

Additional file: Additional table and figures

Preamble

In “A satellite-linked tag for the long-term monitoring of diving behavior in large whales,” we present the development of the Telonics RDW tag, a new Argos-based satellite telemetry device that incorporates sensors for monitoring the movements and dive behavior of large whales in near-real-time over several months without requiring recovery (1). The tag also features onboard software for data processing and detection of behavioral events or activities of interest for transmission. The RDW tag dive summary algorithm was designed to summarize dive behavior from multiple data streams, while the adaptive event detection algorithm was customized to detect rorqual lunge-feeding events from accelerometer data based on thresholds using the cumulative mean and standard deviation of the jerk value.

We implemented a proxy validation of the RDW tag’s dive summary and event detection algorithms using continuously recorded data from a Wildlife Computers TDR10-F medium-duration archival tag deployed on a blue whale (*Balaenoptera musculus*) for 17.8 d while foraging off southern California in summer 2017, as reported in Calambokidis et al. (2). We compared dive summaries, including number of lunge-feeding events per dive, generated from the TDR10 archival data to corresponding selected dive summaries produced by the RDW tag dive summary algorithm from the same record. The primary results of this validation are presented in the main text of Palacios et al. (1). In this Additional file, we present two tables and five figures providing supplementary information related to the proxy validation of the RDW tag dive summary and event detection algorithms. We also present one table providing per-tag information on message corruption rate from transmission through Argos, and one figure showing a simulation of data recovery through Argos using a 12-h transmission schedule.

References

1. Palacios DM, Irvine LM, Lagerquist BA, Fahlbusch JA, Calambokidis J, Tomkiewicz SM, Mate BR. A satellite-linked tag for the long-term monitoring of diving behavior in large whales. *Animal Biotelemetry*. Anim Biotelem. 2022; <https://doi.org/10.1186/s40317-022-00297-9>.
2. Calambokidis J, Fahlbusch JA, Szescioroka AR, Southall BL, Cade DE, Friedlaender AS, et al. Differential vulnerability to ship strikes between day and night for blue, fin, and humpback whales based on dive and movement data from medium duration archival tags. *Front Mar Sci*. 2019;6:543. <https://doi.org/10.3389/fmars.2019.00543>.

Table S1. False negative (FN) and false positive (FP) rates of the RDW tag event detection algorithm relative to the ordinal level of known lunges per dive measured by the TDR10 tag.

Accel. precision	Known lunges/dive	# dives	FN rate	FP rate
1/64 G	0	1117	0.00	0.02
1/64 G	1	45	0.56	0.02
1/64 G	2	94	1.27	0.00
1/64 G	3	106	1.98	0.00
1/64 G	4	295	2.99	0.00
1/64 G	5	541	4.18	0.00
1/64 G	6	216	4.83	0.00
1/64 G	7	41	5.61	0.00
1/64 G	8	5	4.40	0.00
1/64 G	9	1	4.00	0.00
1/64 G	12	1	1.00	0.00
1 mG	0	1117	0.00	0.08
1 mG	1	45	0.29	0.22
1 mG	2	94	0.41	0.14
1 mG	3	106	0.67	0.05
1 mG	4	295	1.17	0.02
1 mG	5	541	1.53	0.02
1 mG	6	216	1.83	0.01
1 mG	7	41	1.68	0.00
1 mG	8	5	0.80	0.00
1 mG	9	1	1.00	0.00
1 mG	12	1	2.00	0.00

Table S2. Summary of RDW event detection algorithm criteria for RDW tags deployed on blue and humpback whales off California during summer 2017. Jerk metrics are in units of 1/64 G/s. N is the number of utility messages received and elapsed time is the time between the first and last utility message received.

Species	Tag ID	N	Elapsed time (d)	Min. mean jerk	Max. mean jerk	Min. sd jerk	Max. sd jerk	Last mean jerk	Last sd jerk
Blue	825	4	1.0	11	15	16	18	12	17
Blue	827	32	120.8	5	15	9	18	7	14
Blue	831	29	40.0	7	12	11	14	8	11
Blue	832	3	0.9	13	19	16	19	16	19
Blue	836	1	0.0	7	7	7	7	7	7
Blue	1385	84	99.9	14	16	18	20	14	19
Blue	1386	2	0.7	7	7	11	11	7	11
Blue	5736	3	1.6	12	31	15	31	31	31
Blue	5800	8	6.6	11	14	15	18	14	18
Blue	5840	96	96.0	9	16	14	17	9	14
Blue	10830	14	16.5	15	25	18	25	15	18
Blue	10831	58	136.5	12	23	17	20	12	17
Blue	10840	45	56.4	10	13	16	19	10	18
Blue	23031	48	43.1	8	13	14	18	8	14
Humpback	838	8	2.5	11	16	14	18	16	18
Humpback	840	11	3.3	15	19	14	17	18	17
Humpback	848	14	3.1	11	15	15	17	13	15
Humpback	2083	2	0.1	8	8	6	6	8	6
Humpback	4173	9	8.0	8	19	9	14	10	11
Humpback	4175	34	47.5	9	13	11	13	12	13

