The following supplement accompanies the article

Marine predators and phytoplankton: how elephant seals use the recurrent Kerguelen plume

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Supplementary Material

1. Deployment and tag specification details

Thirty-eight female SES were captured at Iles Kerguelen (49°20´S, 70°20´E) during October/November prior to their post-breeding trip from 2010 and 2013 (Table 1). The seals were approached by foot and temporarily restrained with a head bag and anaesthetised intravenously with a 1:1 mixture of Tiletamine and Zolazepam (0.5 mg kg^{-1}) [1]. All seals were equipped with either a GPS logger (n=23) or an Argos transmitter (n=15) (SPLASH10-Fast-Loc GPS/Argos, Wildlife Computers), in addition to a time-depth and accelerometer data logger (MK10-X or TDR10-Daily Diary, Wildlife Computers). Devices were attached to the head (except for TDR10-Daily Diary tags that were attached to the dorsal midline between the scapulae) using a two-component industrial epoxy (Araldite AW 2101) [2]. Seals were observed during recovery from anaesthesia and allowed to enter the water when no longer sedated. Data loggers were retrieved by repeating the above restraint procedures at the end of the 2 – 3 month foraging trip once the seal had hauled out on land. The tracking devices/data loggers or attachment method did not adversely affect individual performance and fitness over the short (seal growth) or long (seal survival) term [3].

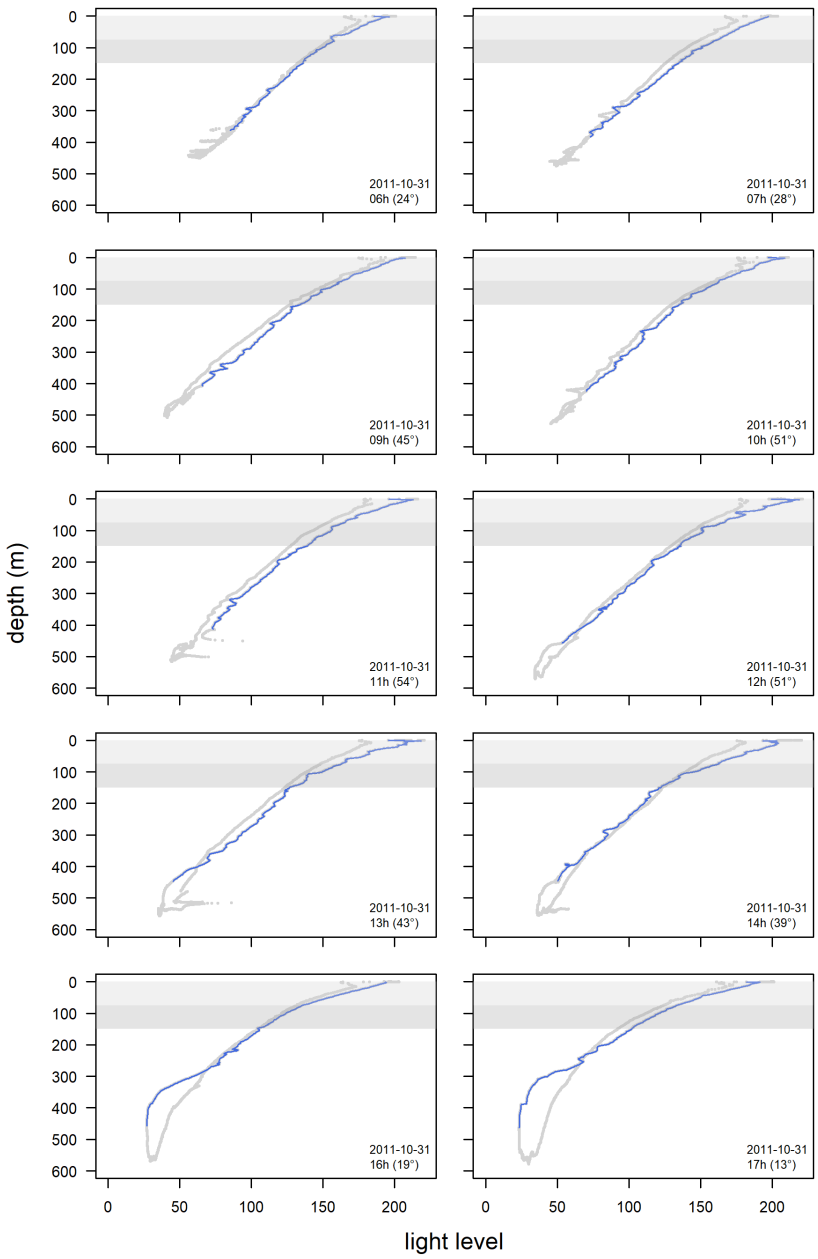
Tags do suffer from temporal drift, though its affect is considered negligible because accelerometers only record over a relatively short period of time (*e.g.* tags drift less than 2 s and 6 Hz over a 2 month period, per. comm. Baptiste Picard). Depth measurements were made by a pressure transducer calibrated by the manufacturer (± 1 m). Light level values (W cm^{-2}) were converted using on-board logarithmic conversion algorithms (per. comm. Wildlife Computers) to compress the light measurements to a 3 digit value, and increase the resolution at lower light levels. The light sensors were able to identify dawn/dusk events [for details see 4] down to 300 m in clear waters and were temperature-compensated for the entire light level range (per. comm. Wildlife Computers). The wavelength at the centre of the light sensor parabolic-shaped pass-band filter is ~430 nm and consequently the sensor only read the violet/blue light band (370 nm – 470 nm). All other bands of light were rejected and not measured. The light sensor measured on a scale of 20 readings per decade, so the light level error is considered to be $1/20^{th}$ of a decade.

2. Prey encounter events

Only movement events that could be detected simultaneously on the 3 axes were considered as true prey encounter events (PEE); others were considered to correspond with transit activity within the dive. Movement events (or PEE) were detected either from head- (MK10-X) or back-mounted (Daily Diary tags) devices; detection of PEE using data from either device is consistent with one another (C. Guinet unpublished data). Prey encounter events separated by periods longer than 1 s were considered an independent PEE and were calculated for each dive and its bottom phase.

3. Light-depth profiles

Examples of light levels plotted as a function of depth for 10 dive records: full dive (grey line) and dive ascent (blue line). Shaded areas indicate the euphotic zone: upper euphotic layer (light grey) and lower euphotic layer (dark grey). Dives recorded on 31-10-2011 at 06 h, 07 h, 09 h, 10 h, 11 h, 12 h, 13 h, 14 h, 16 h and 17 h (local time). Light level is related to blue light intensity (W cm^{-2}). Calibrations are checked at levels 10^{-5}, 10^{-7} and 10^{-9} W cm^{-2}, which correlates to light levels at 150, 110 and 70 respectively (see O'Toole et al. 2014).



4. Identify mesoscale patches of phytoplankton estimates from light data

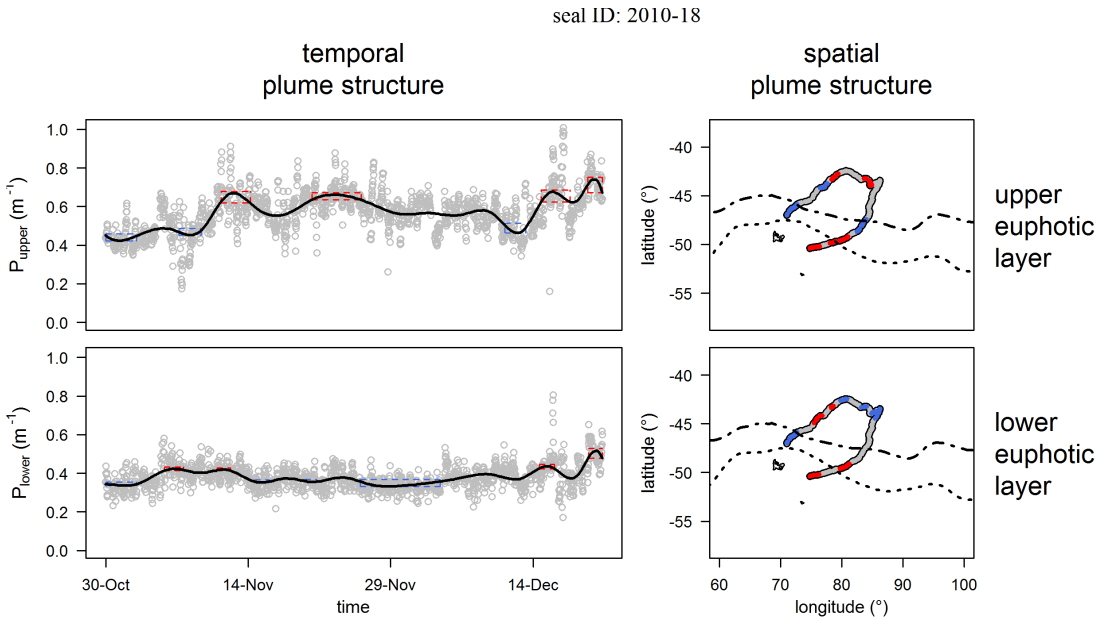
We identified dives associated with each trough and peak value encountered along each trip. Each peak event, which we considered to be a high-density patch, included all dives bound by the adjacent troughs with predicted plankton values greater than 75 percent of the peak predicted plankton value; all remaining dives were grouped into low-density patches (*see* figure S1). Along each seals' track we used fitted plankton values (P_{upper} or P_{lower}) from our cubic smoothing analysis to reveal multiple meso-scale patches associated with high- and low-density plankton values along seal tracks. We calculated the mean values of high- and low-density plankton patches for each seal. Mean patch values above the overall mean high-density plankton patch threshold were considered key high-density plankton patches, and mean patch values below the overall mean low-density plankton patches threshold were considered key low-density plankton patches; repeated also for the lower euphotic layer (see plots in Appendix 6).

