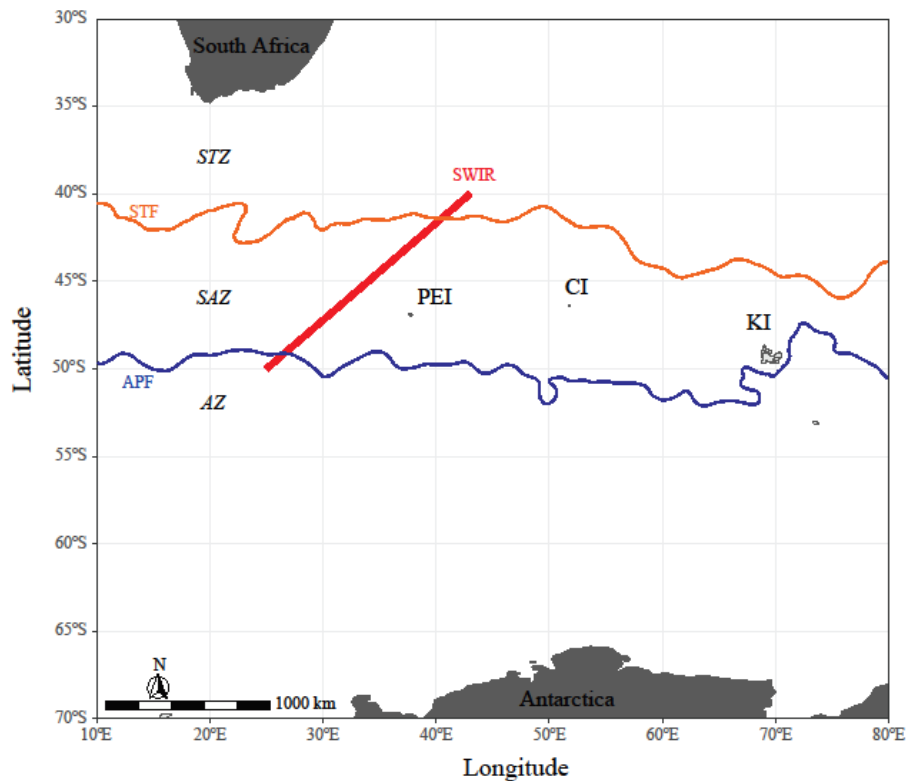


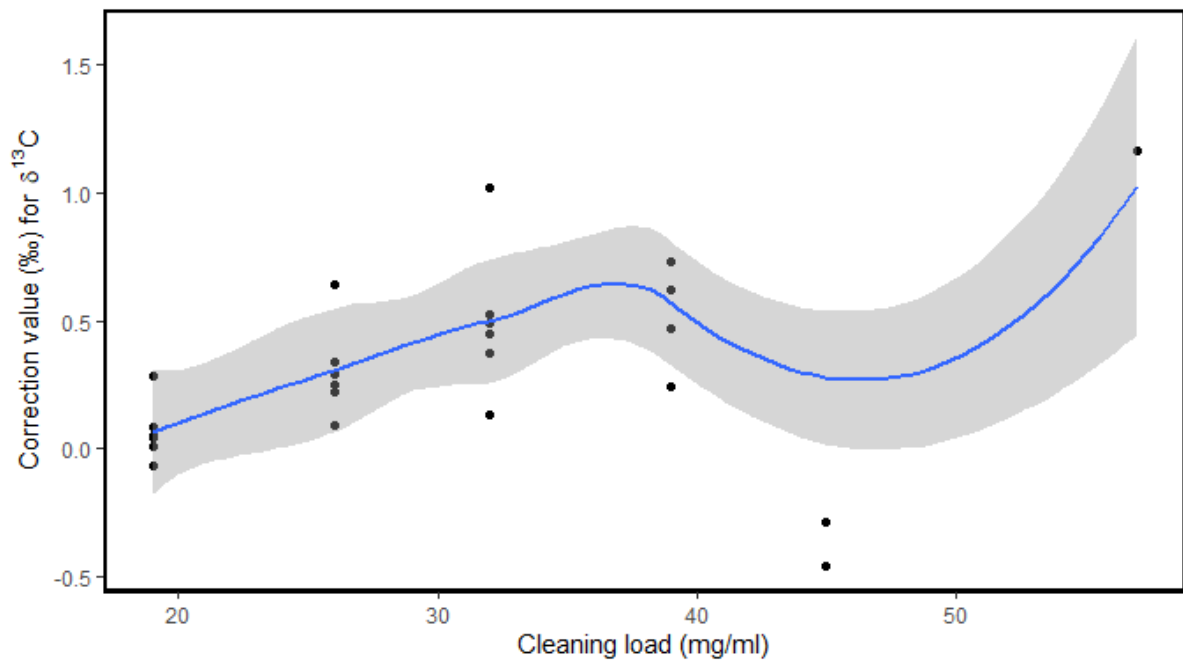
**Figures in MSc dissertation: ‘Stable isotope values of Marion Island
myctophids using otoliths from fur seal faecal samples’ – A van Tonder 2023**

