Supplementary Materials

Supplementary Methods

SM1: Alternative Lagrangian Model Configurations

While the main manuscript focuses on transport pathways between spawning and nursery grounds, the broader research effort assessed the interplay between larval krill behavior and interannual oceanographic variations across the Southern Ocean. As part of this effort, we conducted additional simulations that varied diel vertical migration (DVM) behavior and sea ice advection rules while keeping mortality assumptions and release timing consistent across configurations. All simulations released particles in 14-day intervals across the austral summer, with instant mortality applied upon seafloor contact as described in the methods. Configuration summaries are detailed below and in Table S1.

1. Ocean-only – Drifters followed three-dimensional ocean velocities only; no sea ice advection was applied. Standard DVM was used with a maximum depth of 150 m. Initial embryo size: 620 µm.
2. Sea-ice – Standard DVM (150 m max depth) combined with sea ice advection. Drifters switched to modeled ice velocities if within 2 m of the surface, >120 h post-release, and when sea ice concentration exceeded 50%. Initial embryo size: 620 µm.
3. Modified-DVM – Sea ice advection applied. DVM behavior varied with ice presence: 200 m maximum depth in open water, reverse DVM (200 m day / 20 m night) when ice concentration exceeded 25%. Initial embryo size: 620 µm.
4. Embryo-size – Identical to the Modified-DVM configuration but with a larger initial embryo size (640 µm) to represent reduced early-stage mortality.

Supplementary Table S1 – Overview of simulation configurations, including horizontal advection trajectories, diel vertical migration (DVM) patterns, maximum DVM depths, and initial embryo sizes for the four simulation types.

Simulation Title	**Sea Ice Advection**	**DVM Pattern**	**Max DVM depth (m)**	**Max DVM Depth, Ice Present (m)**	**Initial Embryo Size (µm)**	**Description**
Ocean-only	None	Standard DVM	150	N/A	620	Drifters follow three-dimensional ocean velocities; no sea ice behavior is included.
Sea-ice	Yes	Standard DVM	150	N/A	620	Drifters switch to sea ice velocities if within 2 m of the surface, >120 hrs post-release, and sea ice concentration >50%.
Modified-DVM	Yes	Sea ice presence dependent	200	20	620	Includes deeper DVM in open ocean and reverse DVM when sea ice concentration exceeds 25%; sea ice advection applied.
Embryo-size	Yes	Sea ice presence dependent	200	20	640	Sea ice advection applied. Modified-DVM pattern applied.

Model output is available for download from the Biological and Chemical Oceanography Data Management Office and should be cited as

Brooks, C. M., Dinniman, M., Sylvester, Z., Bernard, K. S., Thorpe, S. (2025) Modeled locations of drifters representing transport of early life stages of Antarctic krill from 2016 to 2019. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-06-12. doi:10.26008/1912/bco-dmo.964861.1

Sensitivity Analyses of Behavioral Differences

To evaluate the influence of drifter behavior on transport outcomes, we conducted sensitivity analyses comparing the four model configurations (Table S1). These tests examined how diel vertical migration patterns and sea ice advection rules altered transport pathways under different seasonal and regional contexts. For the austral summer and the western Antarctic Peninsula region analyzed in this study, sea ice was largely absent during the drifter tracking period, and the simulated results from the Sea-ice and Modified-DVM configurations were therefore nearly identical to those from the Ocean-only configuration. Consequently, differences among behavioral configurations were minimal in this specific case. Selection of the most appropriate configuration should therefore be guided by the research question and environmental context. In regions or seasons with more extensive sea ice, the differences between behavioral configurations may be more pronounced, especially where reverse DVM or sea ice advection could substantially alter particle pathways.

SM2: Spatial Boundaries of Nursery Grounds

1. Bransfield Strait NG (BS-NG):
    a. Longitude: [302, 300, 300, 298, 298, 300, 300, 302, 302]
    b. Latitude: [-62.5, -62.5, -62.6, -62.6, -63.7, -63.7, -63.5, -63.5, -62.5]
2. Gerlache Strait NG (GS-NG):
    a. Longitude: [296.1, 298.5, 299.6, 297.6]
    b. Latitude: [-64.7, -63.6, -64.0, -65.3]
3. Grandidier Passage NG (GP-NG):
    a. Longitude: [291.6, 295.5, 297.6, 294.0]
    b. Latitude: [-66.7, -64.5, -65.3, -67.4]
4. Marguerite Bay NG (MB-NG):
    a. Longitude: [287.7, 290.5, 294.0, 292.0]
    b. Latitude: [-69.1, -67.5, -68.5, -69.7]

Supplementary Table S2

Larval krill use of nursery grounds by initial embryo size, reported separately for each start year (2016–2018) and nursery ground (NG). Larval influx is the number of larvae that entered the NG. Retention duration is shown as the median retention duration and interquartile range (IQR). Larvae retained is the number of larvae retained for 21 days or longer. Retention rate is the percent of the larval influx that was retained. The localized spawning percentage is the proportion of retained larvae inferred to have originated (spawned) locally within the nursery region. Annual averages are reported in Table 2 of the main text. Retention duration distributions for 620 μm visualized in Supplementary Figure S1.

