

Behavioral Ecology and Sociobiology

Supplementary Information

Cook Inlet beluga whale calling varies by group characteristics, behavior, and tidal state

Arial M. Brewer,^{1*} Amy M. Van Cise,¹ Christopher Garner,² Andrea Gilstad,² Manuel Castellote,³ Sarah J. Converse,⁴ Kimberly T. Goetz,⁵ Andrew M. Berdahl¹

¹ School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington, USA

² US Air Force Conservation Department, Joint Base Elmendorf Richardson, Anchorage, Alaska, USA

³ Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, Washington, USA

⁴ U.S. Geological Survey, Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fishery Sciences & School of Environmental and Forest Sciences, University of Washington, Seattle, Washington, USA

⁵ Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington, USA

*Corresponding author: A. Brewer (arialb@uw.edu)

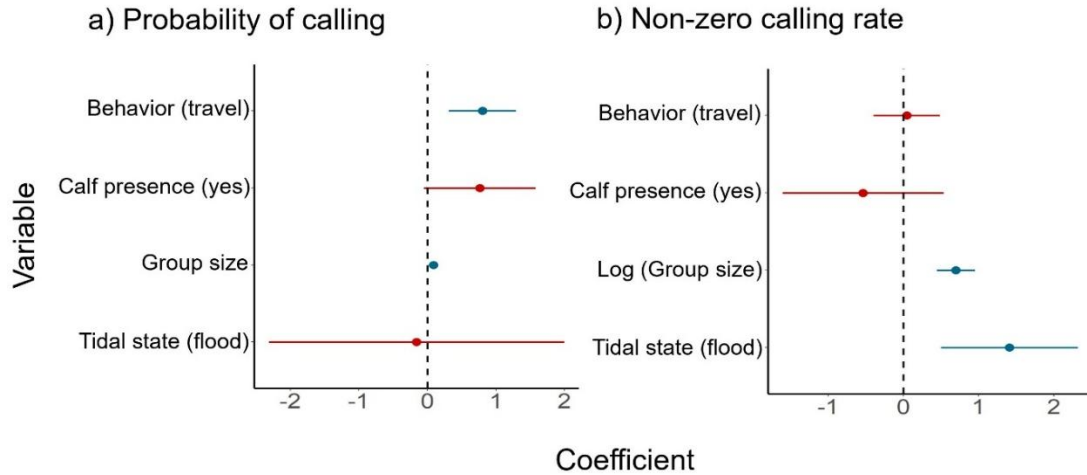


Fig. S1 Model coefficients and 95% confidence intervals from the hurdle model for a) the probability of calling and b) non-zero calling rate. The behavior coefficient is the effect of traveling relative to milling, the calf presence coefficient is the effect of calf presence relative to calf absence, and the tidal state coefficient is the effect of a flood tide relative to an ebb tide. Colors represent the effect of a given variable: blue indicates an effect, red indicates no effect.