Table S3. Summary of RDW tag Argos message corruption rate for RDW tags deployed on blue and humpback whales off California during summer 2017.

Tag ID	Species	Tag type	N messages	N corrupt messages	% corrupt messages
825	Blue	RDW-665	103	33	32.0
827	Blue	RDW-665	920	401	43.6
831	Blue	RDW-665	892	465	52.1
832	Blue	RDW-665	87	27	31.0
836	Blue	RDW-665	49	26	53.1
1385	Blue	RDW-665	2439	999	41.0
1386	Blue	RDW-665	57	23	40.4
5736	Blue	RDW-665	71	38	53.5
5800	Blue	RDW-665	264	131	49.6
5840	Blue	RDW-665	2815	792	28.1
10830	Blue	RDW-665	424	245	57.8
10831	Blue	RDW-665	2049	1009	49.2
10840	Blue	RDW-665	1416	643	45.4
23031	Blue	RDW-665	1197	452	37.8
830	Humpback	RDW-640	1480	198	13.4
833	Humpback	RDW-665	233	74	31.8
834	Humpback	RDW-640	2882	337	11.7
838	Humpback	RDW-665	311	62	19.9
840	Humpback	RDW-665	299	90	30.1
848	Humpback	RDW-665	295	91	30.8
1389	Humpback	RDW-640	1265	165	13.0
1390	Humpback	RDW-640	1874	288	15.4
2083	Humpback	RDW-665	24	4	16.7
4173	Humpback	RDW-665	307	78	25.4
4175	Humpback	RDW-665	1164	375	32.2
10822	Humpback	RDW-640	800	220	27.5
10842	Humpback	RDW-640	1617	161	10.0
23038	Humpback	RDW-640	1346	155	11.5