Overview of study area

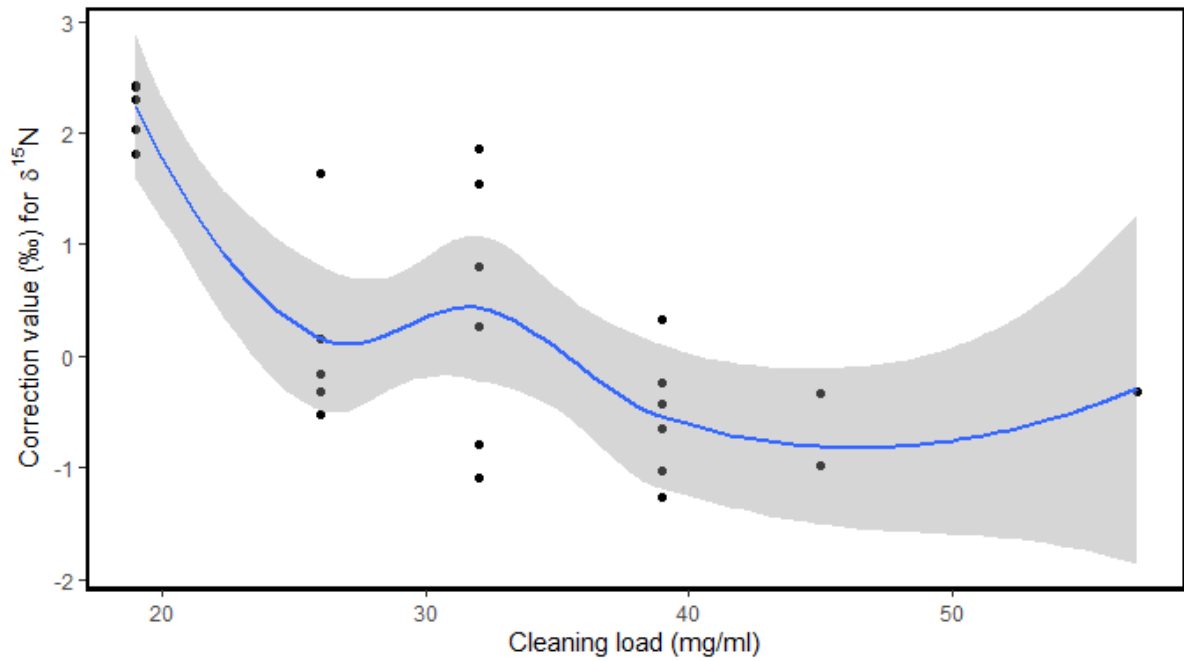


Representation of frontal and bathymetric features in the Indian Ocean sector of the Southern Ocean. STZ = Sub-Tropical Zone; STF = Sub-Tropical Front; SAZ = Sub-Antarctic Zone; APF = Antarctic Polar Front; AZ = Antarctic Zone. SWIR = Southwest Indian Ridge and archipelagos shown are Prince Edward Islands (PEI), Îles Crozet (CI) and Îles Kerguelen (KI). Frontal data is available online (Park & Durand 2019, Park et al. 2019).

Correcting stable isotope values of study otoliths before applying offset to estimated muscle values