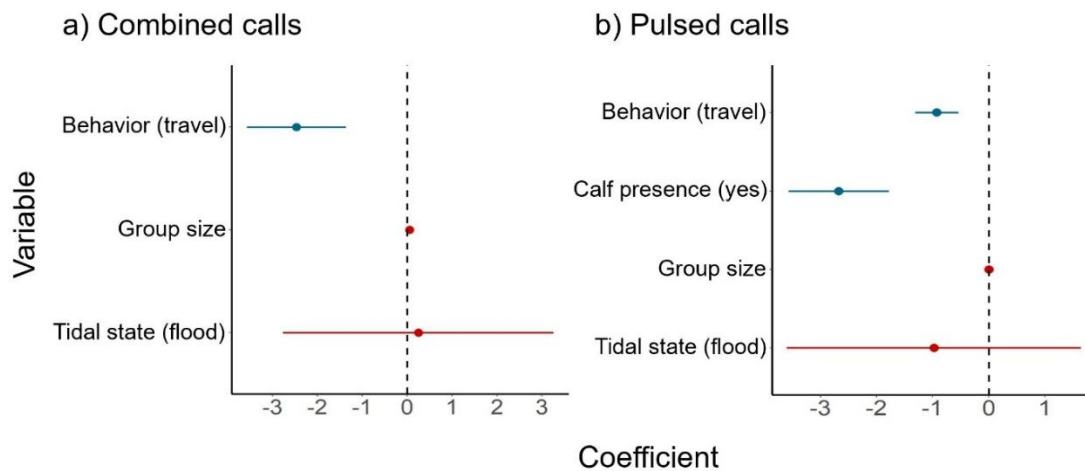


Fig. S2 Model coefficients and 95% confidence intervals of modeled call category use for a) combined calls relative to whistles, and b) pulsed calls relative to whistles. The behavior coefficient is the effect of traveling relative to milling, the calf presence coefficient is the effect of calf presence relative to calf absence, and the tidal state coefficient is the effect of a flood tide relative to an ebb tide. Colors represent the effect of a given variable: blue indicates an effect, red indicates no effect.

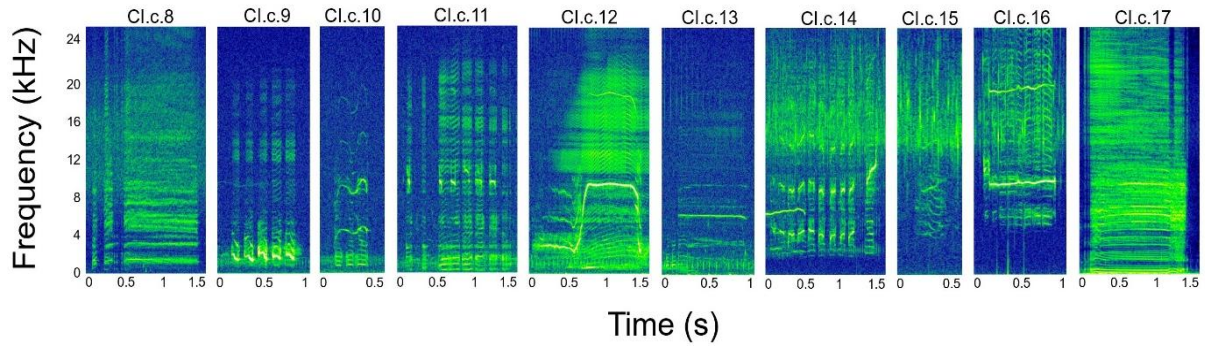


Fig. S3 Spectrograms of combined calls produced by Cook Inlet beluga whales in Eagle Bay, Alaska using the nomenclature described in Brewer et al. (2023). Spectrograms are 1024-point Fast Fourier Transform and generated in Raven Pro 1.6.