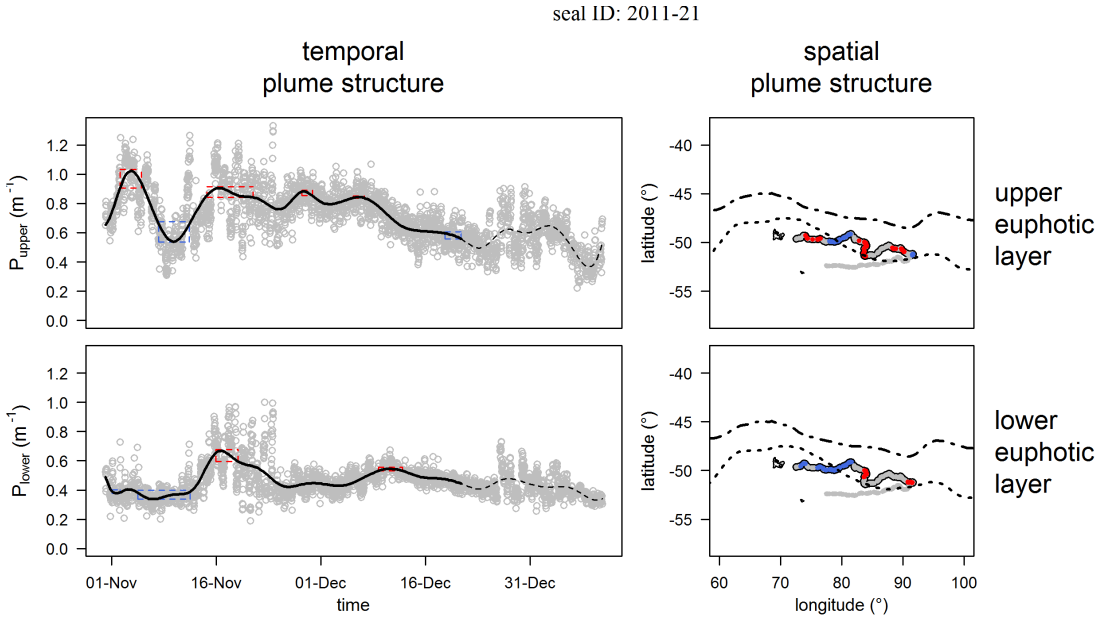
5. Elephant seal response to mesoscale patches of phytoplankton

```
## Permutation test
## Tests H0: two groups have the same distribution
## Against H1: the two groups have difference distributions
## Ref Phillip Good, Permutation, Parametric, and Bootstrap Tests of Hypothesesd$group[d$ptype=="LowDensity"] <- 1
d$group[d$ptype=="HighDensity"] <- 2

r <- 500
diffs <- double(r)
diff0 <- mean(d$max_depth[d$group==1])-mean(d$max_depth[d$group==2])
for(k in 1:r) {
g <- sample(d$group)
diffs[k] <- mean(d$max_depth[g==1])-mean(d$max_depth[g==2])
}

pval <- sum(abs(diffs) > abs(diff0))/r
```

6. Phytoplankton densities encountered along the track of each seal

Phytoplankton densities were estimated for the upper and lower euphotic layer in time and space. Temporal plume structure (*left*) is represented by dive-scale plankton density estimates (grey points) and the smoothed trend (black line: solid – accelerometer data; dashed – accelerometer data unavailable). Red boxes represent high-density plankton patches and blue boxes represent low-density plankton patches. Spatial plume structure (*right*) is represented by high- and low-density plankton patches in respect to corresponding seal tracks (grey line) and accelerometry data (grey line highlighted by black). Fronts include the sub-Antarctic Front (SAF – dotted-dashed) and Polar Front (PF - dotted).





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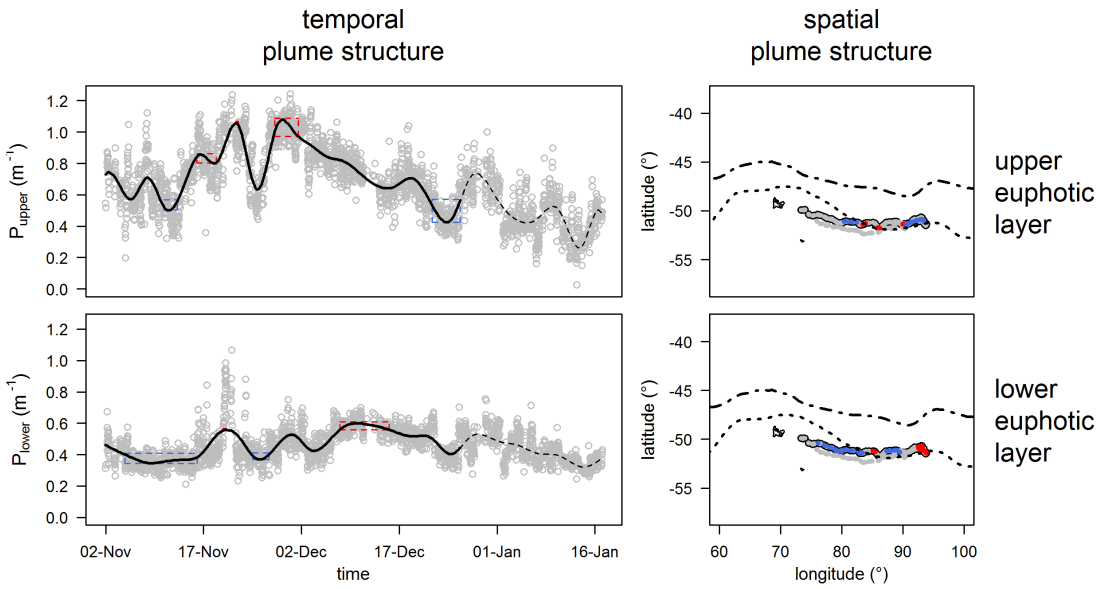

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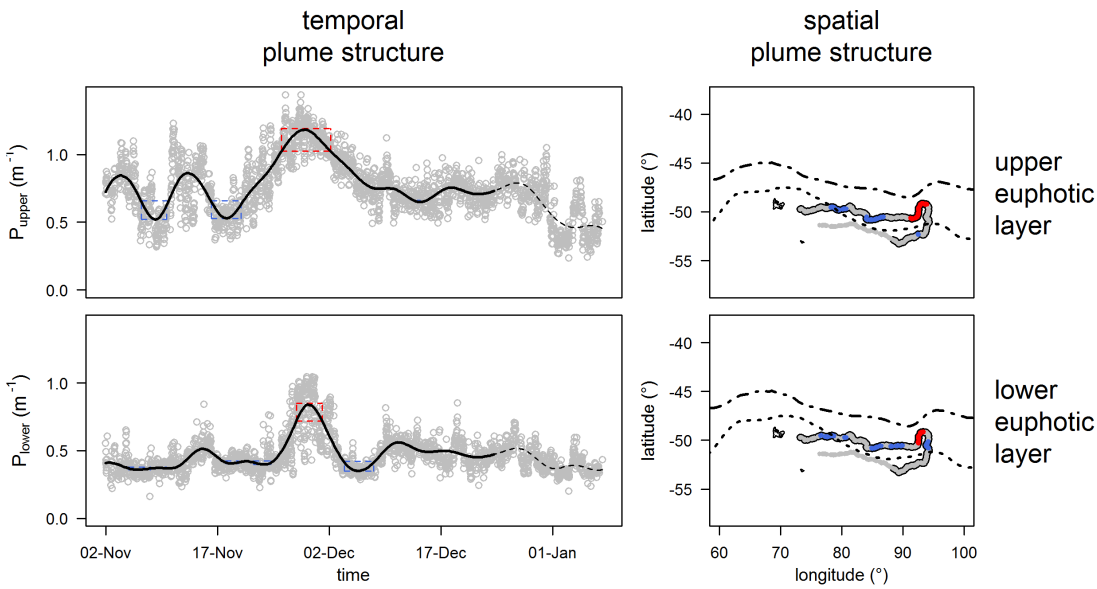

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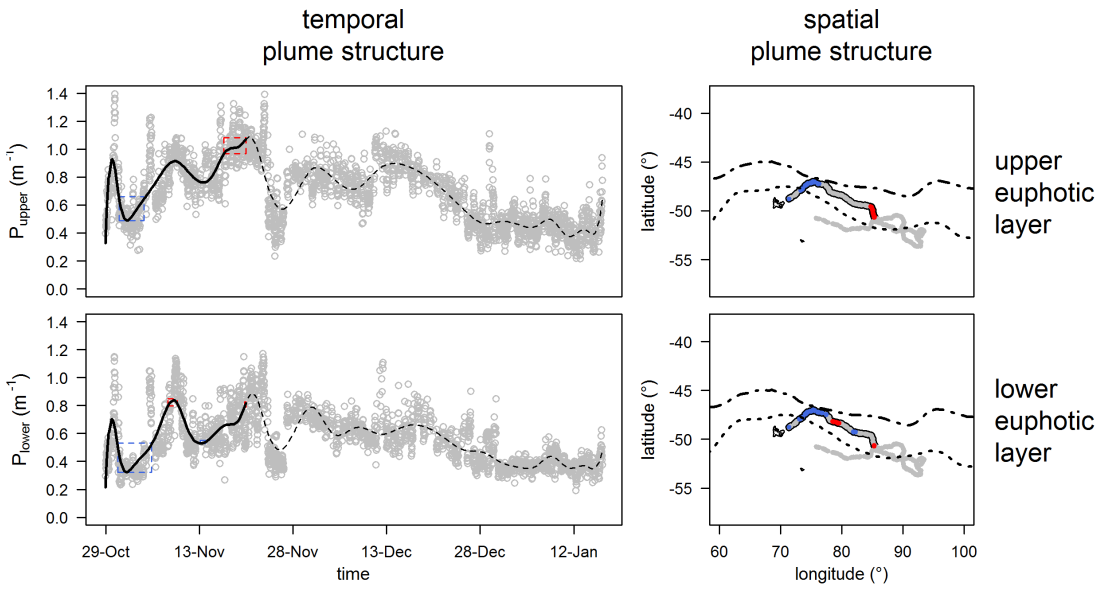

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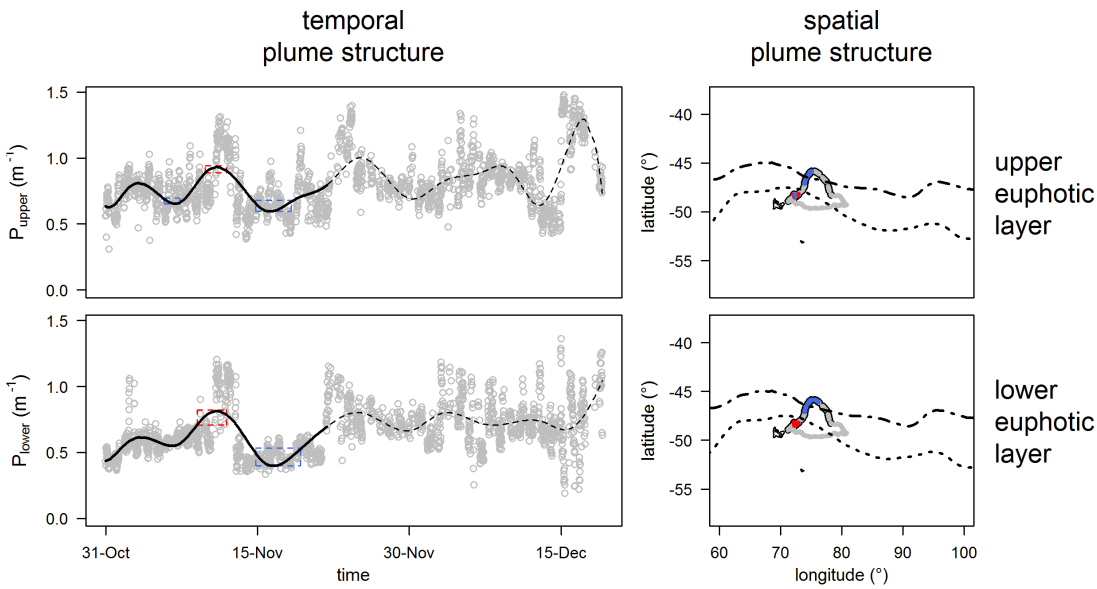

