Supplementary material

Killer whale acoustic patterns respond to prey abundance and environmental variability around the Prince Edward Islands, Southern Ocean

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S1. Estimation of unique killer whale numbers

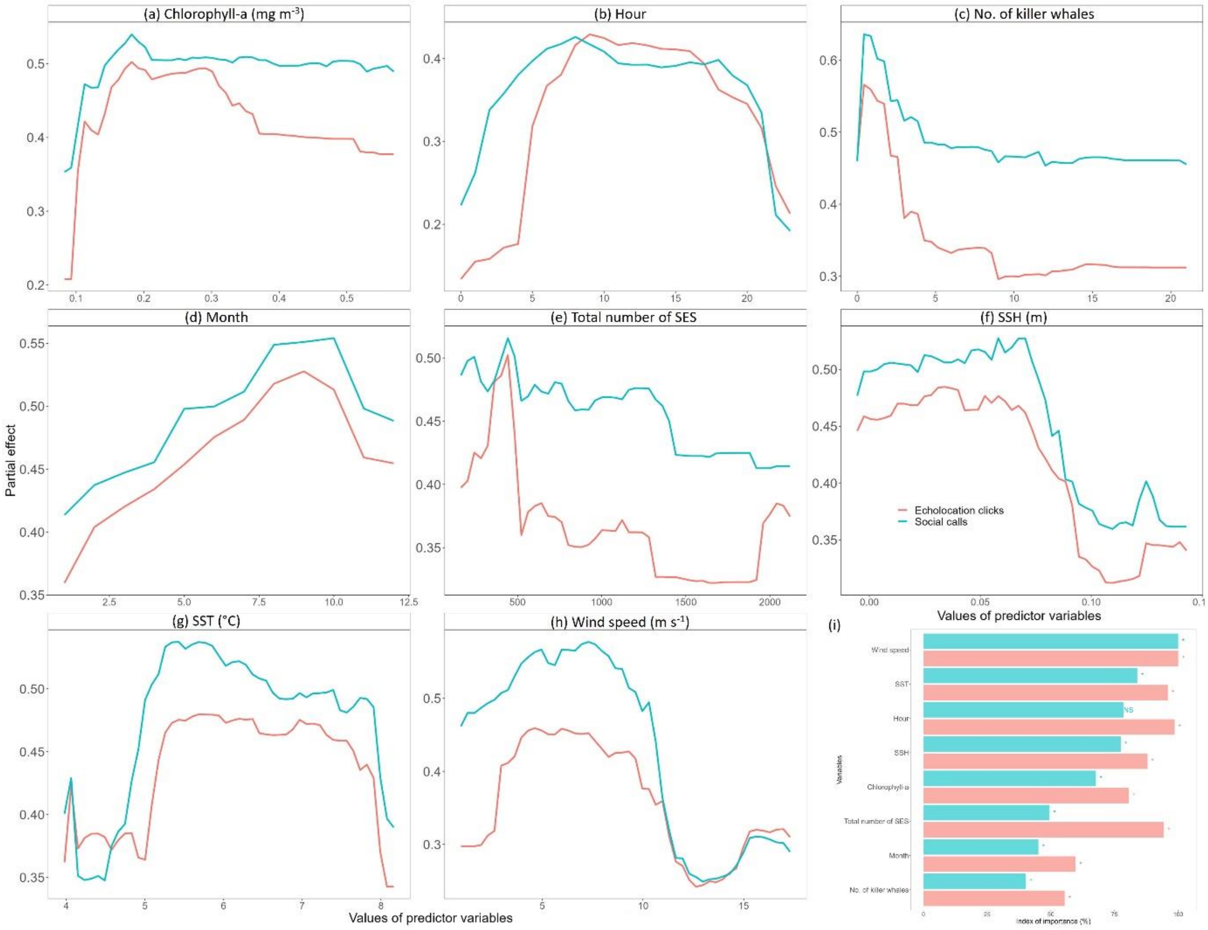
A quality score ranging from 1 (unusable) to 5 (excellent) was assigned to all photographs taken. This score was based on focus, lighting, exposure and the size, level of obscurity and angle of the dorsal fin in the photograph. All photographs with a quality score ≥ 3 were considered for analyses. These photos were matched to identification catalogues [1,2], using nicks, notches and mutilations in dorsal fins and saddle patches to identify individuals [3]. From these data, the number of unique killer whales observed to be present each day was obtained.