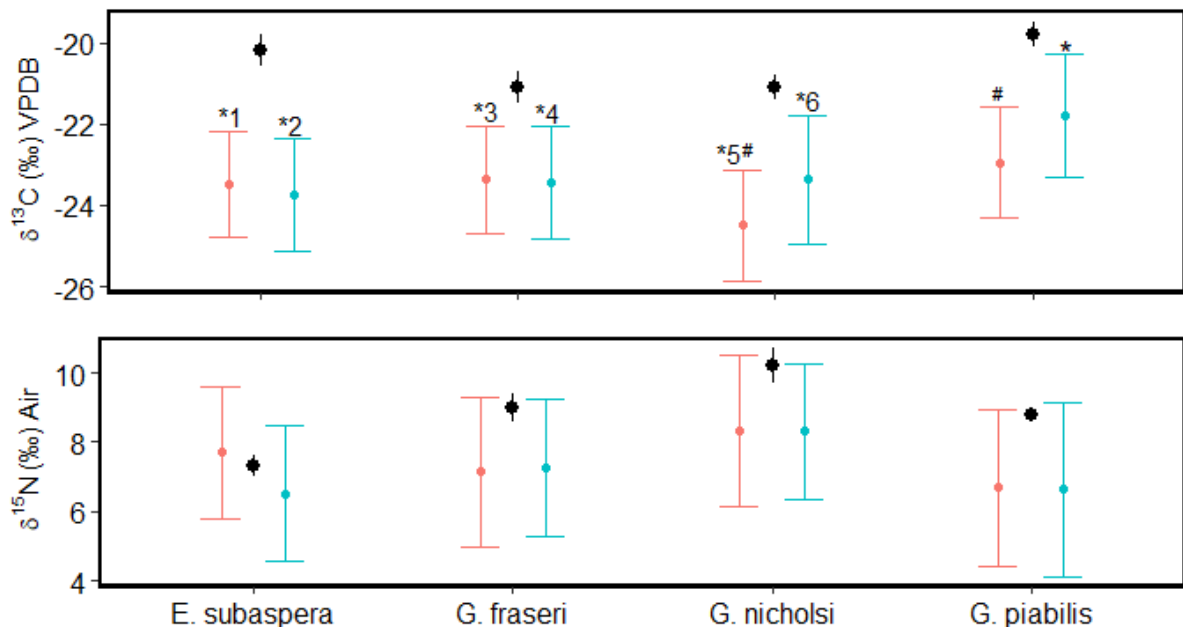


Correction curve for stable carbon isotope ratios ($\delta^{13}\text{C}$) of otolith material based on cleaning load – mass of otolith powder (mg) to volume of NaOCl (ml). The curve is a nearest neighbour regression curve (*loess*) at a 95% confidence level span = 0.75, and was produced using R (R Core Team 2020, RStudio Team 2020). It represents otolith material of *Gymnoscopelus piabilis* from Antarctic fur seal faecal (*Arctocephalus gazella*) samples collected at the Prince Edward Islands.

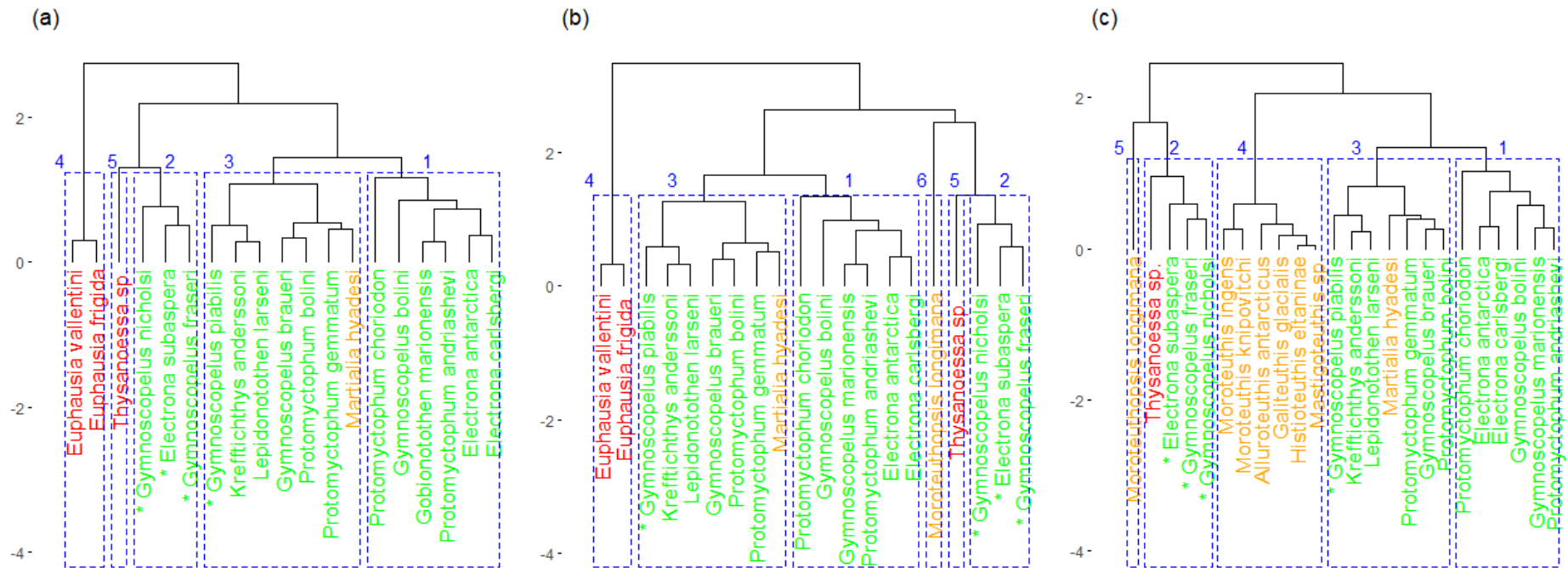


Correction curve for stable nitrogen isotope ratios ($\delta^{15}\text{N}$) of otolith material based on cleaning load – mass of otolith powder (mg) to volume of NaOCl (ml). The curve is a nearest neighbour regression curve (*loess*) at a 95% confidence level, span = 0.75, and was produced using R (R Core Team 2020, RStudio Team 2020). It represents otolith material of *Gymnoscopelus piabilis* from Antarctic fur seal faecal (*Arctocephalus gazella*) samples collected at the Prince Edward Islands