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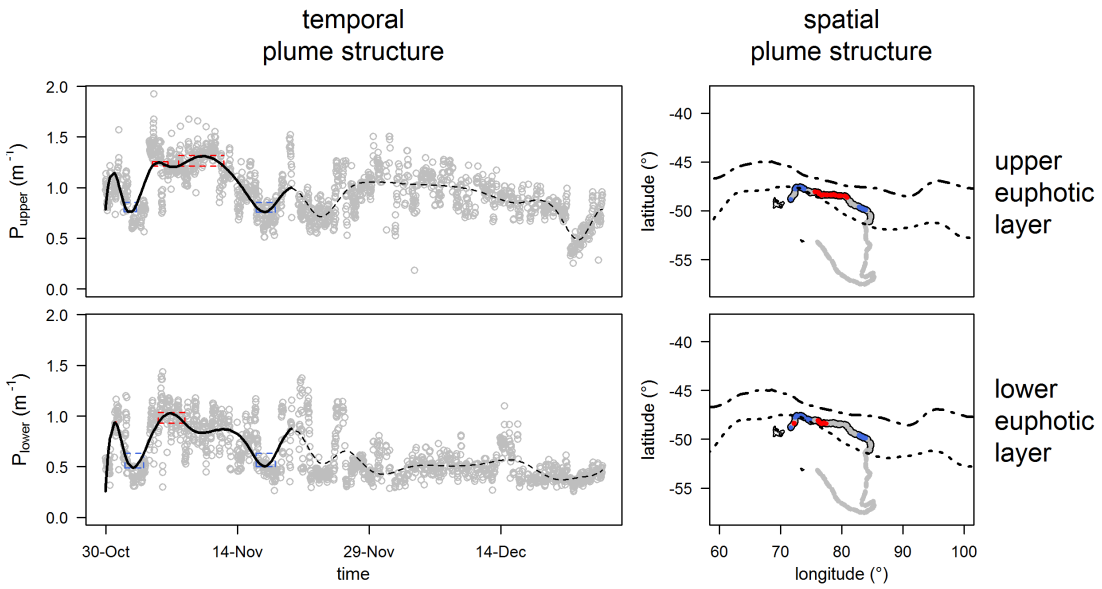

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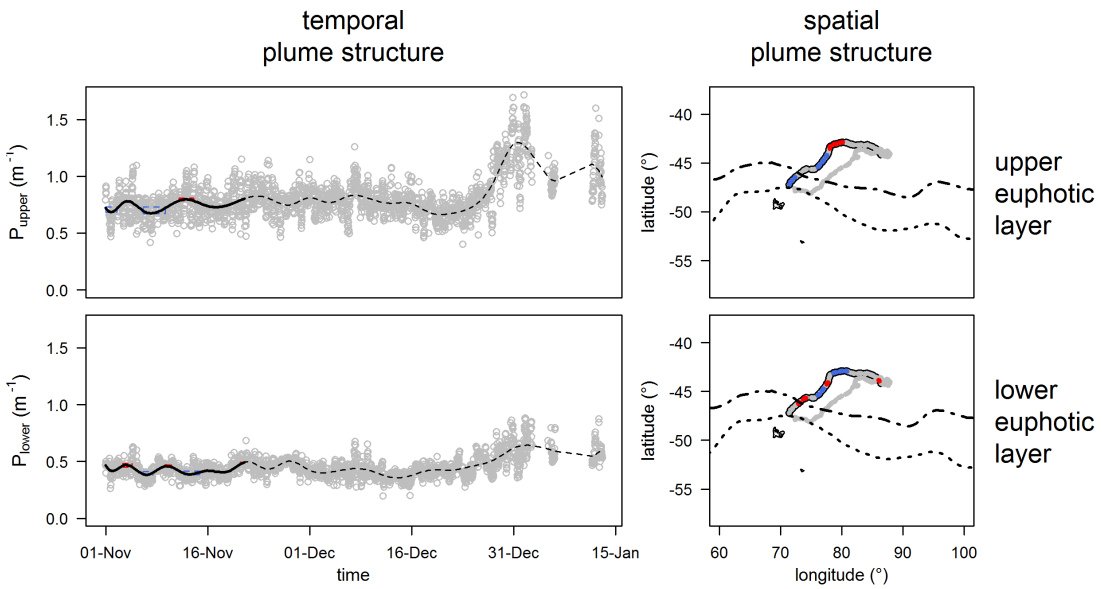

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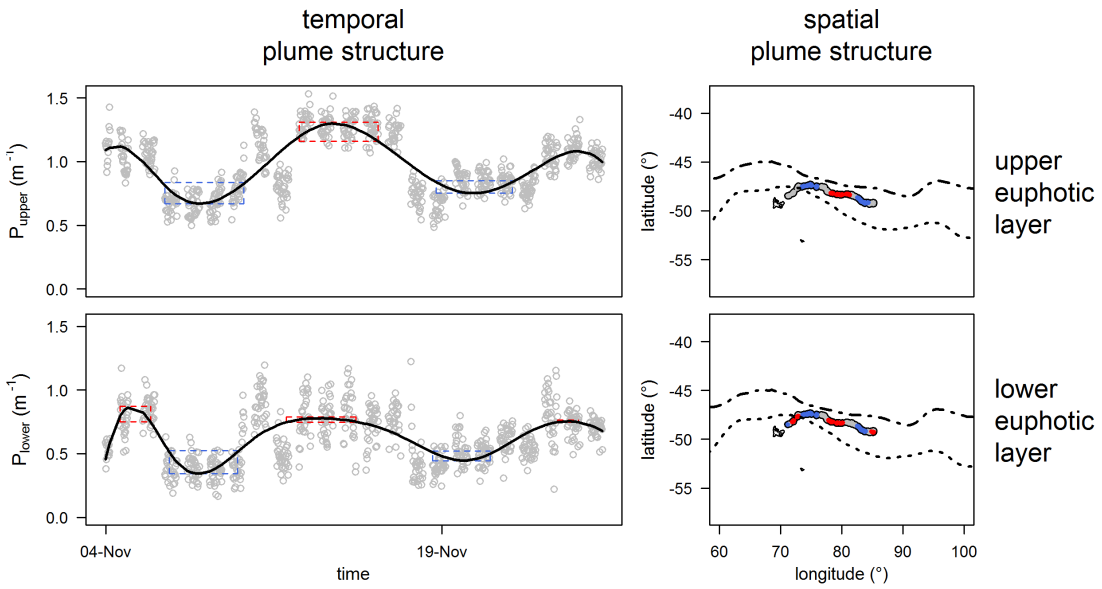

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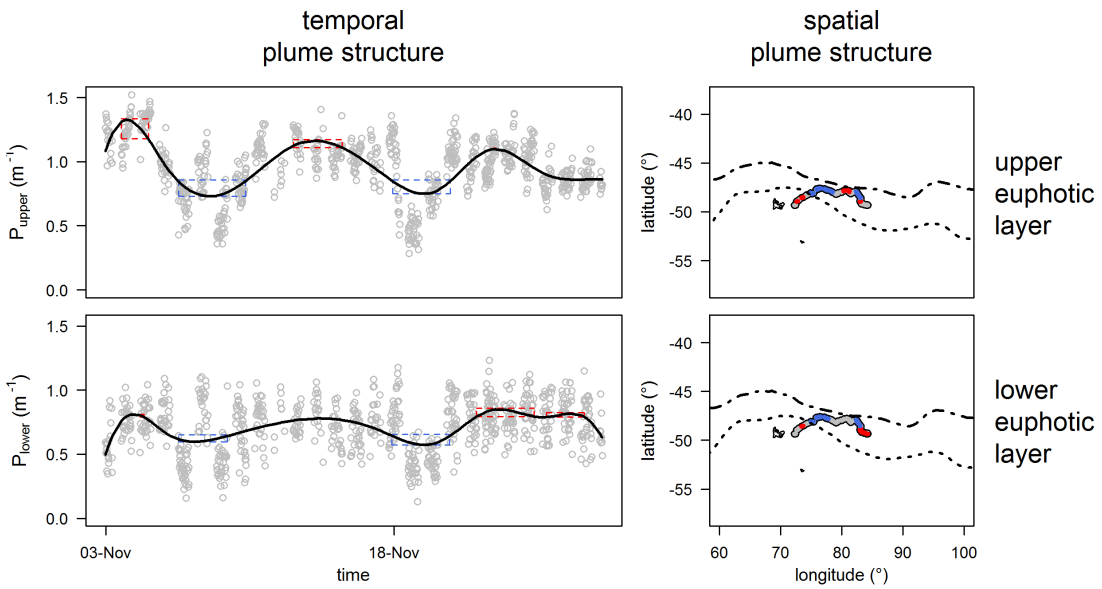

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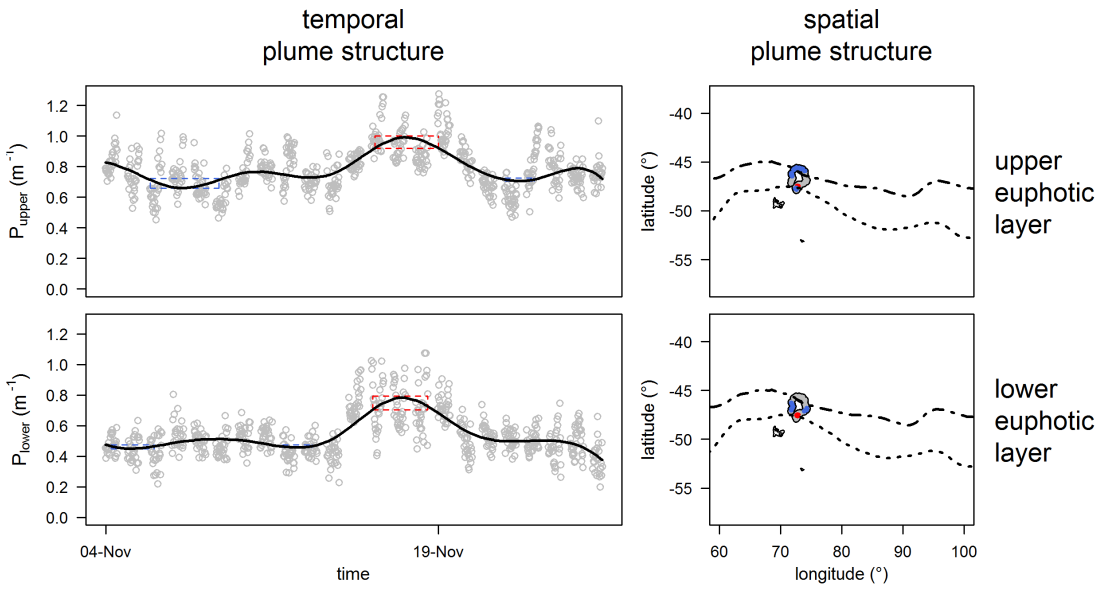