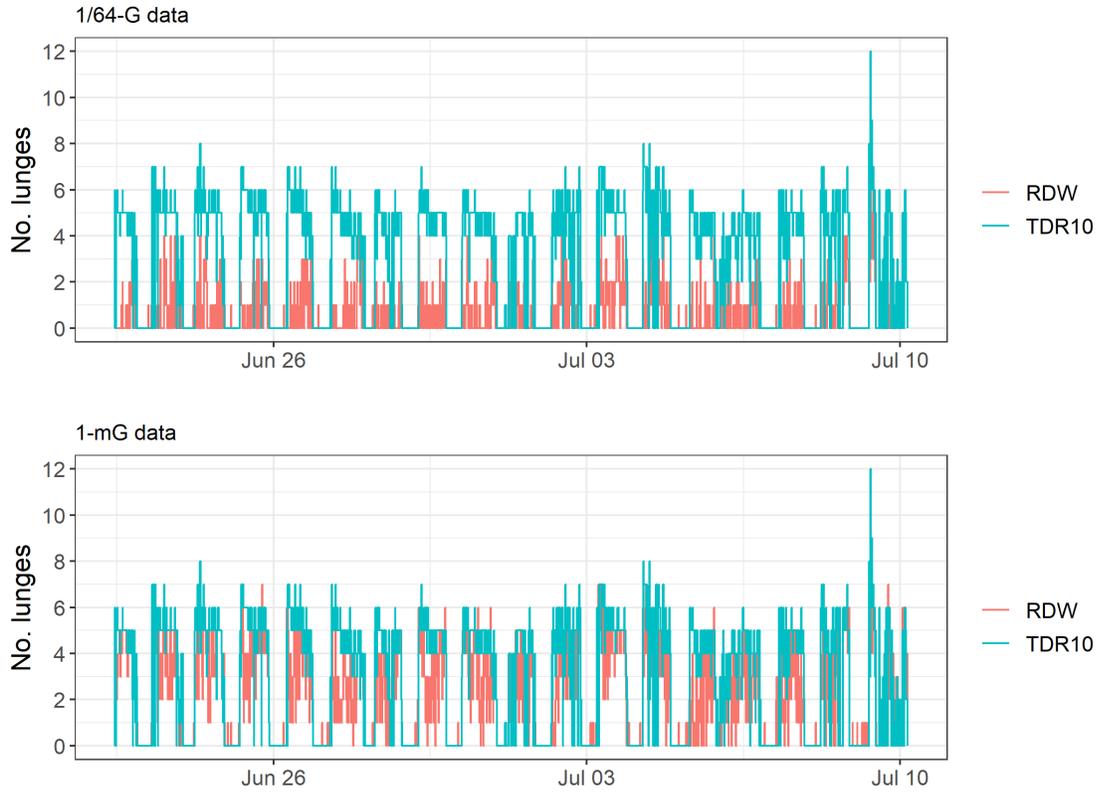


Figure S1. Stairstep plot showing the time series of the number of true feeding lunges per dive measured by a TDR10 archival tag (blue line) and detected by the RDW event detection algorithm (red line). Top panel shows results for 1/64-G precision data while the bottom panel shows results for 1-mG precision data.

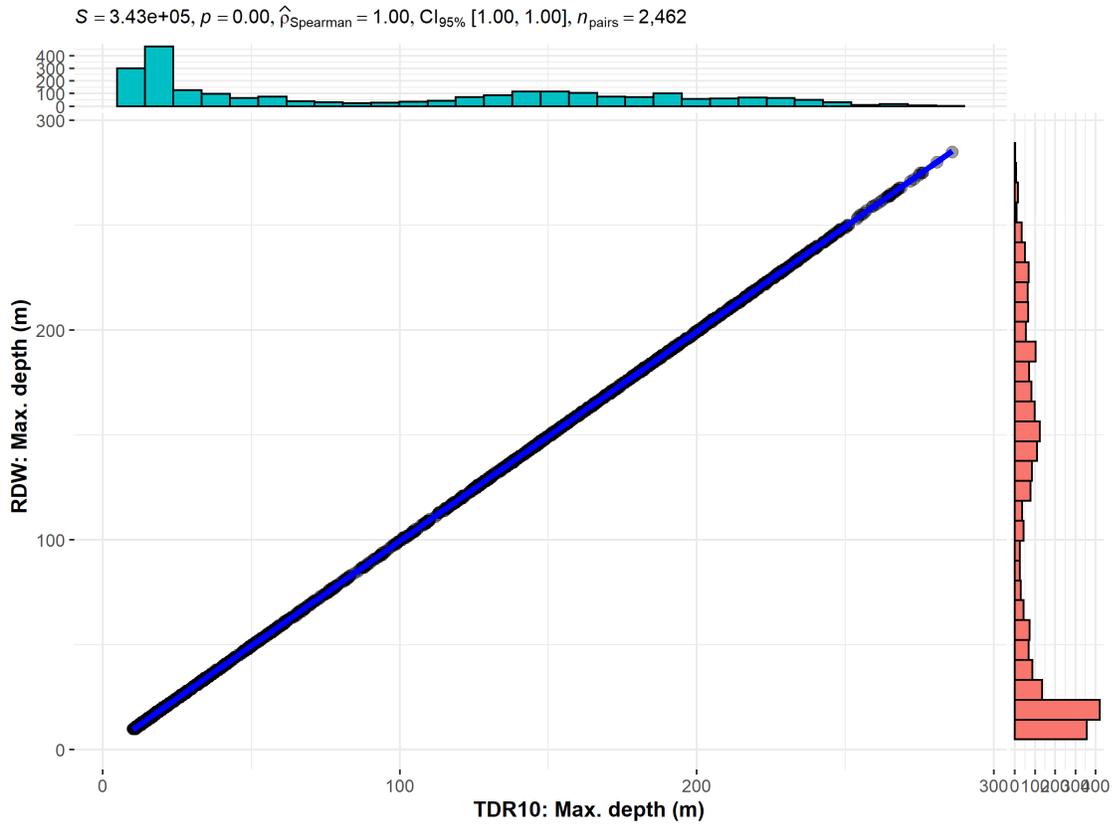


Figure S2. Scatterplot and marginal univariate frequency histograms for the linear regression of maximum dive depth estimated from TDR10 archival tag data to maximum dive depth reported by the RDW dive summary algorithm.