Comparing muscle estimates (obtained by applying otolith-to-muscle offset to cleaned and corrected otolith values) with each other and to published counterparts, and using muscle estimates in stable isotope dietary modelling



Estimated stable isotope values of muscle values of myctophids (*Electrona* and *Gymnoscopelus*) around the sub-Antarctic Prince Edward Islands around January 2005 (blue) and December 2010 (red). Estimates were obtained by applying an otolith-to-muscle offset to values of oxidant-cleaned otoliths obtained from fur seal faecal samples. The mean and final standard deviations are shown. The final standard deviation includes uncertainty from measurements, correction for insufficient oxidative cleaning, and application of the otolith-to-muscle offset, as well as variance within sampling units. The asterisk (*) indicates that *G. piabilis* 2005 had significantly different $\delta^{13}\text{C}$ values compared other species. There was also a significant $\delta^{13}\text{C}$ difference for *G. nicholsi* 2010 and *G. piabilis* 2010 (#). Black points and bars represent mean and standard deviations of conspecific values from Îles Kerguelen samples in 2005 (Cherel et al. 2010).3.4 Sampling units at the PEIs, and conspecific comparison with Îles Kerguelen (uncertainty propagated)



Dendrograms indicating the composition of clusters for (a) juvenile, (b) sub-adults and adult female and (c) adult male southern elephant seals (*Mirounga leonina*). Clusters in (a) are the same as (b), aside from the absence of *Moroteuthopsis longimana*. Sources include values from the Prince Edward Islands (PEIs), Îles Crozet and Îles Kerguelen. Sources preceded with an asterisk (*) are adopted from Chapter 2 (PEIs) of this dissertation. Red coloured sources are krill species, green sources are fish and orange sources are squid.