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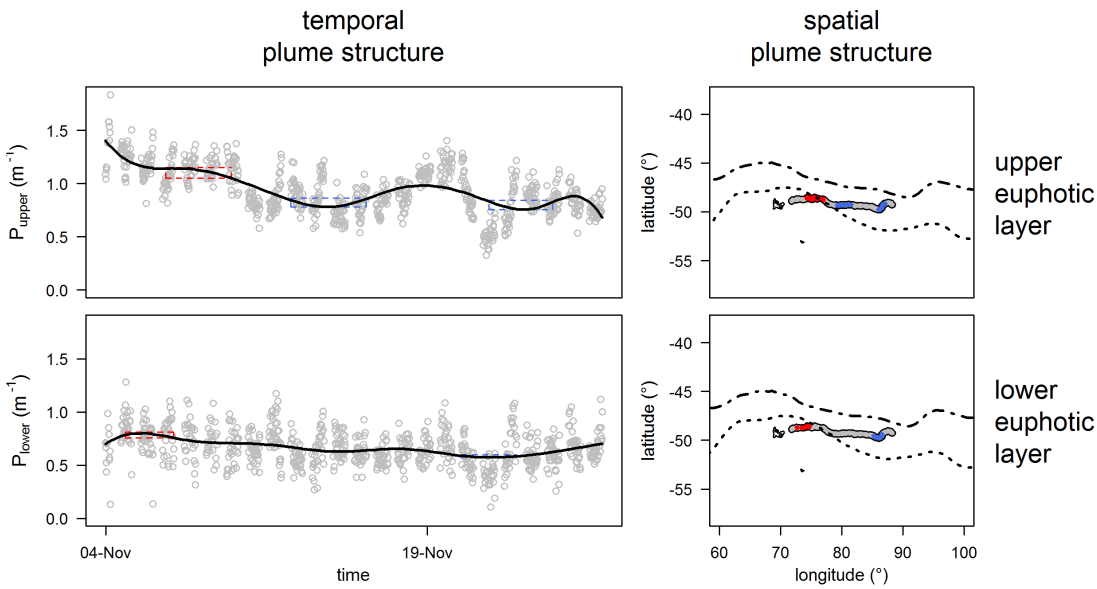

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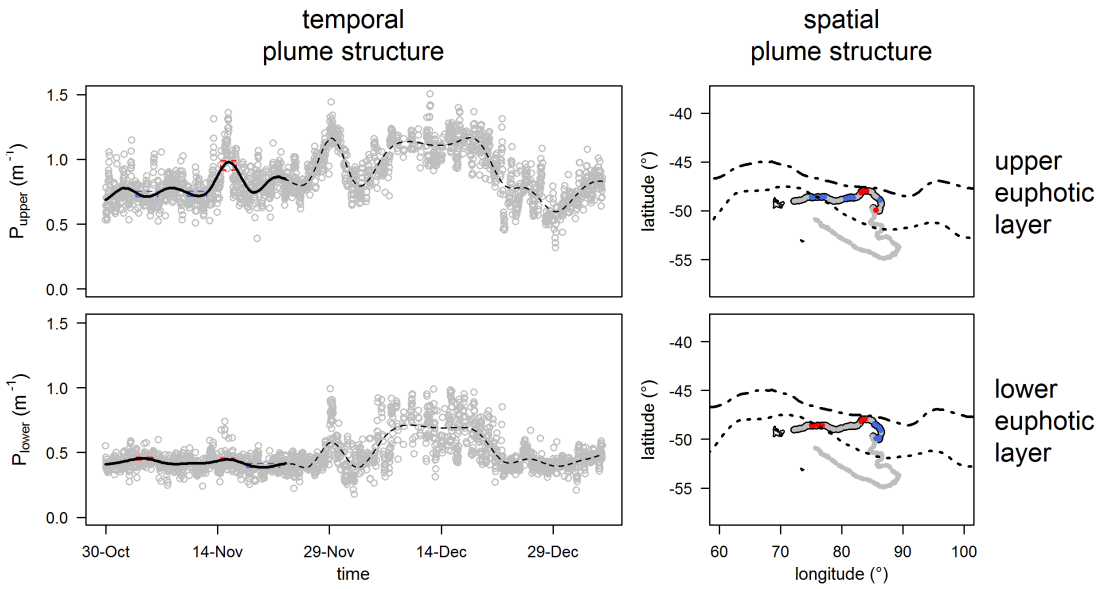

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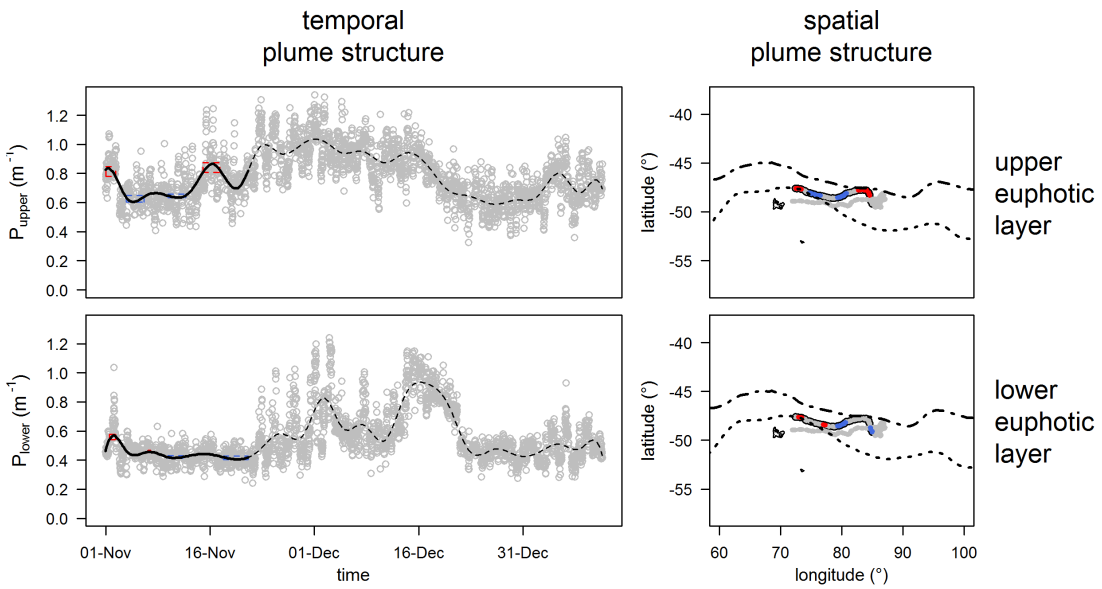

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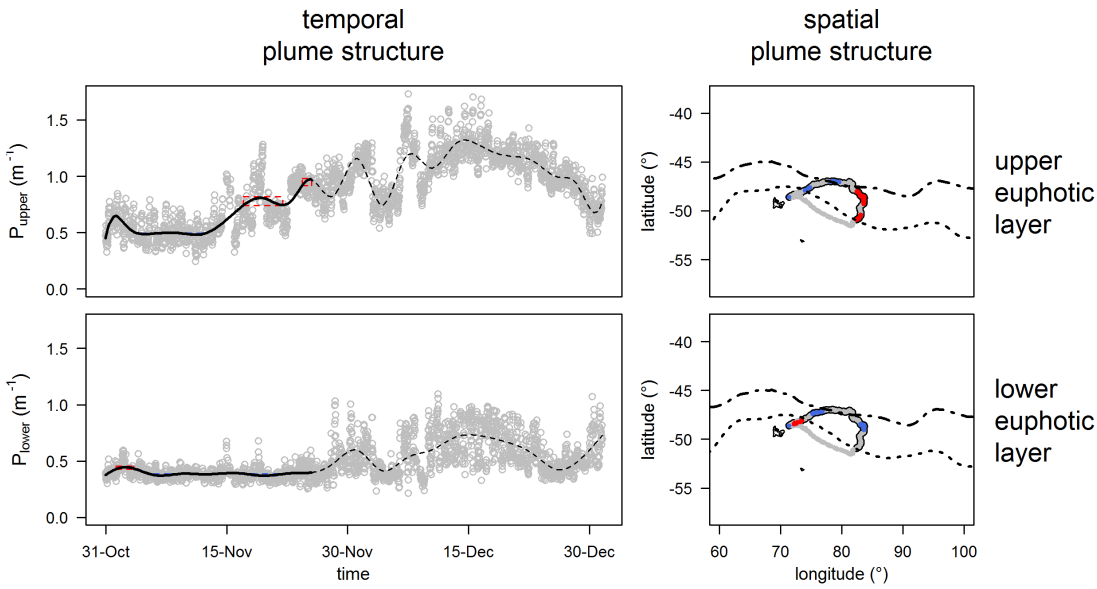

7. Behavioural differences between patches of dense and low density phytoplankton

Prey encounter events (PEE; *left plots*) and dive depth (Depth; *right plots*) differences in dense patches of phytoplankton (red) and low density patches of phytoplankton (blue). Differences are represented in the upper euphotic layer (*top plots*) and lower euphotic layer (*bottom plots*). Analysis includes data from all each seal during daylight hours (see methods for definition).

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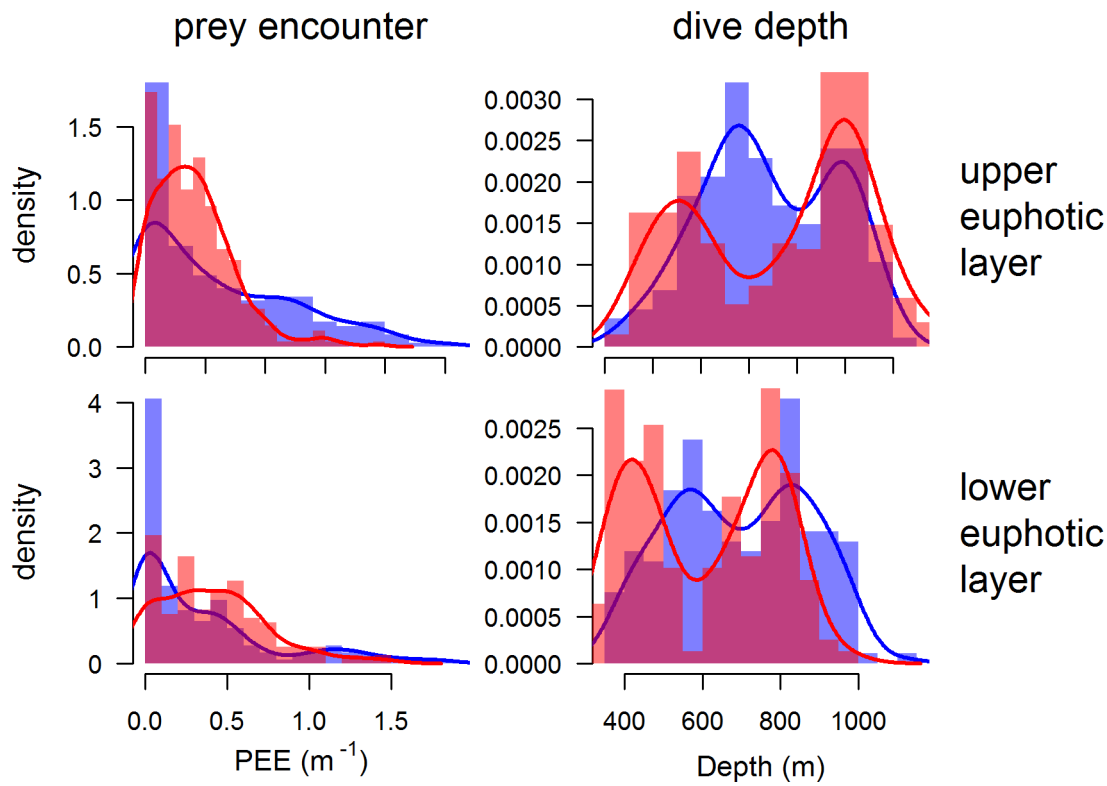