Em Sz (μm)	NG	Release Year	Larval Influx (N)	Median Retention Duration (IQR)	Larvae Retained (N)	Retention Rate %	percent filtered out	Localized Spawning %
620	BS	2016	366	52.5 (68.0)	290	79	20.8	44
620	BS	2017	263	49.0 (67.5)	184	70	30	67
620	BS	2018	320	43.5 (47.2)	237	74	25.9	51
620	GS	2016	107	16.0 (37.0)	45	42	57.9	0
620	GS	2017	72	10.0 (29.2)	29	40	59.7	0
620	GS	2018	108	6.0 (25.0)	32	30	70.4	0
620	GP	2016	141	18.0 (37.0)	66	47	53.2	0
620	GP	2017	52	24.5 (39.2)	28	54	46.2	0
620	GP	2018	58	16.5 (23.8)	22	38	62.1	0
620	MB	2016	91	40.0 (79.5)	60	66	34.1	63
620	MB	2017	88	53.5 (57.0)	71	81	19.3	52
620	MB	2018	47	56.0 (63.5)	36	77	23.4	78
640	BS	2016	1213	46.0 (69.0)	891	73	26.5	34
640	BS	2017	1056	40.0 (63.0)	710	67	32.8	40
640	BS	2018	1304	38.0 (50.0)	899	69	31.1	30
640	GS	2016	561	27.0 (50.0)	310	55	44.7	25
640	GS	2017	494	27.0 (39.0)	269	54	45.5	31
640	GS	2018	668	20.0 (36.2)	318	48	52.4	23
640	GP	2016	1484	48.0 (83.0)	1063	72	28.4	27
640	GP	2017	1217	48.0 (87.0)	862	71	29.2	36
640	GP	2018	1164	37.0 (69.0)	761	65	34.6	38
640	MB	2016	1287	60.0 (83.0)	1002	78	22.1	33
640	MB	2017	1150	55.0 (65.0)	942	82	18.1	36
640	MB	2018	1075	59.0 (64.0)	935	87	13	34

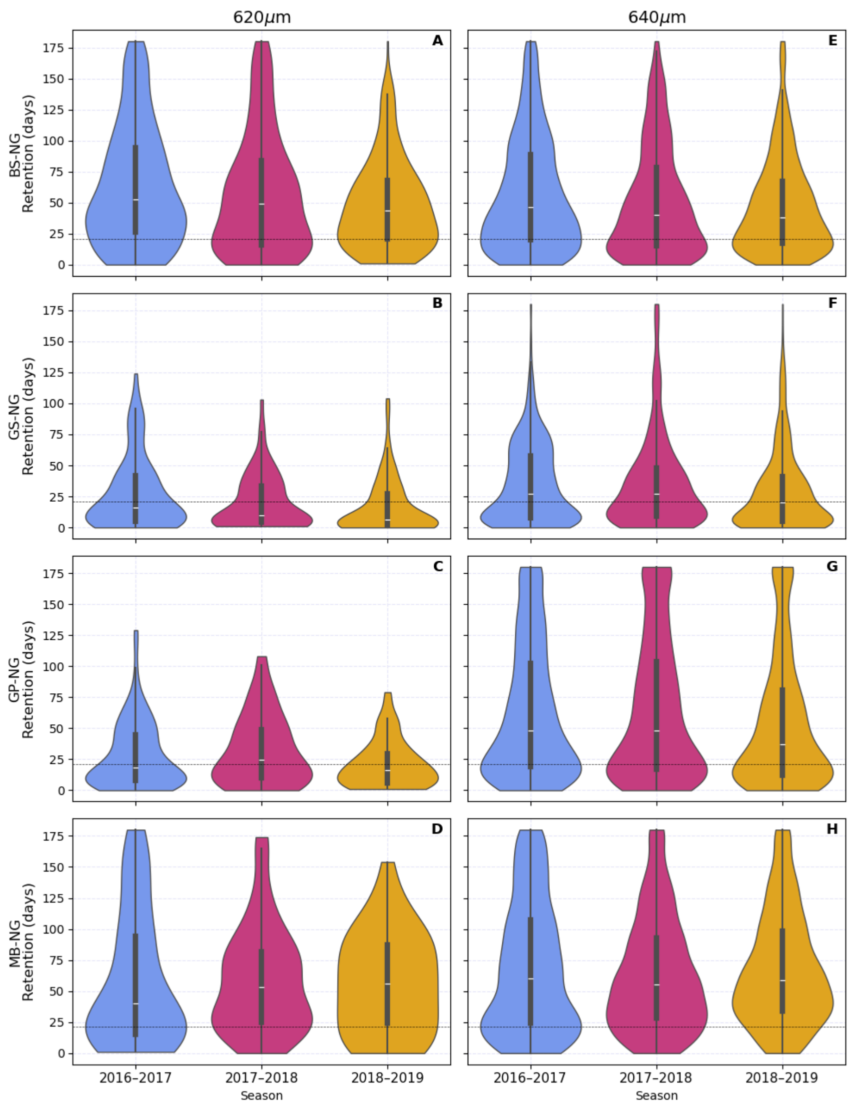

Figure SM1. Distribution of retention durations for larval krill within each nursery ground by embryo size and simulation year. Each panel represents a nursery ground (rows), with separate columns for simulations initialized with 620 µm and 640 µm embryos. Violin plots display the distribution of consecutive days larvae remained within a nursery region, with colors denoting simulation years (blue: 2016–2017, magenta: 2017–2018, mustard: 2018–2019). Violin widths reflect kernel density estimates of the underlying distribution. White dots indicate medians, and black bars show interquartile ranges. A dashed horizontal line at 21 days denotes the threshold used to define nursery ground use. Summary statistics are provided in Supplementary Table 1.