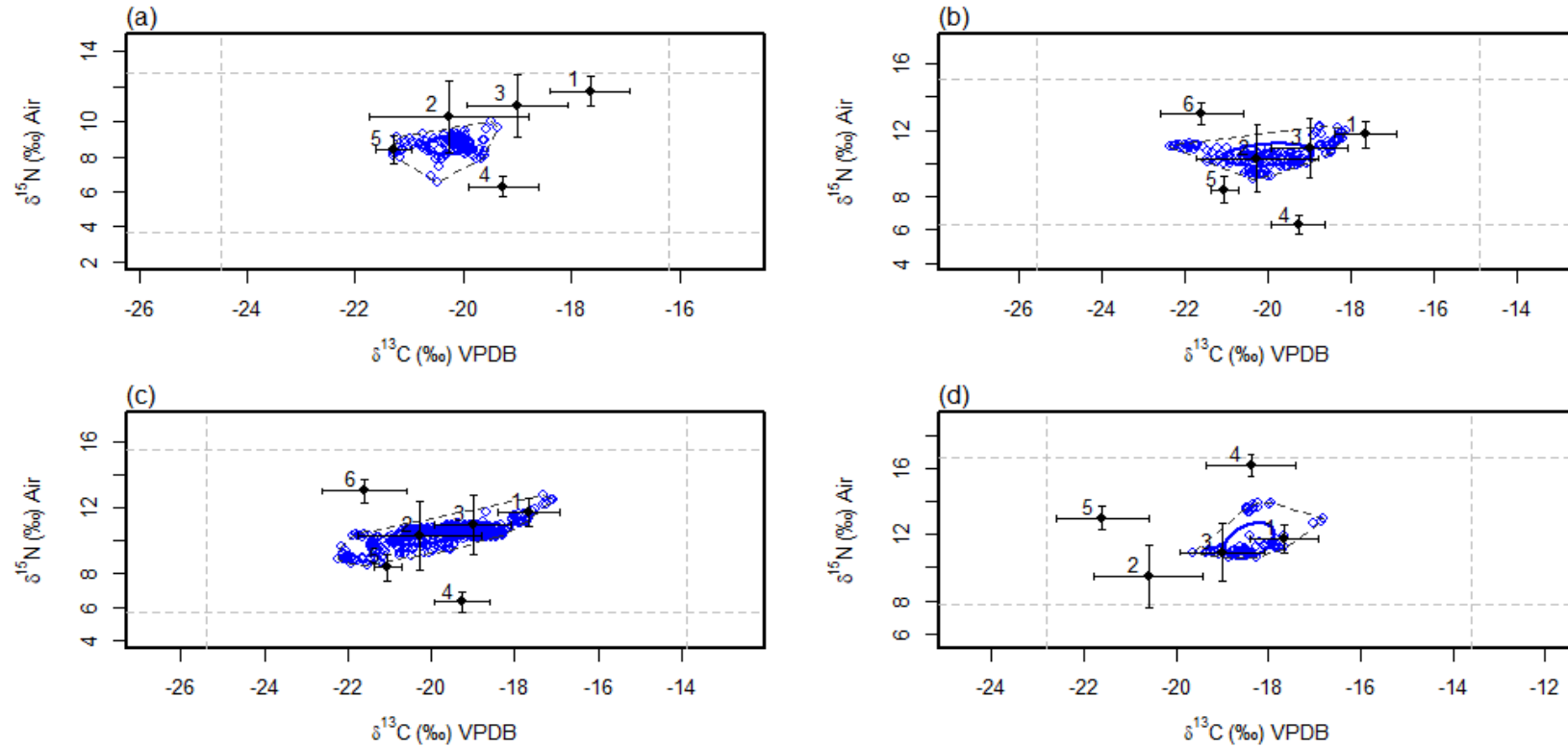
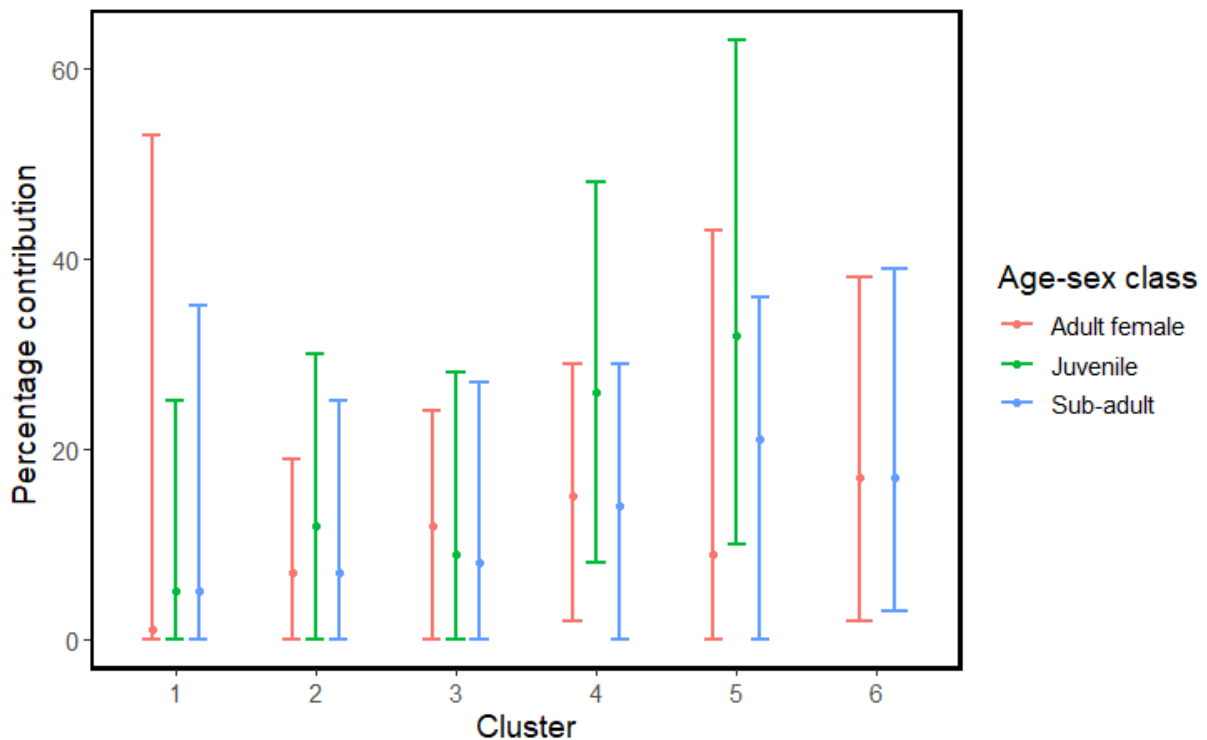
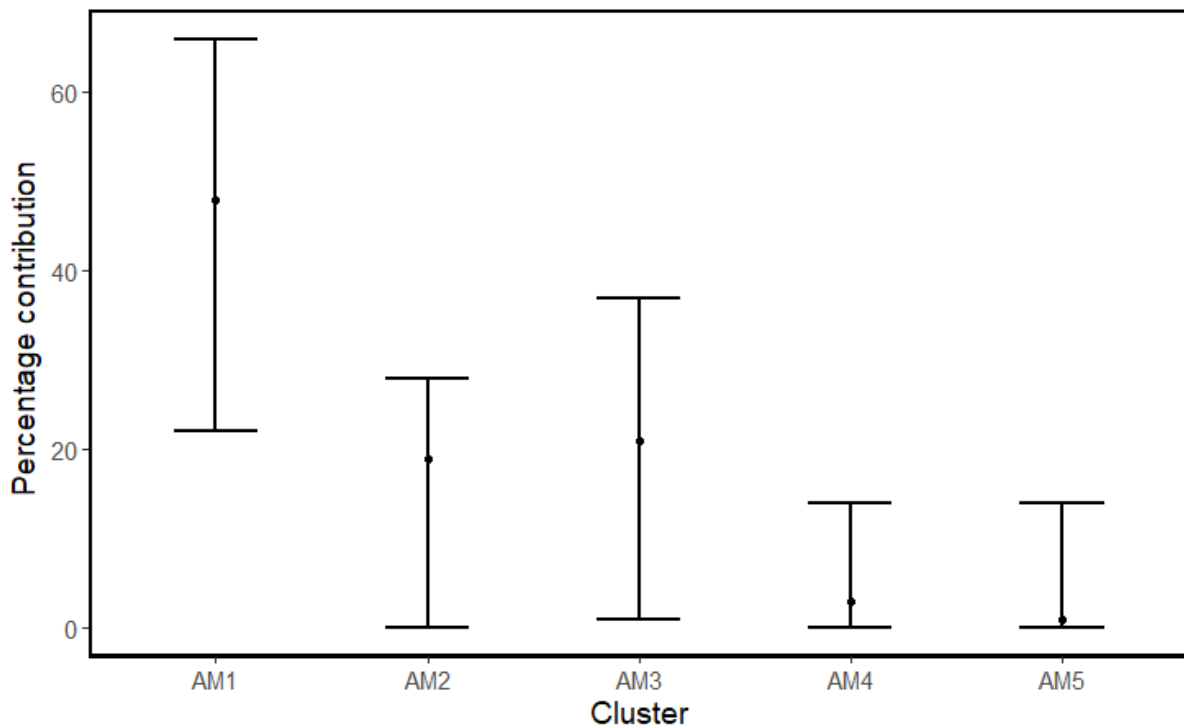