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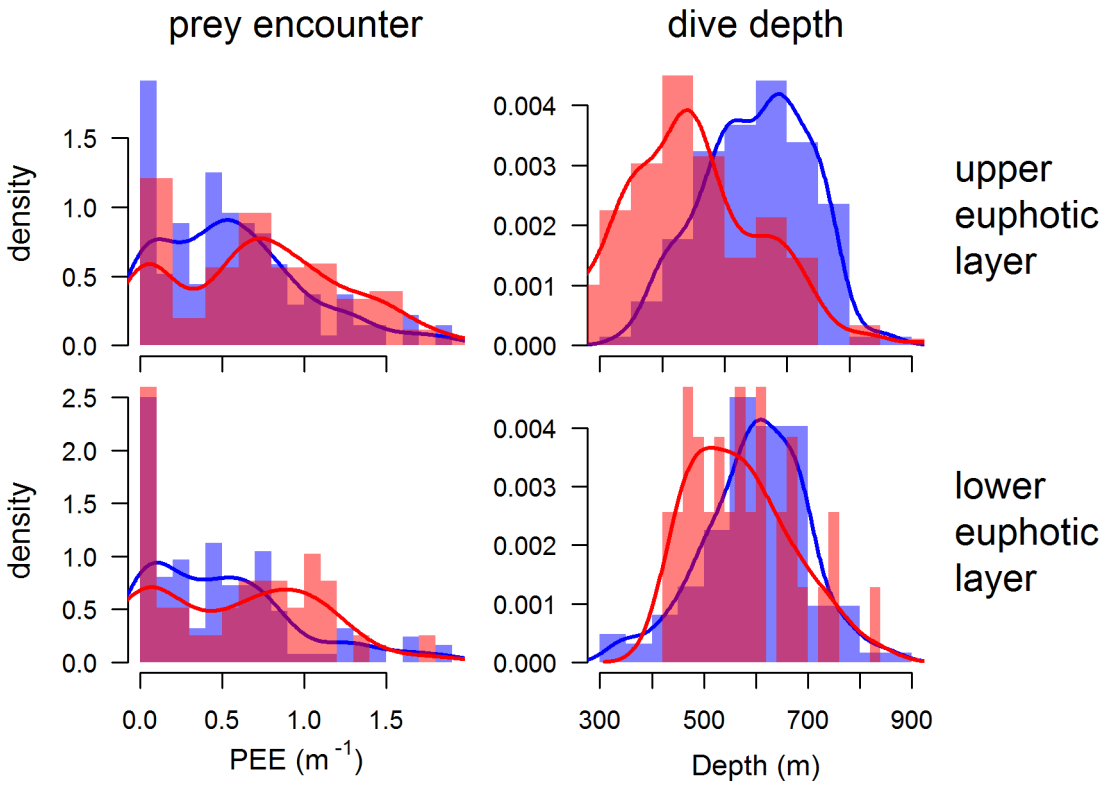

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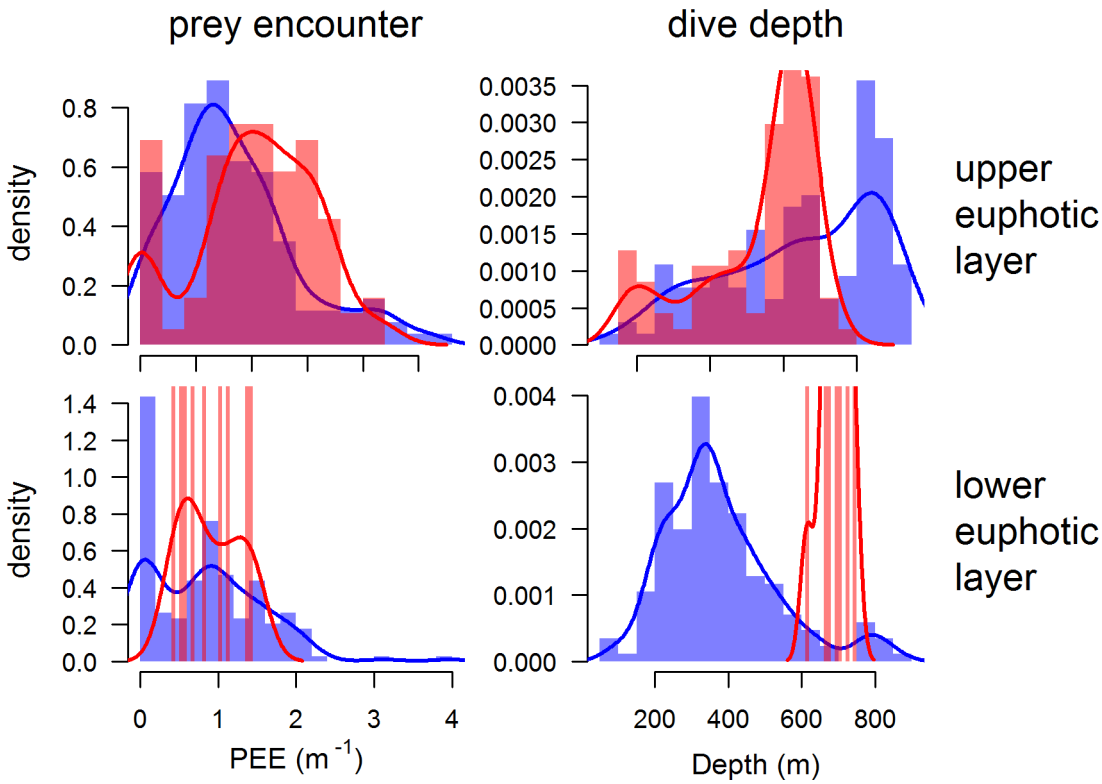

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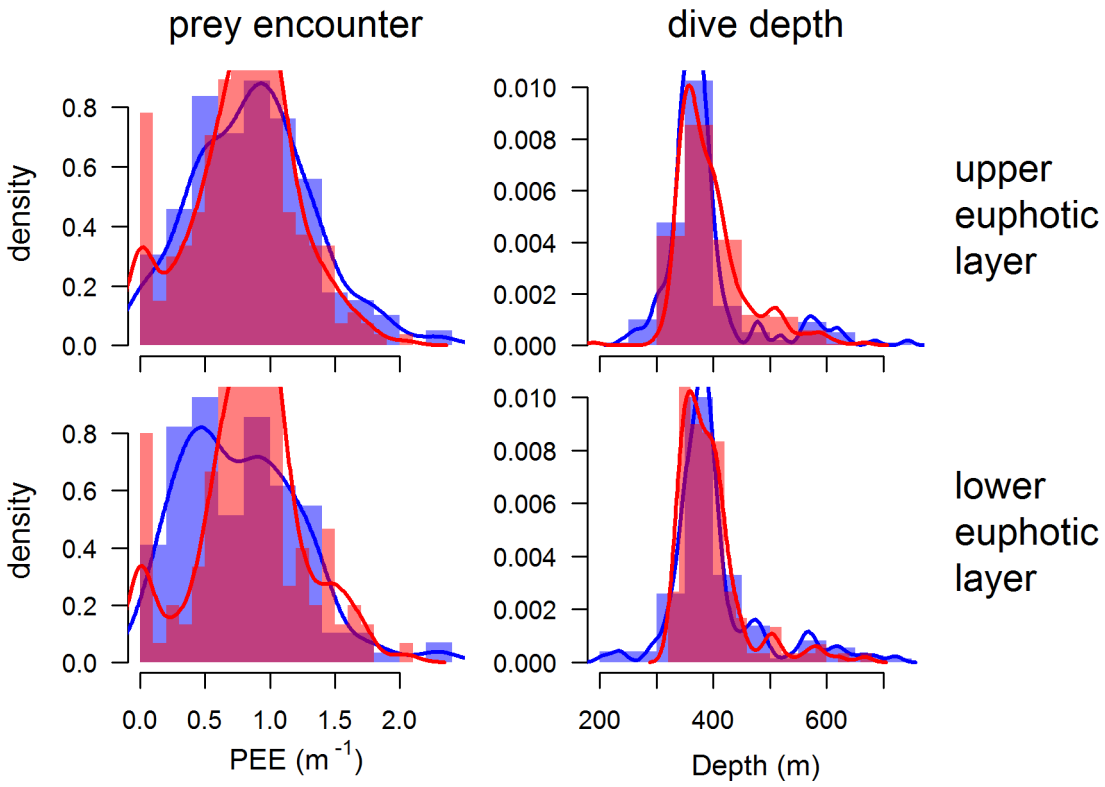

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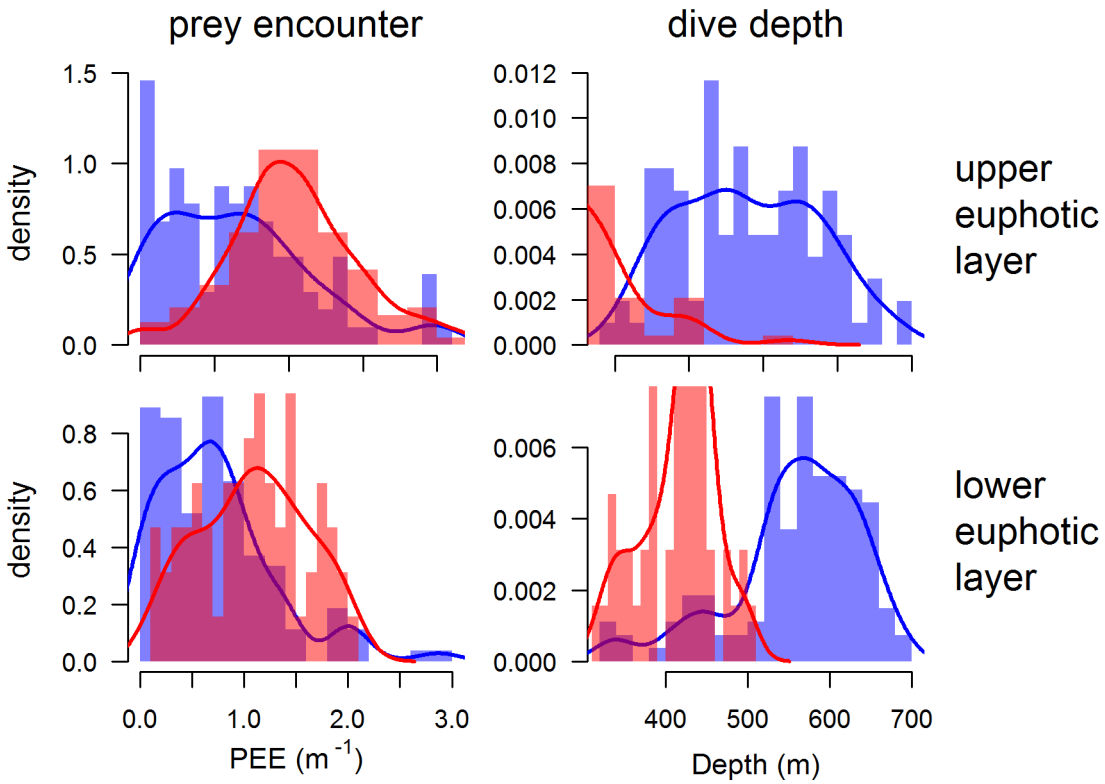