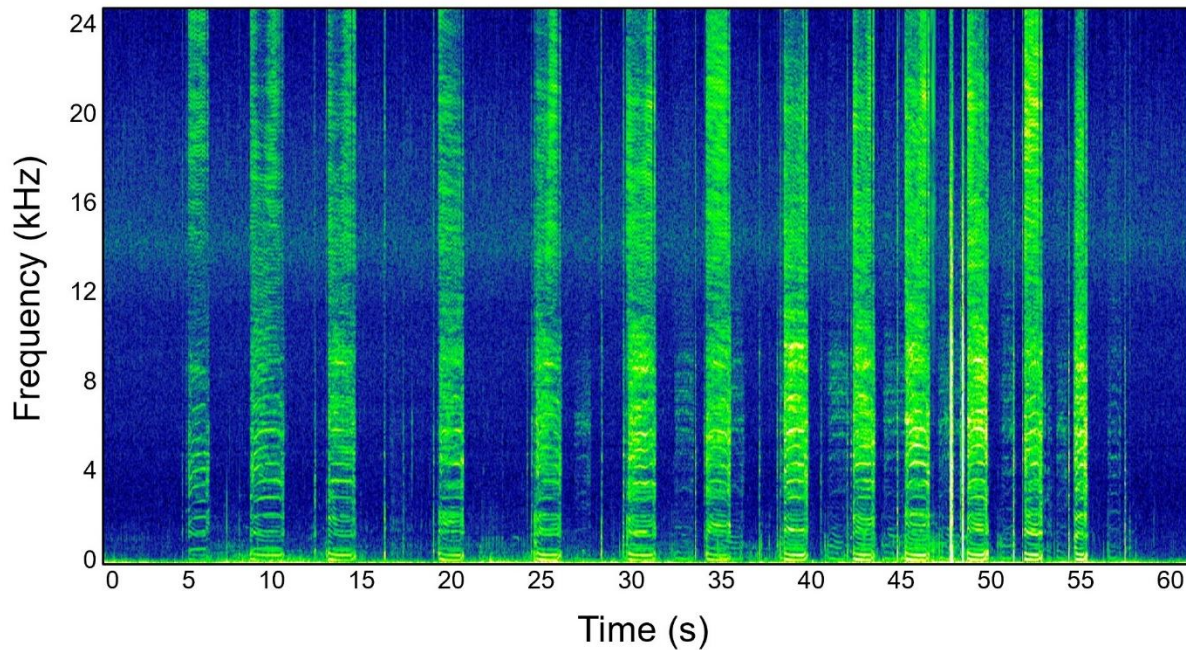


Fig. S4 A spectrogram of repeated, stereotyped combined calls produced by Cook Inlet beluga whales in Eagle Bay, Alaska during encounter 13 on August 24, 2022. A repeated, high amplitude combined call begins at time 5 s, followed by a repeated, low amplitude version of this call beginning at time 26 s. Spectrogram is 1024-point Fast Fourier Transform and generated in Raven Pro 1.6.

Table S1 Description of Cook Inlet beluga whale call types described in this study along with their respective call categories and acoustic measurements (mean $\pm$ standard deviation; for calls observed once, the single measured value is reported). Full repertoire and nomenclature descriptions can be found in Brewer et al. (2023).

