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Supplementary material

Appendix 1: Kelp Distributions

Both *Durvillaea antarctica* and *Macrocystis pyrifera* grow at high densities in the sub-Antarctic, and along the coasts of New Zealand and Chile (Fraser et al. 2009, Macaya and Zuccarello 2010), and have been shown to transport of a range of epifaunal organisms via rafting, including near the APF (e.g., Helmuth et al. 1994, Wichmann et al. 2012). Although there are some differences in their distributions, both are unable to survive in areas subject to frequent ice-scour (Fraser et al. 2009, Macaya and Zuccarello 2010), and so are not found below the Antarctic Polar Front, with the exception of two islands just south of the APF, South Georgia and Heard Island. On South Georgia, *D. antarctica* can grow but is patchy, occurring only in few, relatively protected bays where sea ice and ice from the island's calving glaciers does not regularly reach (Hay 1988). On Heard Island, populations are likewise patchy and occur only where the glaciers do not reach the shore (Klemm and Hallam 1988). *Macrocystis pyrifera* is not found at Heard Island (Smith 2002), but does occur at South Georgia.

Because of the extreme rarity of both *M. pyrifera* and *D. antarctica* growing below the APF, we are confident that our observations of these species south of the APF cannot be solely the result of drift kelp from South Georgia (far upstream) or Heard Island (downstream). Indeed, South Georgia is more than 4,500 km upstream of our kelp observations south of Marion Island, and has very sparse *D. antarctica* populations, yet many observations of *D. antarctica* were made on steaming transects from Marion Island southward across the APF, including during APF traverses. Previous oceanographic research in the region has shown that eddies of sub-Antarctic water can move through the APF in this zone. Our observations of kelp at and south of the APF are consistent with our hypothesis that eddies transport organisms through the front into Antarctic water.

Appendix 2: Materials and Methods

Survey data were collected on three research voyages aboard the SA Agulhas or SA Agulhas II: one in the South Atlantic from November 2013 to February 2014, and two in the Indian Ocean, with one in April 2008, and one from April to May 2014. All voyages crossed the APF, with observations made above and below the front (see figure 1). Floating kelp were counted during the day (roughly 6h30-17h30 local time) on transects while the ship moved at 9-12 knots (16.5-22 $km.h^{-1}$). Observations were made from the ship's bridge (9-12 m above

sea level), looking past the bow on the side of the ship that offered the best visibility. Kelp individuals were counted every minute by scanning a 300 m block perpendicular and extending forward from the bow with binoculars, but data were pooled into hourly blocks for analysis. Estimated distance (within 300 m) of rafts from the ship, and size of each clump, were also recorded, although these data were not used in analyses as they were not necessary for testing our hypothesis. No records from temperate waters were included in analyses, and any records from within 5 km of a sub-Antarctic island (South Georgia, Marion or Prince Edward Islands) were excluded as they were unlikely to be representative of drift-kelp densities in the open ocean. Tests were made using several other island-buffer values, and 5 km was deemed to adequately reduce island-associated bias.

We defined the position of the APF by assessing where the frontal boundary zone separating sub-Antarctic and Antarctic waters occurred, based on Maps of Absolute Dynamic Topography (MADT) (Swart et al. 2010). MADT show surface altimetry determined by sea level anomaly added to mean dynamic topography (Rio et al. 2011). MADT are produced by CLS/Aviso, with data obtained from Jason-1, Envisat, ERS and Topex/Poseidon satellites from daily snapshots on a 0.25 degree resolution grid (http://www.aviso.altimetry.fr/en/data). MADT are used to remotely identify key oceanographic features (e.g., mesoscale fronts and eddies), and provide valuable information about the horizontal spatial structure and intensity of such features. The MADT data used for this work comprised monthly means for April 2008, December 2013 and April 2014 (to correspond with cruise dates).

We fitted generalised linear mixed models (GLMMs; Zuur et al. 2009) with a Poisson distribution (log-link) to test (i) whether there was a significant difference in the density of kelp above or below the APF, and (ii) whether density decreased with distance from the front. Our response variables were count data aggregated for each hour of the surveys. Models were offset by the area of each survey period to control for any differences. To address our questions, we (i) fitted the zone (Antarctic or sub-Antarctic) and (ii) the distance from the APF (both values based on front position at the time of each survey) as explanatory variables in separate models: [Species ~ Zone + offset(area) + (1| Day)] and [Species ~ Distance + offset(area) + (1|Day)]. To control for possible non-independence among observations (aggregation of kelp rafts at sea according to fine-scale oceanographic features such as Langmuir Cells), we included survey day as a random effect for our models. We checked for over-dispersion by dividing the Pearson goodness-of-fit statistic by the residual degrees of freedom and found no values greater than one, suggesting that our data were not over-

dispersed (McCullagh and Nelder 1989). We inspected the residual vs. fitted plots of each model to confirm that residuals were approximately randomly distributed with respect to fitted values (see below). We fitted models using the *lme4* package for R (Bates et al. 2015).

Appendix 3: Results

Table: Results of GLMM analyses.

Response	Model terms	Estimate	SE	F	P
Macrocystis	Zone	3.232	1.027	3.148	0.002
	Distance	-0.824	0.230	-3.589	0.000
Durvillaea	Zone	1.718	0.402	4.278	0.000
	Distance	-0.470	0.085	-5.500	0.000

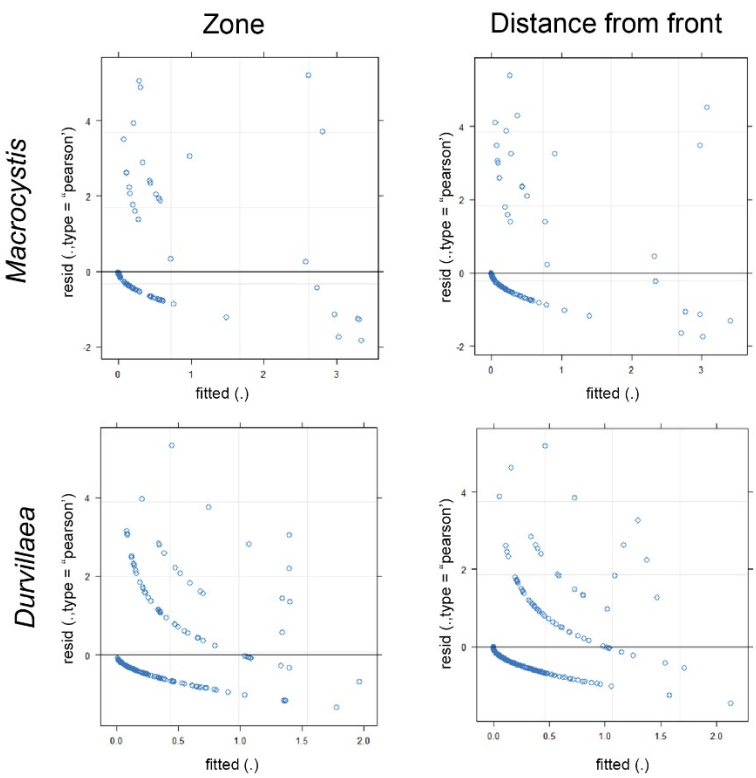

Figure: Plots of the residuals vs. fitted values for each analysis.

Appendix 4: Acknowledgements

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