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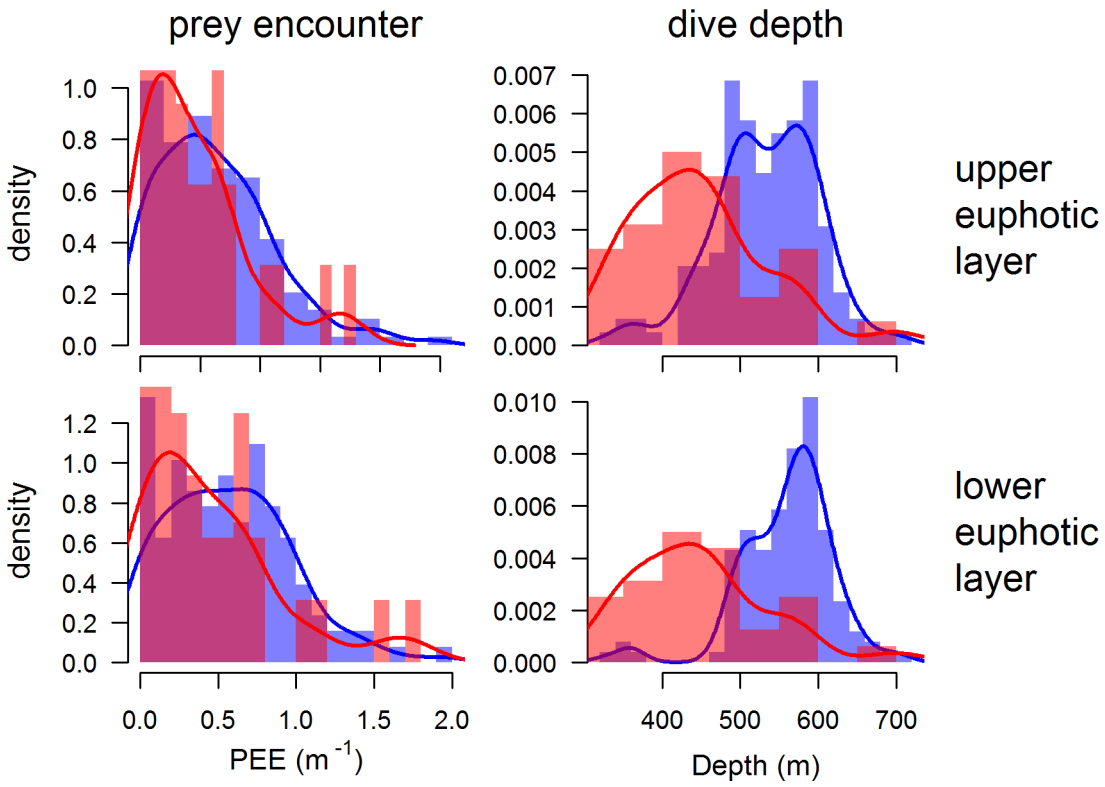

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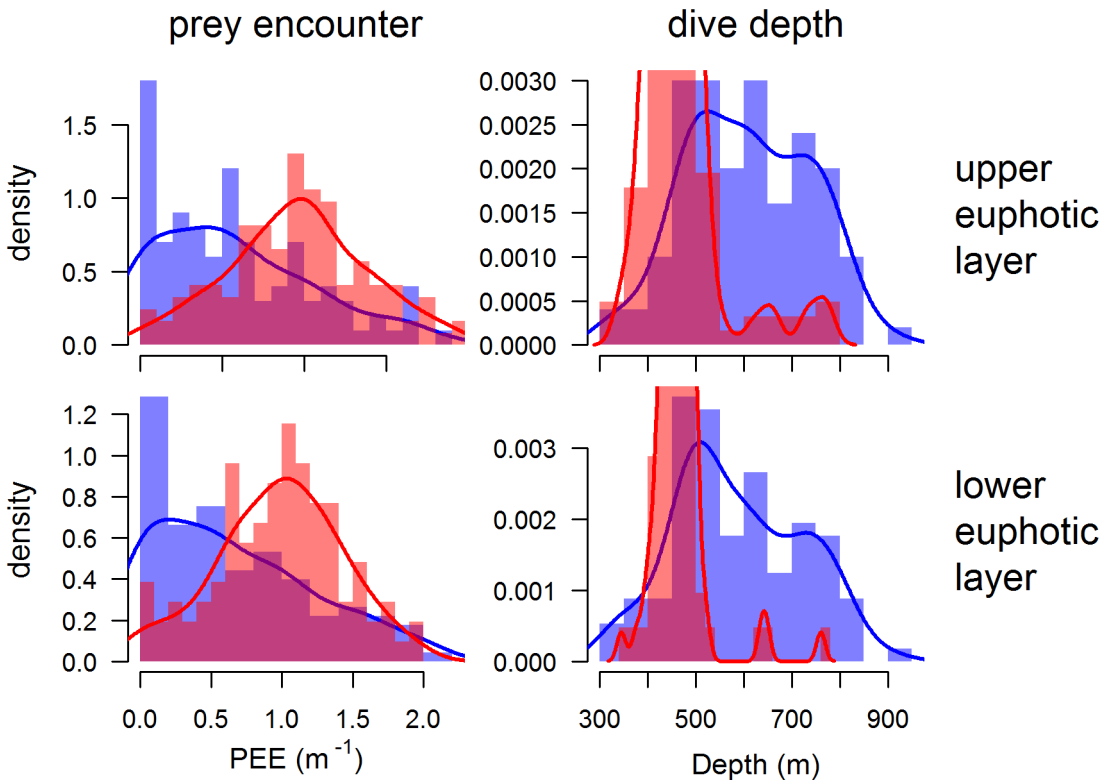

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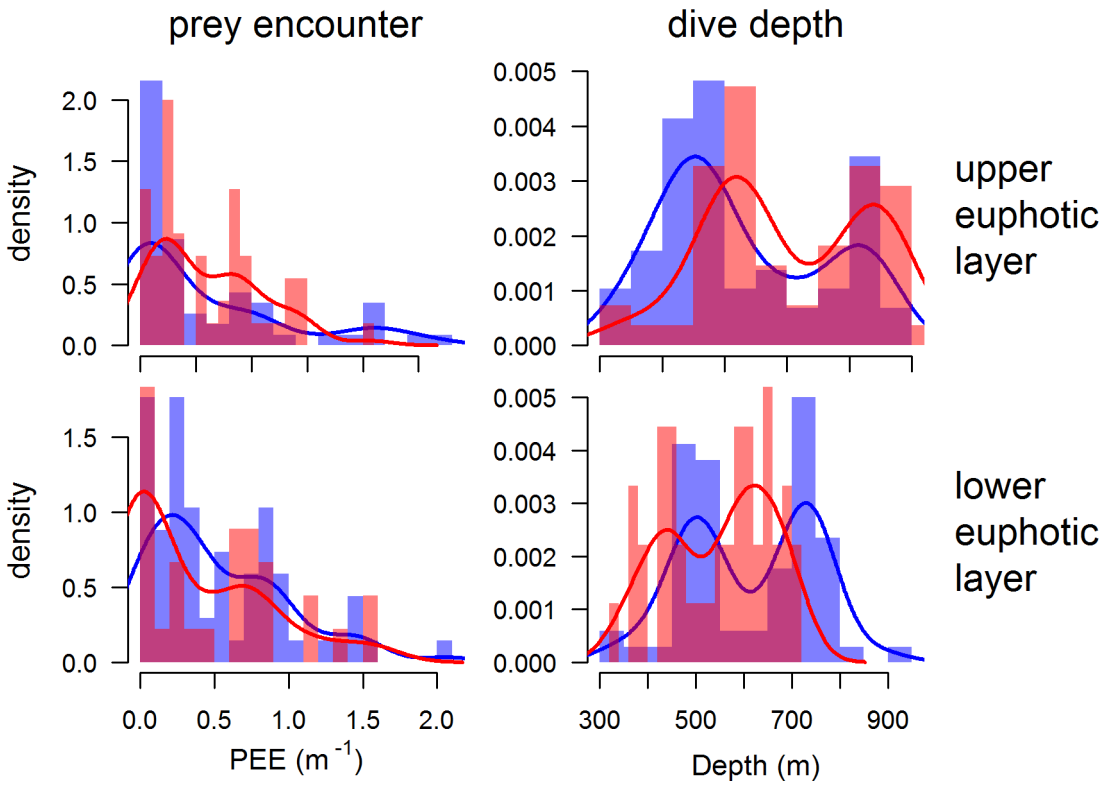

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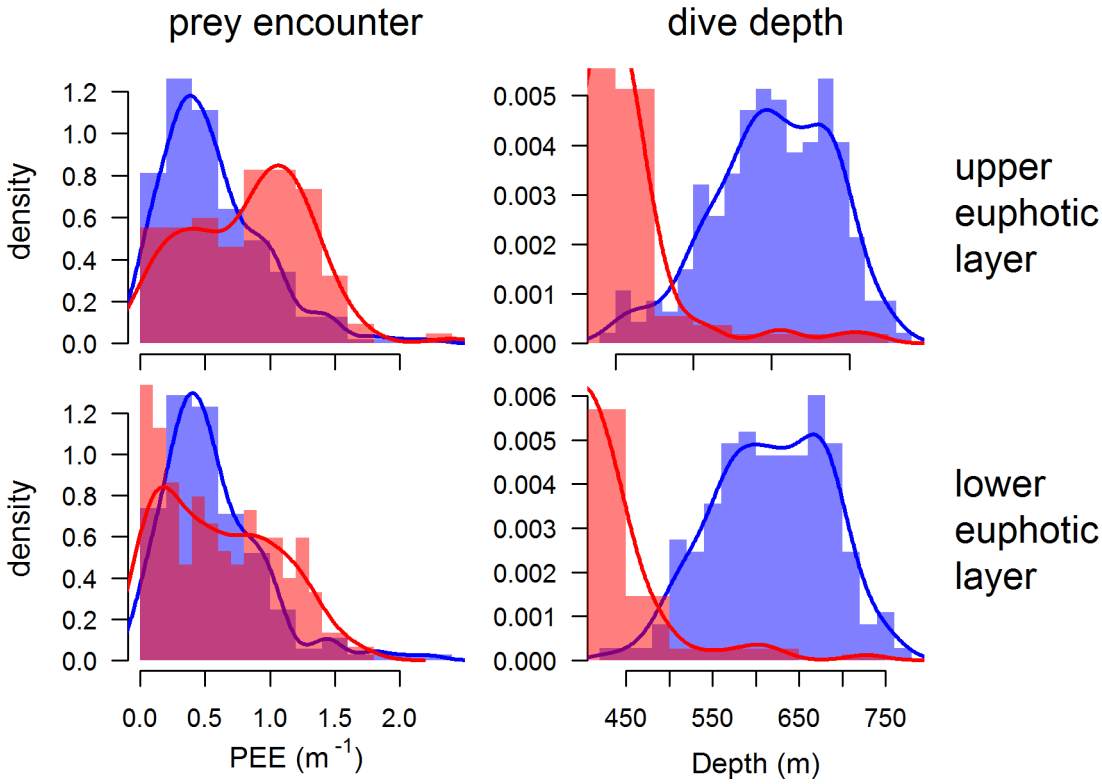