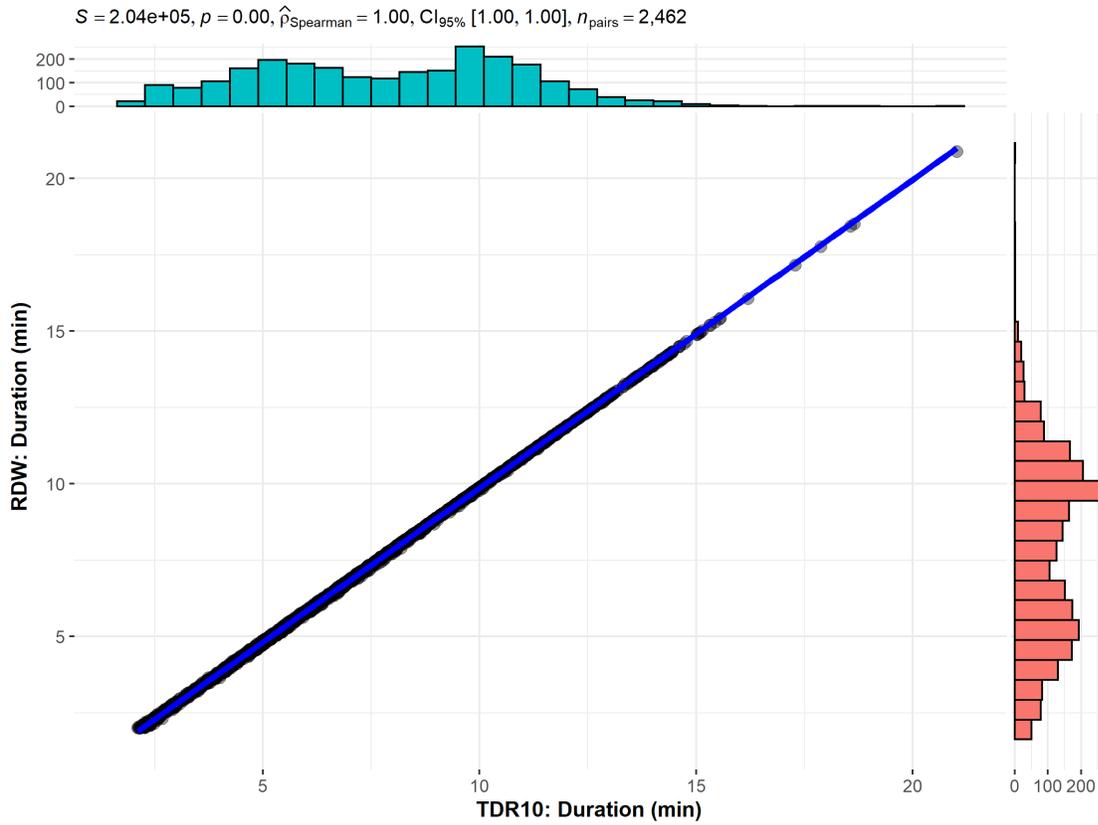


Figure S3. Scatterplot and marginal univariate frequency histograms for the linear regression of dive duration estimated from TDR10 archival tag data to dive duration reported by the RDW dive summary algorithm.