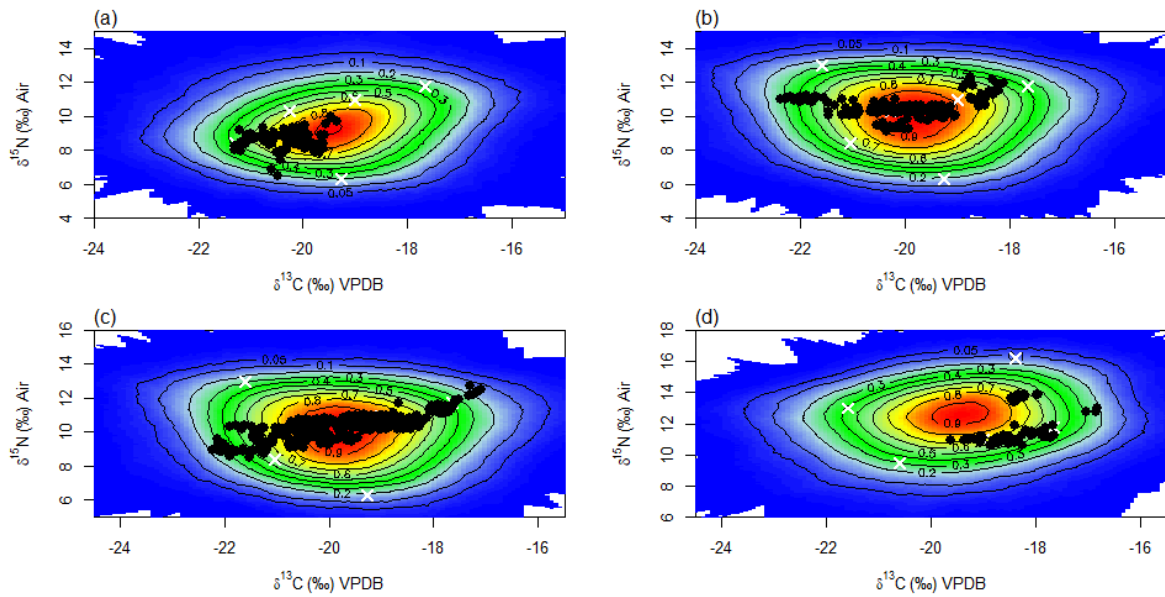
Figure 1: Graphical representation of the bivariate stable isotope mixing space for (a) juvenile, (b) sub-adult, (c) adult female and (d) adult male southern elephant seals (*Mirounga leonina*) at the sub-Antarctic Prince Edward Islands during foraging (fasting excluded). The black squares represent clusters of potential prey values and one standard deviation, after applying the appropriate trophic discrimination factor (TDF), but not incorporating TDF uncertainty (Hobson et al. 1996, Lübcker et al. 2017). The sources in these models include values for fish sampled around the PEIs specifically, and other sources from Îles Crozet and Îles Kerguelen. The dashed grey boxes are the bounds within which potential source values, adjusted for TDF, were considered. The numbers assigned to clusters and its constituents can be found in associated Tables, with source clustering consistent for juveniles (aside from having no cluster 6), sub-adults and adult females. The adult male model considered a different set of sources.



