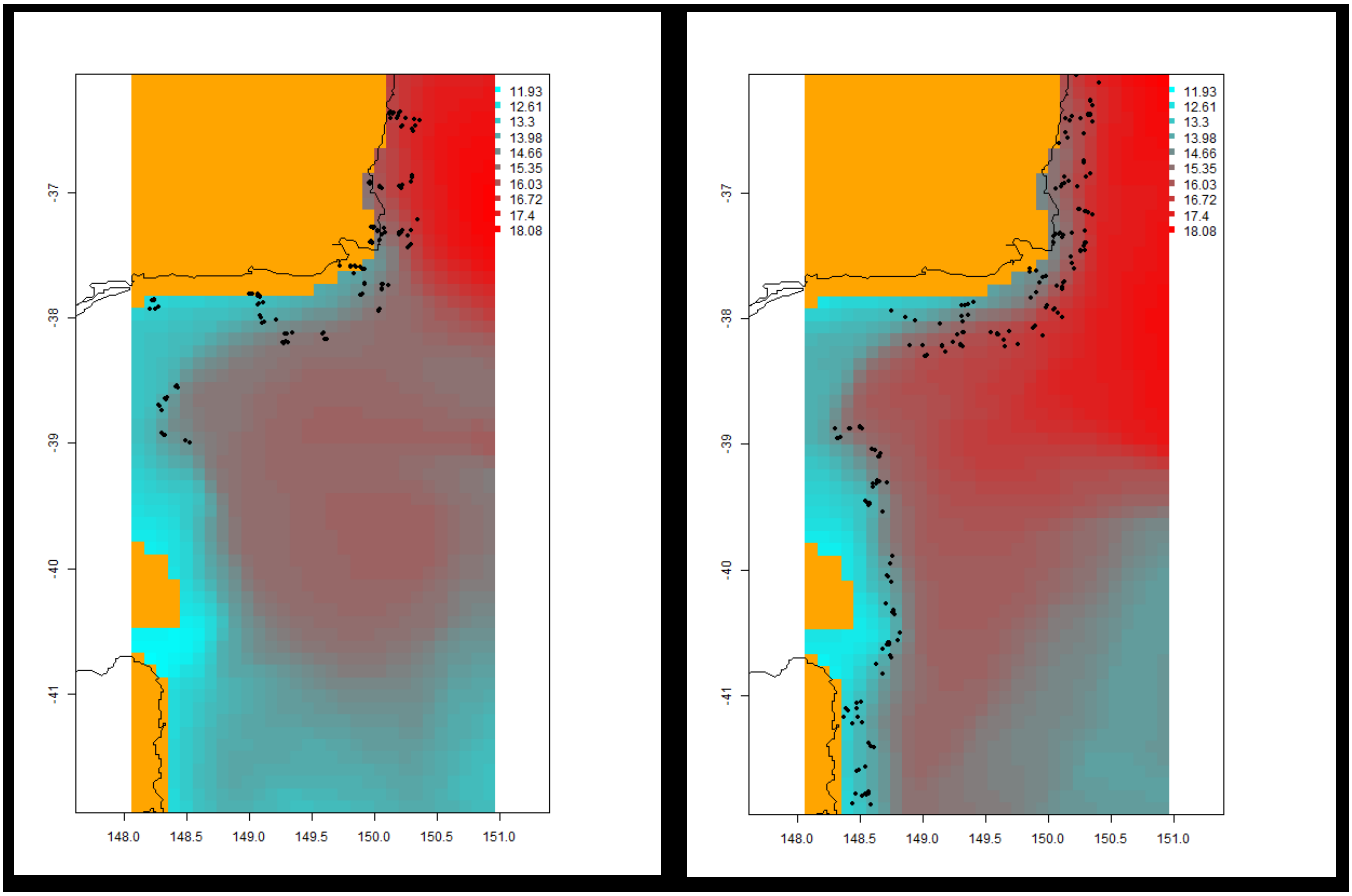

Figure 10. Mean monthly sea surface temperature (°C) during July 1993 (left) and July 2023 (right). Dots are survey trawl sample locations: SEFES (left) and SEA-MES (right).