S2. Random forest model equation

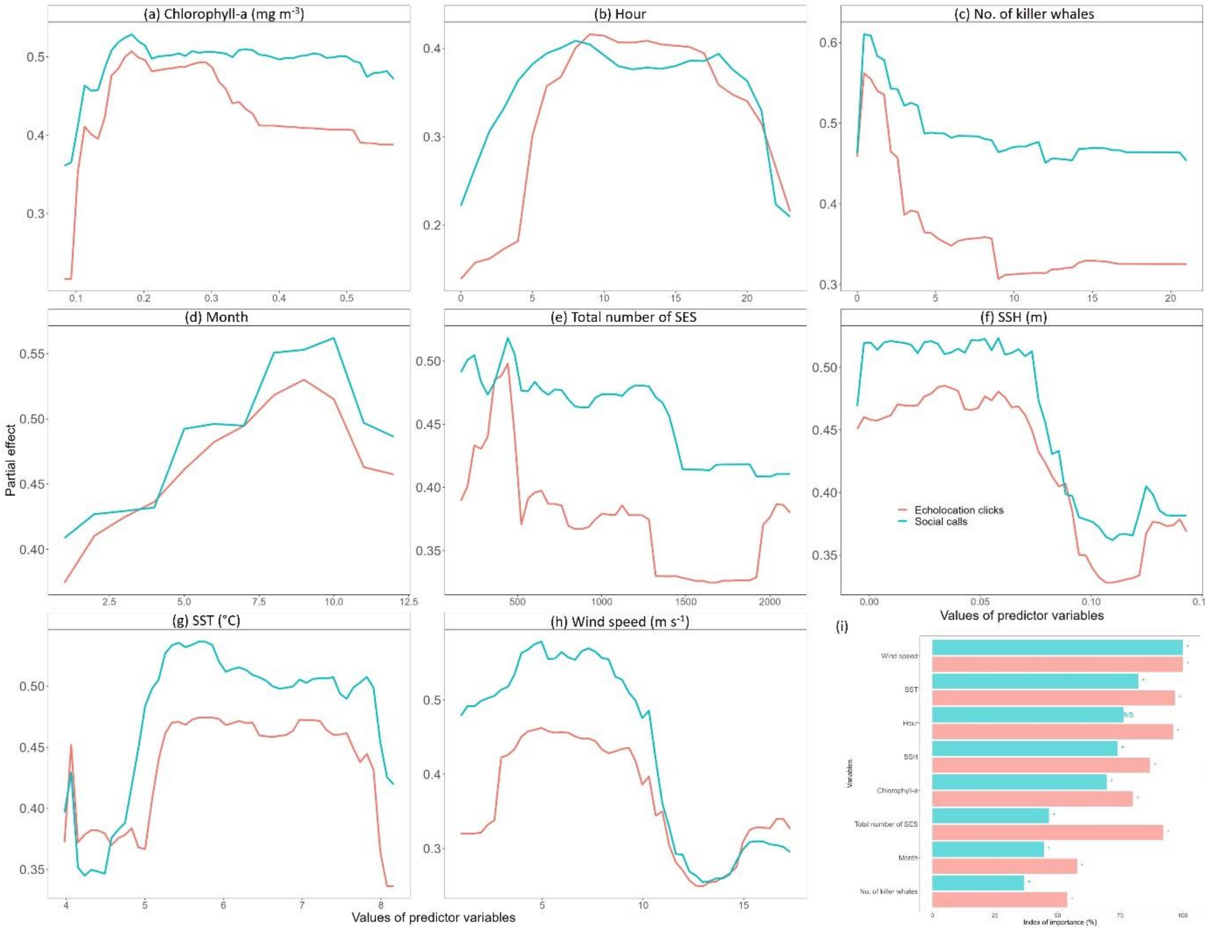
$$PA \sim Month + Hour + SES + no.of\ unique\ KWs + SST + chl\_a + SSH + wind\ speed \quad \text{(S1)}$$

where PA is the presence or absence of echolocation clicks or social calls within a 14-minute sampling session.