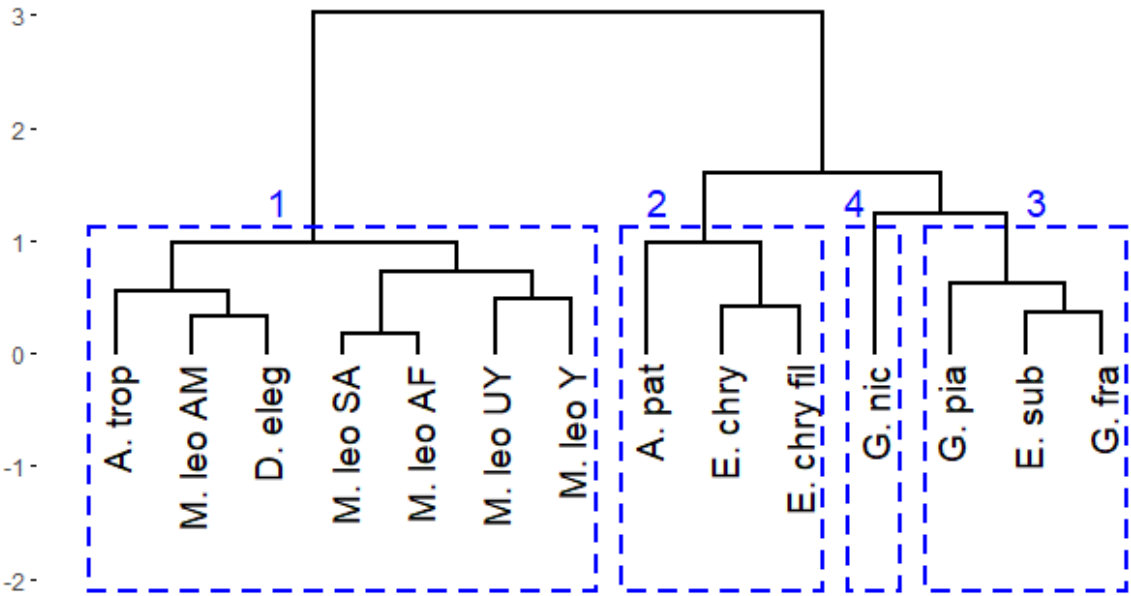
Percentage contributions, mode and 95% credibility intervals, of prey groups to different age-sex classes of southern elephant seal (*Mirounga leonina*) at the sub-Antarctic Prince Edward Islands. The distributions are the frequentist-results of posteriors generated using the *siar* package in R. Modelling for juveniles did not consider a sixth cluster. Adult males are not depicted here, as the clusters for that class were made up differently than for juveniles, sub-adults and adult females.