Full name description	Call type	Call category	Duration (s)	Min. Freq. (Hz)	Max. Freq. (Hz)	Bandwidth (Hz)
ascending whistle	aws	Whistle	0.18 $\pm$ 0.12	4662.76 $\pm$ 3509.72	5946.54 $\pm$ 4092.71	1283.78 $\pm$ 1169.82
ascending segmented whistle	aws.seg	Whistle	0.49 $\pm$ 0.34	7659.72 $\pm$ 3805.57	10408.40 $\pm$ 5032.21	2748.68 $\pm$ 2282.06
descending whistle	dws	Whistle	0.23 $\pm$ 0.23	4710.91 $\pm$ 3446.11	6050.73 $\pm$ 3725.94	1339.83 $\pm$ 1021.83
flat whistle	flatws	Whistle	0.41 $\pm$ 0.38	4016.30 $\pm$ 2932.27	4399.85 $\pm$ 3048.28	383.56 $\pm$ 296.37
flat segmented whistle	flatws.seg	Whistle	0.80 $\pm$ 0.55	4360.87 $\pm$ 3038.05	4821.97 $\pm$ 3153.40	461.10 $\pm$ 210.74
modulated whistle	modws	Whistle	0.57 $\pm$ 0.46	4966.96 $\pm$ 2583.78	6704.64 $\pm$ 3055.66	1737.68 $\pm$ 1377.85
modulated segmented whistle	modws.seg	Whistle	1.02 $\pm$ 0.88	5101.71 $\pm$ 2023.79	8726.77 $\pm$ 2969.79	3625.06 $\pm$ 2298.76
modulated m-shape whistle	modws.m	Whistle	0.24 $\pm$ 0.19	4387.83 $\pm$ 3077.32	5948.63 $\pm$ 3981.72	1560.80 $\pm$ 1275.57
n-shape whistle	nws	Whistle	0.12 $\pm$ 0.07	5134.74 $\pm$ 2082.80	6411.24 $\pm$ 2013.70	1276.50 $\pm$ 671.07
n-shape whistle sequence	nws.seq	Whistle	1.01 $\pm$ 0.70	3837.49 $\pm$ 2480.57	5087.13 $\pm$ 2499.90	1249.64 $\pm$ 422.19
r-shape whistle	rws	Whistle	0.19 $\pm$ 0.09	3050.15 $\pm$ 2174.96	4870.66 $\pm$ 2946.81	1820.52 $\pm$ 1471.94
u-shape whistle	uws	Whistle	0.20 $\pm$ 0.10	4863.39 $\pm$ 3157.46	6511.20 $\pm$ 3251.46	1647.81 $\pm$ 812.44
trill	trill	Whistle	1.26 $\pm$ 0.63	5055.29 $\pm$ 1816.60	6372.35 $\pm$ 1621.97	1317.06 $\pm$ 624.42
ascending pulsed call	pulse.a	Pulsed call	0.32 $\pm$ 0.26	2744.71 $\pm$ 2430.51	12447.89 $\pm$ 6596.13	9703.17 $\pm$ 5560.90
descending pulsed call	pulse.d	Pulsed call	0.57 $\pm$ 0.42	3042.08 $\pm$ 2114.58	10930.23 $\pm$ 6327.12	7888.16 $\pm$ 5691.31
flat pulsed call	pulse.flat	Pulsed call	0.88 $\pm$ 0.68	3175.75 $\pm$ 3156.39	12745.38 $\pm$ 7435.87	9569.63 $\pm$ 6430.53
flat segmented pulsed call	pulse.flat.seg	Pulsed call	1.17 $\pm$ 0.79	2445.56 $\pm$ 2382.94	14579.17 $\pm$ 7901.63	12133.60 $\pm$ 7390.96
modulated pulsed call	pulse.mod	Pulsed call	0.91 $\pm$ 0.67	4476.62 $\pm$ 3218.85	12839.93 $\pm$ 6831.40	8363.31 $\pm$ 5097.45
modulated segmented pulsed call	pulse.mod.seg	Pulsed call	1.42 $\pm$ 1.05	3692.55 $\pm$ 1882.73	14270.79 $\pm$ 5773.93	10578.24 $\pm$ 5742.22
n-shape pulsed call	pulse.n	Pulsed call	0.47 $\pm$ 0.24	2649.04 $\pm$ 2524.03	11160.44 $\pm$ 5809.18	8511.41 $\pm$ 5935.76
CI combined call type 8	CI.c.8	Combined call	1.51	528.81	24000.00	23471.19
CI combined call type 9	CI.c.9	Combined call	0.52 $\pm$ 0.17	1089.07 $\pm$ 301.82	18945.70 $\pm$ 4430.95	17856.63 $\pm$ 4504.67
CI combined call type 10	CI.c.10	Combined call	0.42 $\pm$ 0.03	721.09 $\pm$ 62.35	19523.81 $\pm$ 1791.43	18802.72 $\pm$ 1779.30
CI combined call type 11	CI.c.11	Combined call	1.21	339.82	23023.01	22683.19
CI combined call type 12	CI.c.12	Combined call	1.62 $\pm$ 0.42	466.22 $\pm$ 200.67	16358.11 $\pm$ 10807.27	15891.89 $\pm$ 11007.93
CI combined call type 13	CI.c.13	Combined call	0.92 $\pm$ 0.47	575.68 $\pm$ 52.86	16143.24 $\pm$ 6929.67	15567.57 $\pm$ 6941.97
CI combined call type 14	CI.c.14	Combined call	1.39	2080.00	23240.00	21160.00
CI combined call type 15	CI.c.15	Combined call	0.20 $\pm$ 0.00	3613.33 $\pm$ 61.10	15186.67 $\pm$ 2203.03	11573.33 $\pm$ 2245.83
CI combined call type 16	CI.c.16	Combined call	0.82	4262.07	24000.00	19737.93
CI combined call type 17	CI.c.17	Combined call	1.30 $\pm$ 0.32	236.02 $\pm$ 201.08	22766.70 $\pm$ 3418.10	22530.68 $\pm$ 3594.44

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References

Brewer AM, Castellote M, Van Cise AM, Gage T, Berdahl AM (2023) Communication in Cook Inlet beluga whales: Describing the vocal repertoire and masking of calls by commercial ship noise. *J Acoust Soc Am* 154:3487–3505. <https://doi.org/10.1121/10.0022516>