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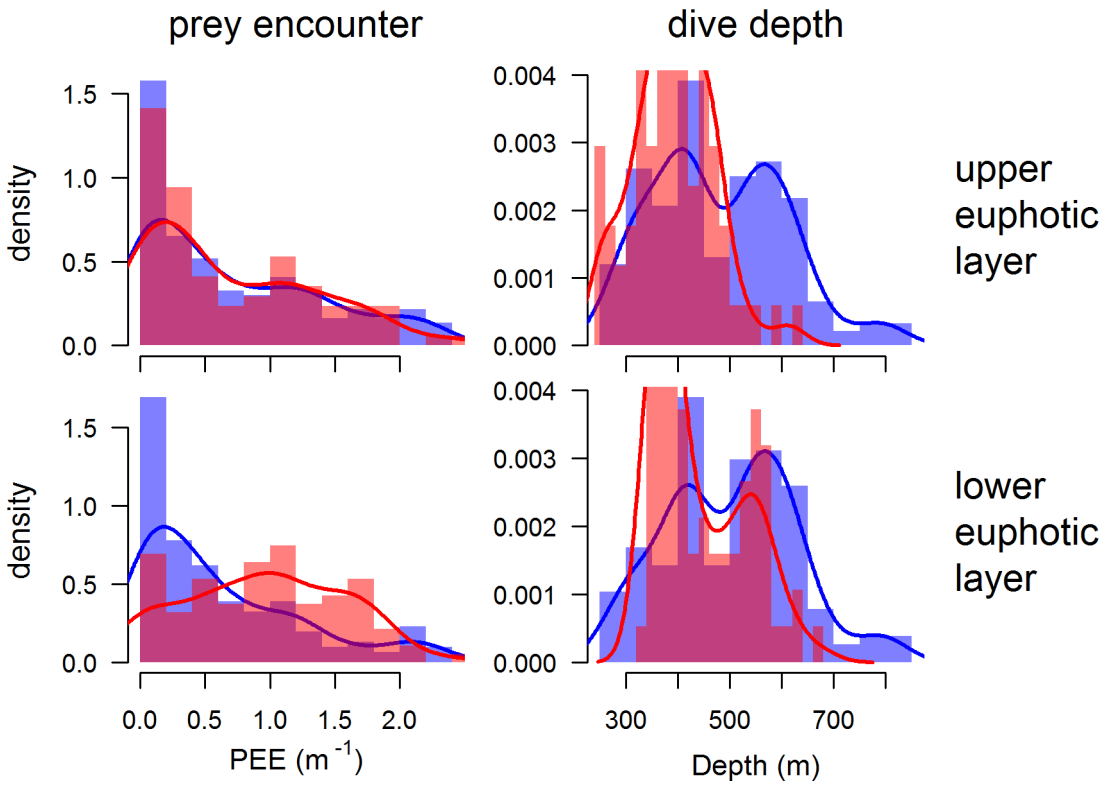

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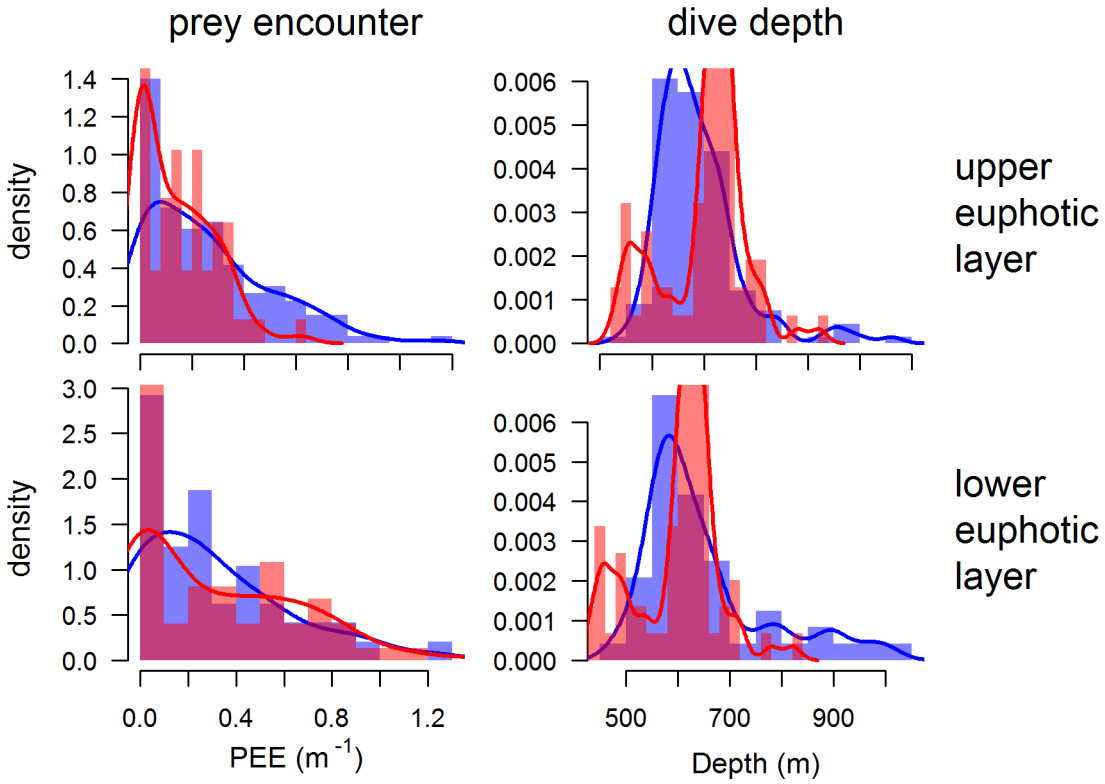

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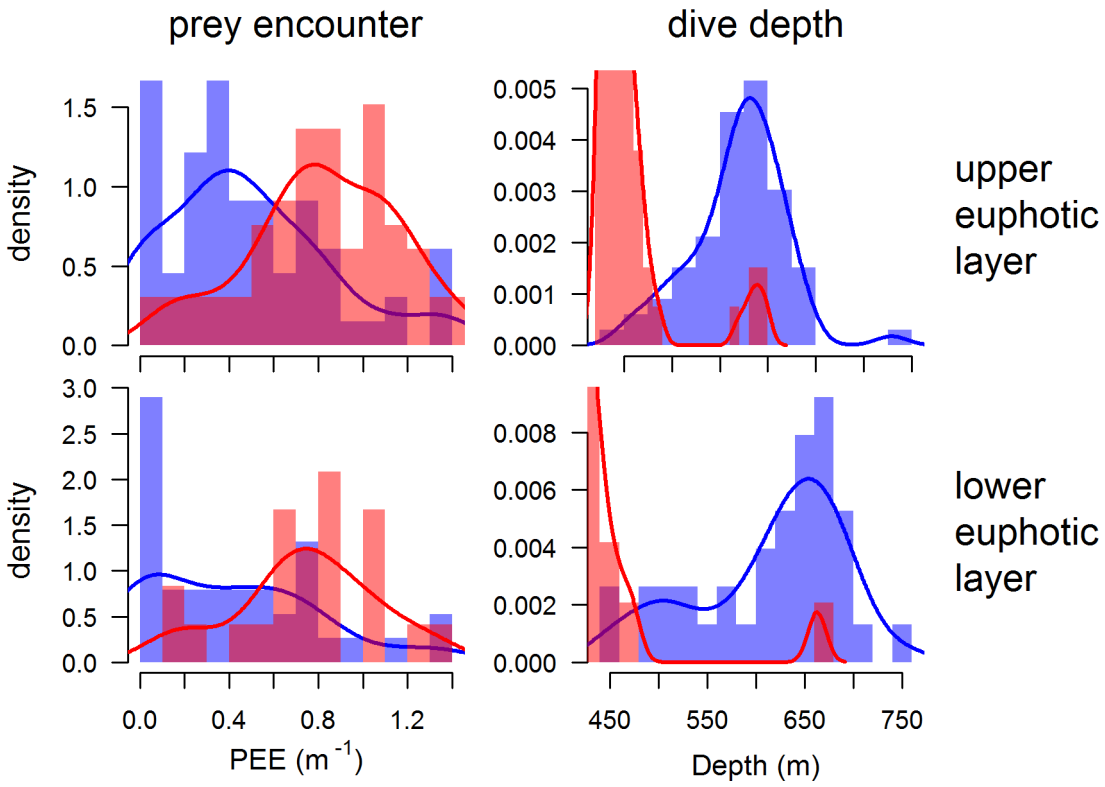

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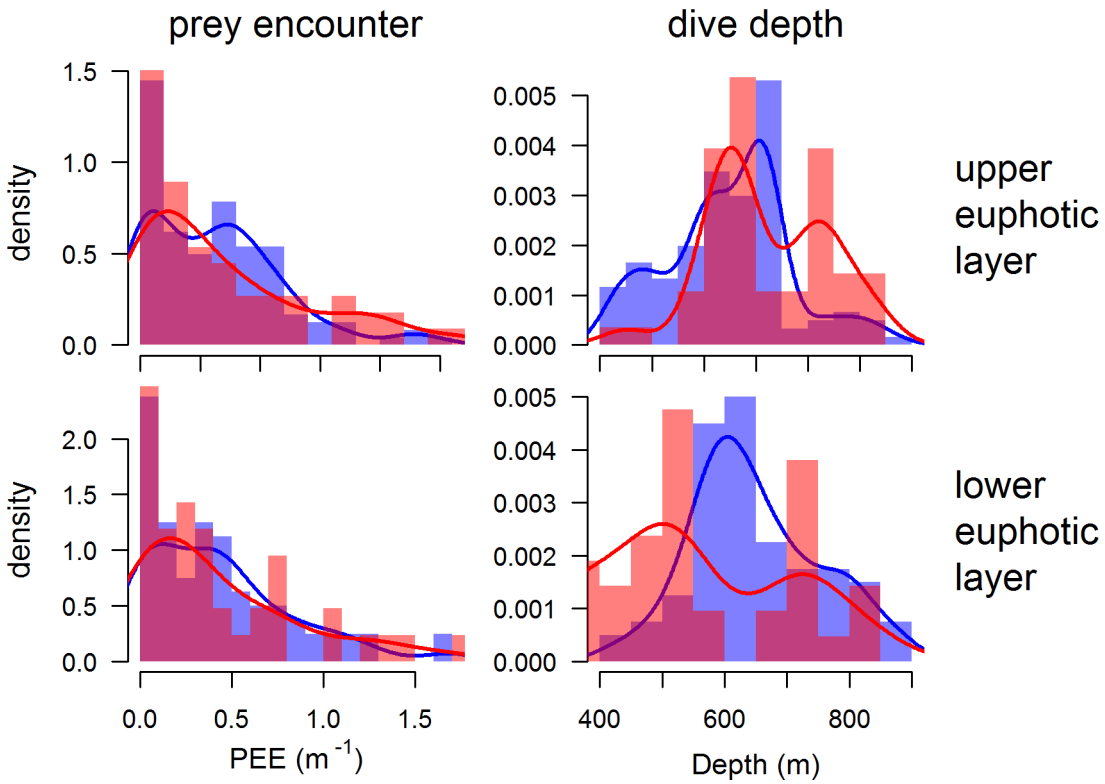