S3. Random forest model results

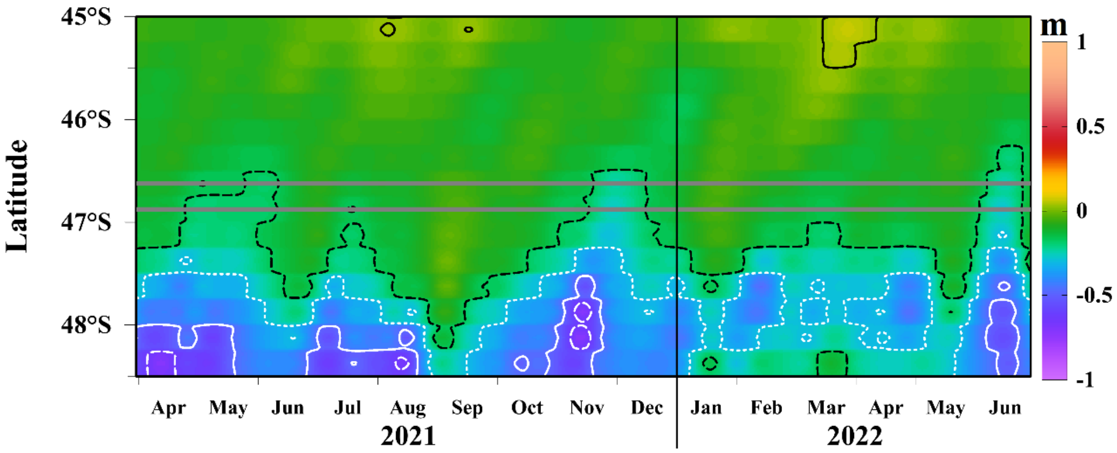


Supplementary Figure S1. Random forest model partial effect (a-h) and relative importance (i) of predictor variables on the probability of the occurrence of echolocation and social calls of killer whales based on ADASYN sample balancing method. Y-axes scales are different between plots in (a) to (h). Asterisks (*) indicate significant importance ($p < 0.05$) and NS indicates non-significant importance ($p > 0.05$).