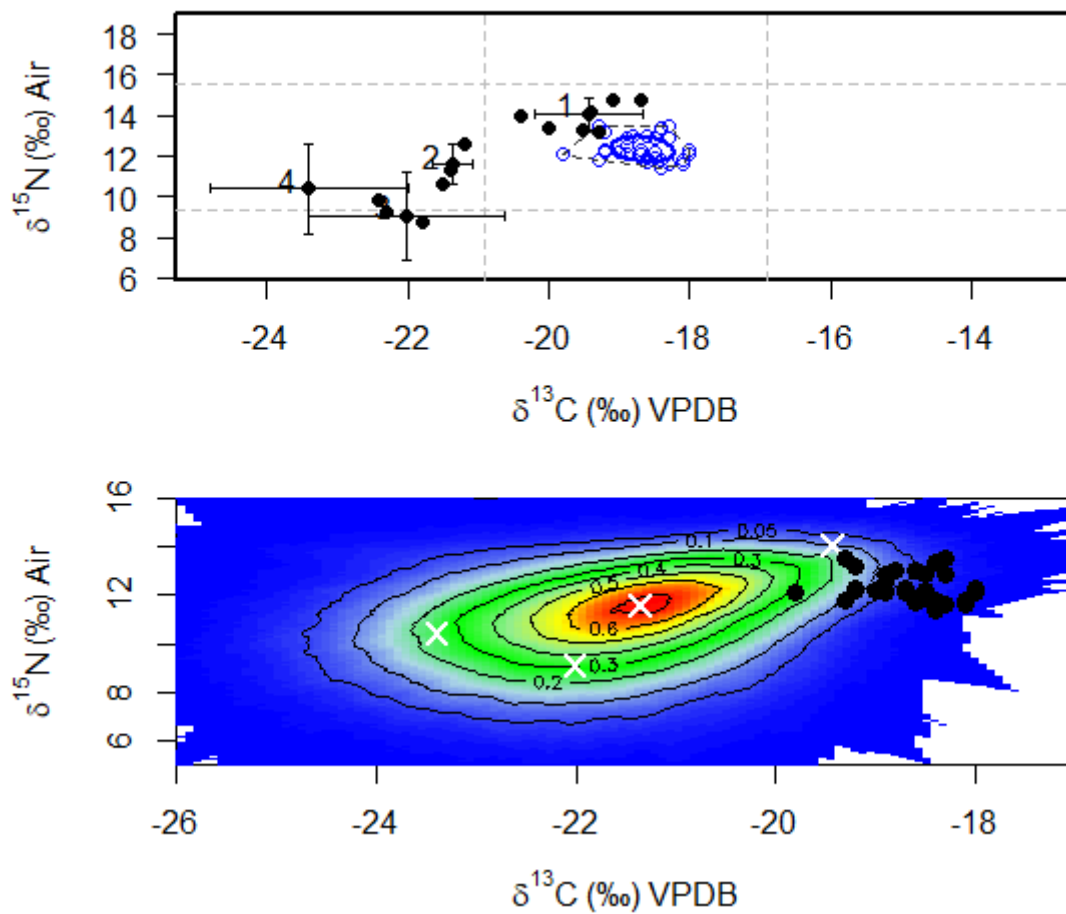
Percentage contributions, mode and 95% credibility intervals, of prey groups to adult male southern elephant seals (*Mirounga leonina*) at the sub-Antarctic Prince Edward Islands. The distributions are the frequentist-results of posteriors generated using the *siar* package in R. Clusters are made up differently to clusters for other age-sex classes, see Figure 6 and Table 10, hence the 'AM' (adult male) denotation in this figure. (See Table 11 for cluster make-up of adult males). When determining relative contribution using simulation modelling, models only indicate the range of mathematical solutions that exist with the sources that are provided and needs to be validated against what is known (Smith et al. 2013, Phillips et al. 2014). As our knowledge of consumers' diets grow, particularly poignant for squid here (Bester & Connan 2022), we can spot and fill gaps in our modelling efforts. The simulation method also weights the outer sources that make up the mixing geometry and devalues 'inner' sources that may be important in reality (Smith et al. 2013). E.g., the contribution of inner clusters 2 and 3 to the diet of sub-adult southern elephant seals may be underestimated relative to outer vertices like clusters 4, 5 and 6 because it is less important in shaping the borders of the mixing space. Yet, it stands to reason that the sources plotting closest to the consumer values are ecologically more closely related, either by overlapping niches or, as inferred in this case, by a strong trophic link (Phillips & Gregg 2003, Moore & Semmens 2008, Parnell et al. 2010, Jackson et al. 2011).



Probability distributions of mixing polygons produced by source clusters of (a) juvenile, (b) sub-adult, (c) adult female and (d) adult male southern elephant seals (*Mirounga leonina*) at the sub-Antarctic Prince Edward Islands. Mixing spaces make use of source values adjusted for trophic discrimination factors (TDFs) between diet and the sampled whiskers tissue (black dots) of seals. Sources were clustered into groups (white crosses), which were similar for juvenile, sub-adults and adult female seals (though juveniles had only five clusters). The composition of clusters is reported in Tables.



Dendrograms indicating the composition of potential prey clusters for killer whales (*Orcinus orca*) at the sub-Antarctic Prince Edward Islands. The constituent species of each cluster and numbers assigned to the clusters can be found in Tables.



Graphical representation of the unresolved stable isotope mixing model for killer whales (*Orcinus orca*) at the sub-Antarctic Prince Edward Islands (PEIs). The black squares represent clusters of potential prey values and one standard deviation, after applying the appropriate trophic discrimination factor (TDF), but not incorporating TDF uncertainty (Hobson et al. 1996, Lübcker et al. 2017). The sources in these models include values for prey sampled around the PEIs specifically. The dashed grey boxes are the bounds within which potential source values, adjusted for TDF, were considered. The numbers assigned to the clusters can be found in Table 12. The lower image shows probability distributions of mixing polygons produced by source clusters of killer whales at the PEIs. Mixing spaces make use of source values adjusted for trophic discrimination factors between diet and the sampled skin tissue (black dots) of killer whales, incorporating uncertainty (1 standard deviation) in both sources and TDFs. Sources were clustered into groups (white crosses), the composition of which is reported in Tables.