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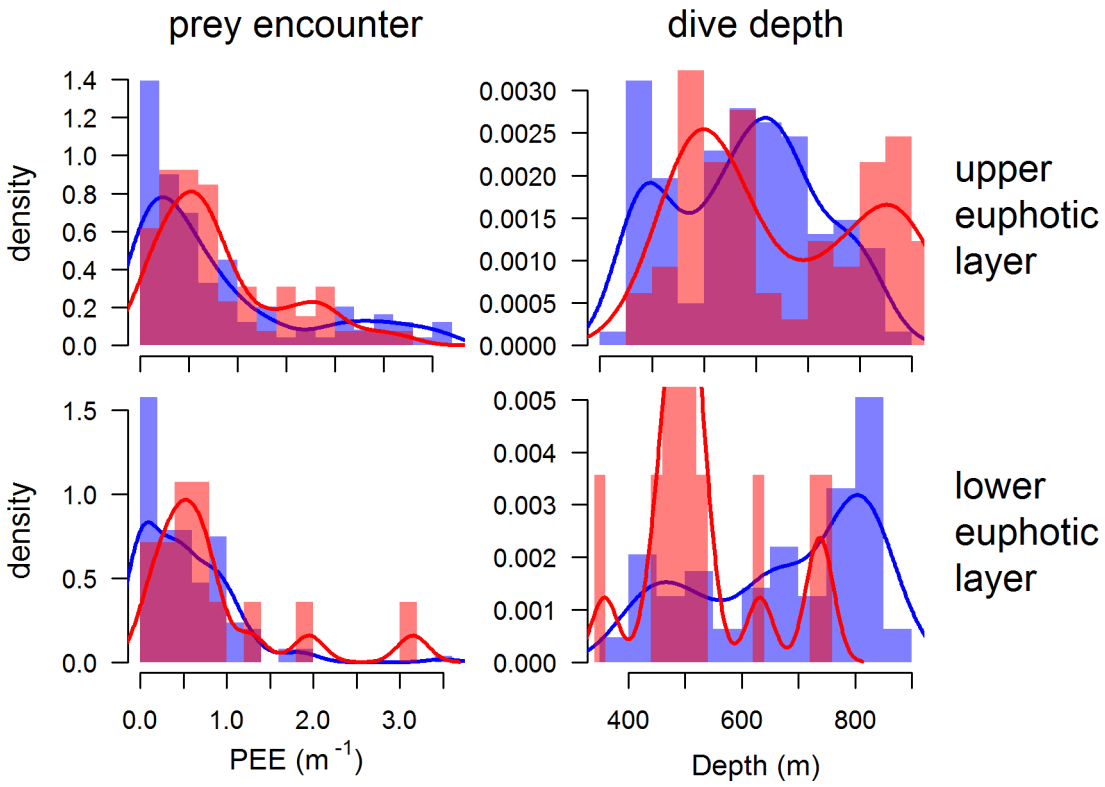

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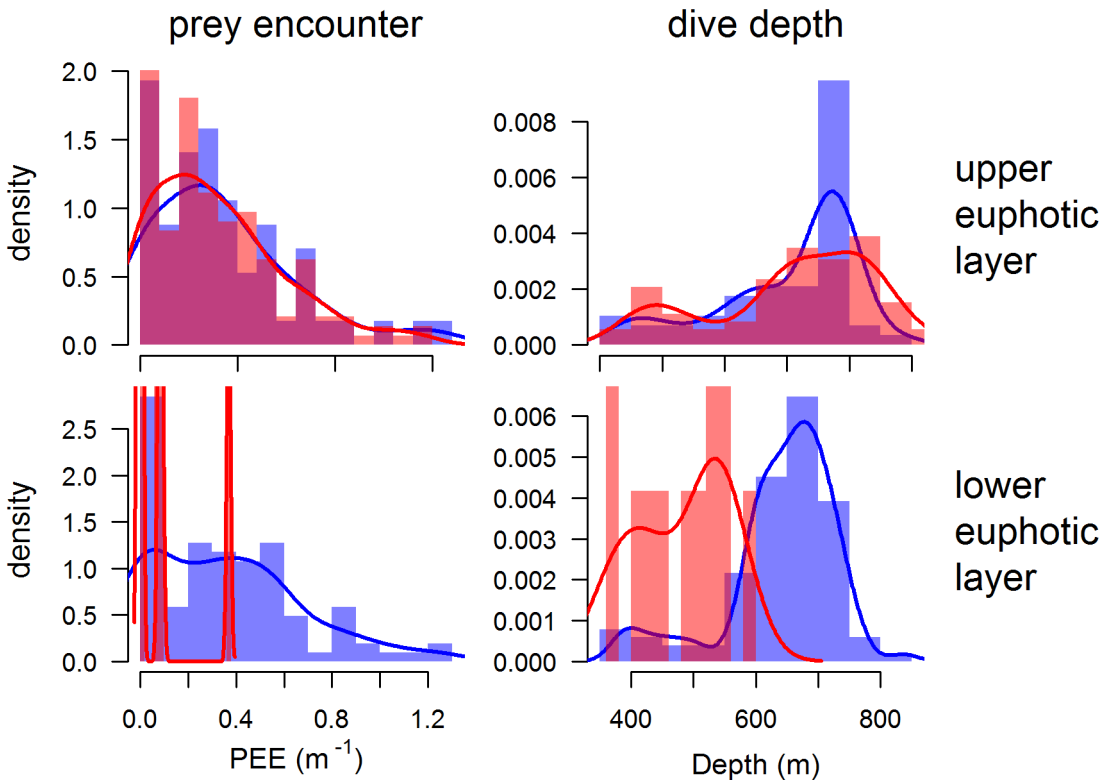
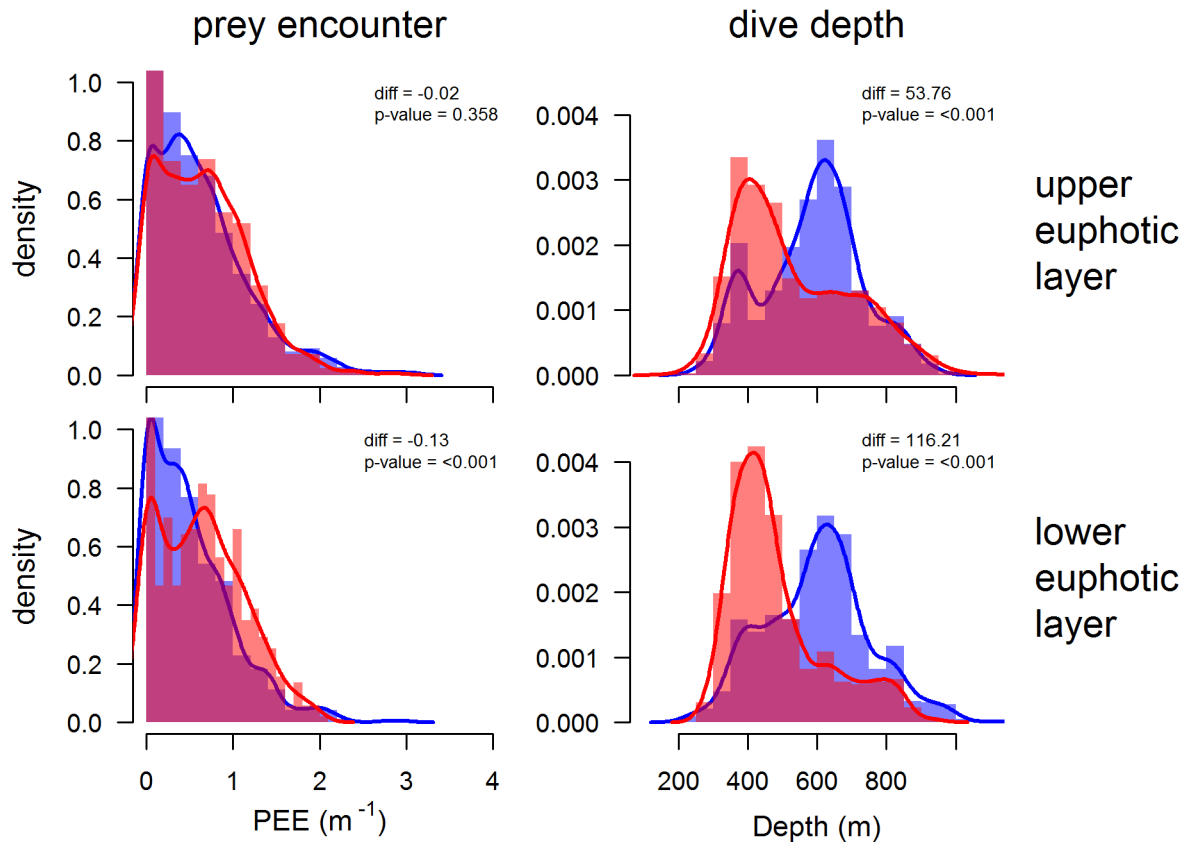


8. Behavioural differences between dense and low density patches of phytoplankton at noon

Analysis using only data around local noon (sun angle > 40°) showed findings similar to our overall daylight analysis (sun angle > 10°) in figure 3. However, our noon analysis did show dive depth larger differences between phytoplankton patch types compared to our daylight analysis. Unfortunately, data availability around noon was deemed insufficient for individual analysis.

Below are the results of our analysis at noon. Prey encounter events (PEE; *left plots*) and dive depth (*right plots*) differences in dense patches of phytoplankton (red) and low density patches of phytoplankton (blue). Differences are represented in the upper euphotic layer (*top plots*) and lower euphotic layer (*bottom plots*). Differences and values of statistical significance are given in the top right corner of each plot. Analysis includes data from all seals (n=15) during noon (sun angle >40°).



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2. Hindell MA, Slip DJ (1997) The importance of being fat: maternal expenditure in the southern elephant seal *Mirounga leonina*. In: Hindell MA, Kemper CM, editors. Marine mammal research in the Southern Hemisphere: Status, ecology and medicine: Surrey Beatty & Sons. pp. 72-77.

3. McMahon CR, Field IC, Bradshaw CJA, White GC, Hindell MA (2008) Tracking and data–logging devices attached to elephant seals do not affect individual mass gain or survival. Journal of Experimental Marine Biology and Ecology 360: 71-77.

4. Sumner MD, Wotherspoon SJ, Hindell MA (2009) Bayesian estimation of animal movement from archival and satellite tags. PLoS One 4: e7324.