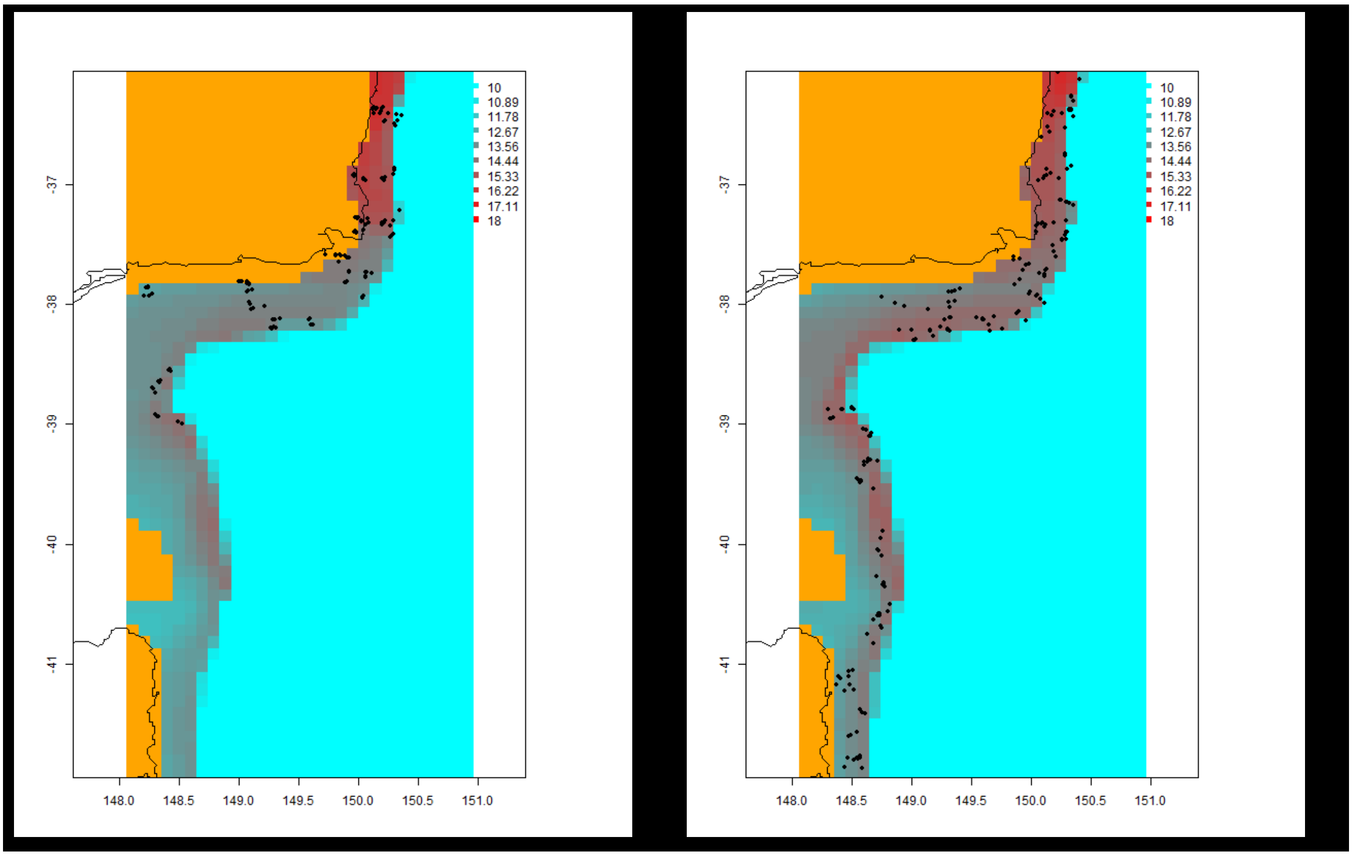

Figure 11. Mean monthly bottom temperature (°C) during July 1993 (left) and July 2023 (right). Dots are survey trawl sample locations: SEFES (left) and SEA-MES (right).

References

Bax, Nicholas J. and Williams, A. 2000. Habitat and fisheries production in the south east fishery ecosystem. Final report to the Fisheries Research and Development Corporation. Project 94/040.

Chamberlain et al. 2021. Next generation of Bluelink ocean reanalysis with multiscale data assimilation: BRAN2020. Earth Syst. Sci. Data, 13, 5663–5688, https://doi.org/10.5194/essd-13-5663-2021

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