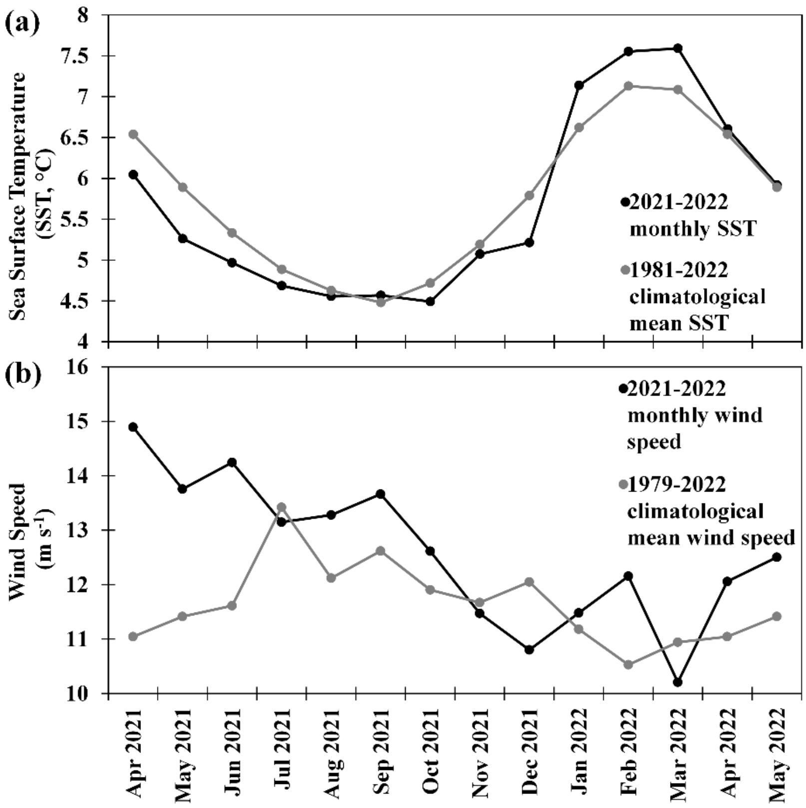


Supplementary Figure S2. Random forest model partial effect (a-h) and relative importance (i) of predictor variables on the probability of the occurrence of echolocation and social calls of killer whales based on SMOTE sample balancing method. Y-axes scales are different between plots in (a) to (h). Asterisks (*) indicate significant importance ($p < 0.05$) and NS indicates non-significant importance ($p > 0.05$).

S4. SSH, SST and wind speed



Supplementary Figure S3. Time series of daily sea surface height (m) along 37.875°E. The grey lines indicate the positions of Marion and Prince Edward Islands, respectively. The solid black/dashed black contours show the middle/southern branches of the sub-Antarctic Front, while the dotted/solid white contours show the northern/middle branches of the Antarctic Polar Front.



Supplementary Figure S4. Climatological and monthly mean (a) sea surface temperature (°C), and (b) wind speed (m s^{-1}), averaged over a 2° x 2° area centred over the Prince Edward Islands.

S5. Environmental variability discussion

Given that the environment surrounding the PEIs is highly variable at short temporal scales [4,5], the observed relationships between the seasonality of the environmental parameters and that of killer whales must be interpreted with caution, especially considering the short length of our dataset. The lowest and highest SST was observed in spring and summer respectively on a daily scale, which corresponds to the average seasonal cycle for SST [6,7; Supplementary Figure S4]. The maximum daily SST of 8.2 °C around PEIs was in January, but February and March (late summer and early autumn) showed the highest monthly averaged SSTs, which also corresponds to the known seasonal variability of SST [6,7; Supplementary Figures S3 and S4). Enhanced chlorophyll-a concentration was observed in summer when SST increased from 5 to 8 °C and corresponds to previous studies that showed that SST and chlorophyll-a cycles are in phase [8,9]. This is largely controlled by incoming solar radiation, which is highest in summer causing increased light availability, which together with water column stratification and sufficient nutrient supply into the euphotic zone, creates the optimum environment for phytoplankton to thrive [9].

No clear pattern was discernible from daily wind speed due to high fluctuation of values; however, monthly averages clearly showed that the highest monthly wind speeds were in autumn and winter. The high wind speed in winter corresponds to the long-term observations whereas high wind speed in autumn is different to the long-term trend [7], indicating interannual variability in environmental conditions. The SSH seasonality observed around the PEIs during the study period was biased by the short-term northward/southward movements of the S-SAF during summer and autumn, which does not fit with the known minimal seasonality of SSH in the region [4,5]. SSH was lower when the southern branch of the SAF was located close to the PEIs and was higher when the S-SAF was further south [10].

Although the SSH variations may be attributed to changes in the position of the S-SAF within this area (Supplementary Figure S3), it is important to remember that transient mesoscale eddies also have a strong influence on the oceanographic conditions on the PEIs shelf, and these eddies would also result in short-term SSH variations [4]. When the S-SAF was south of the PEIs, the waters are overall warmer and there were more subtropical species, while in contrast, when the S-SAF was north of the PEIs, the waters were overall cooler, and there were more sub-Antarctic species [10,11].

References

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