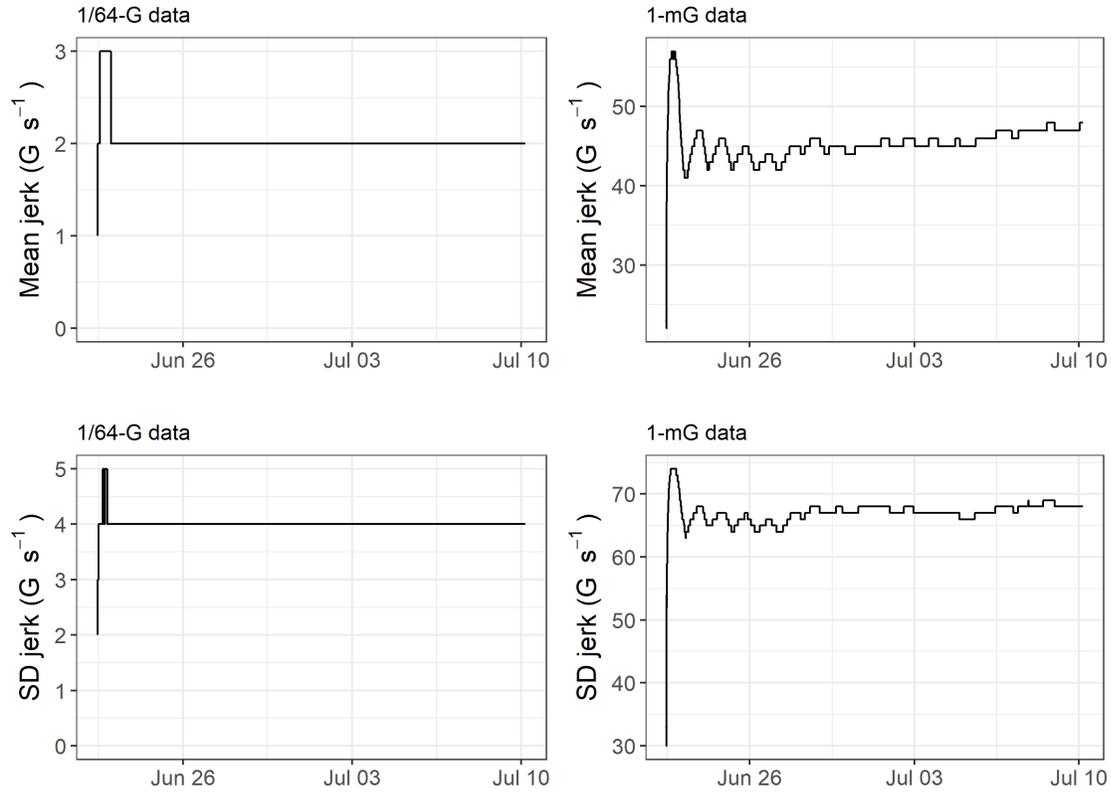


Figure S4. Time series plot of the running mean (top) and standard deviation (bottom) of jerk, used as threshold criteria for lunge-feeding event detection from a TDR10 tag. Left panels display data using 1/64-G precision. Right panels display data using 1-mG precision. Jerk values stabilized after ~ 13 h for 1/64-G data and ~ 19 h for 1-mG data.

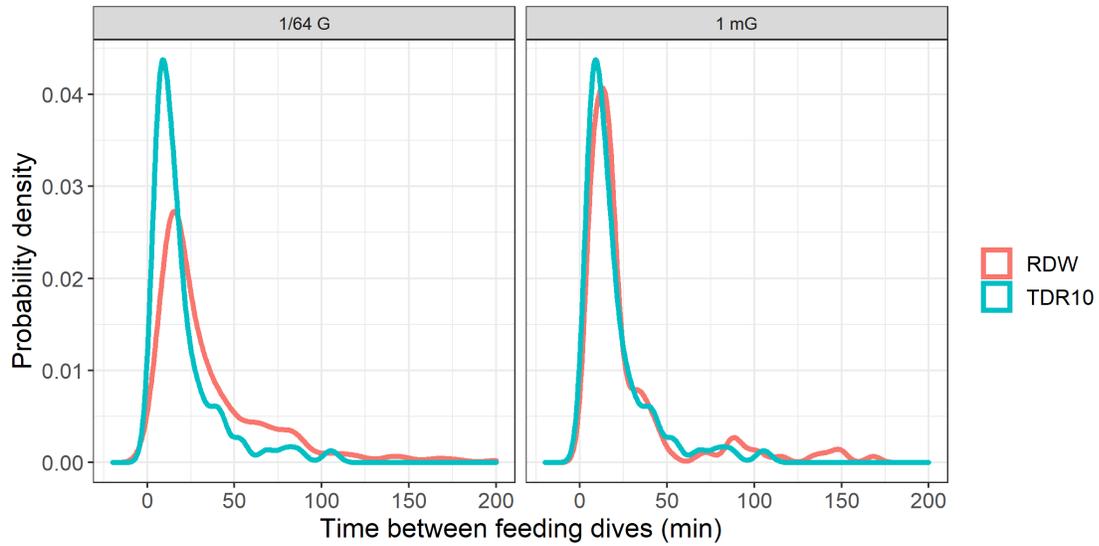


Figure S5. Probability density curves of times between feeding dives measured by a TDR10 archival tag (blue line) and detected by the RDW event detection algorithm (red line). The plots are used to establish a criterion to distinguish between bouts of feeding dives, which for this example was 60 min between feeding dives. The left panel shows results for 1/64-G precision data while the right panel shows results for 1-mG precision data.

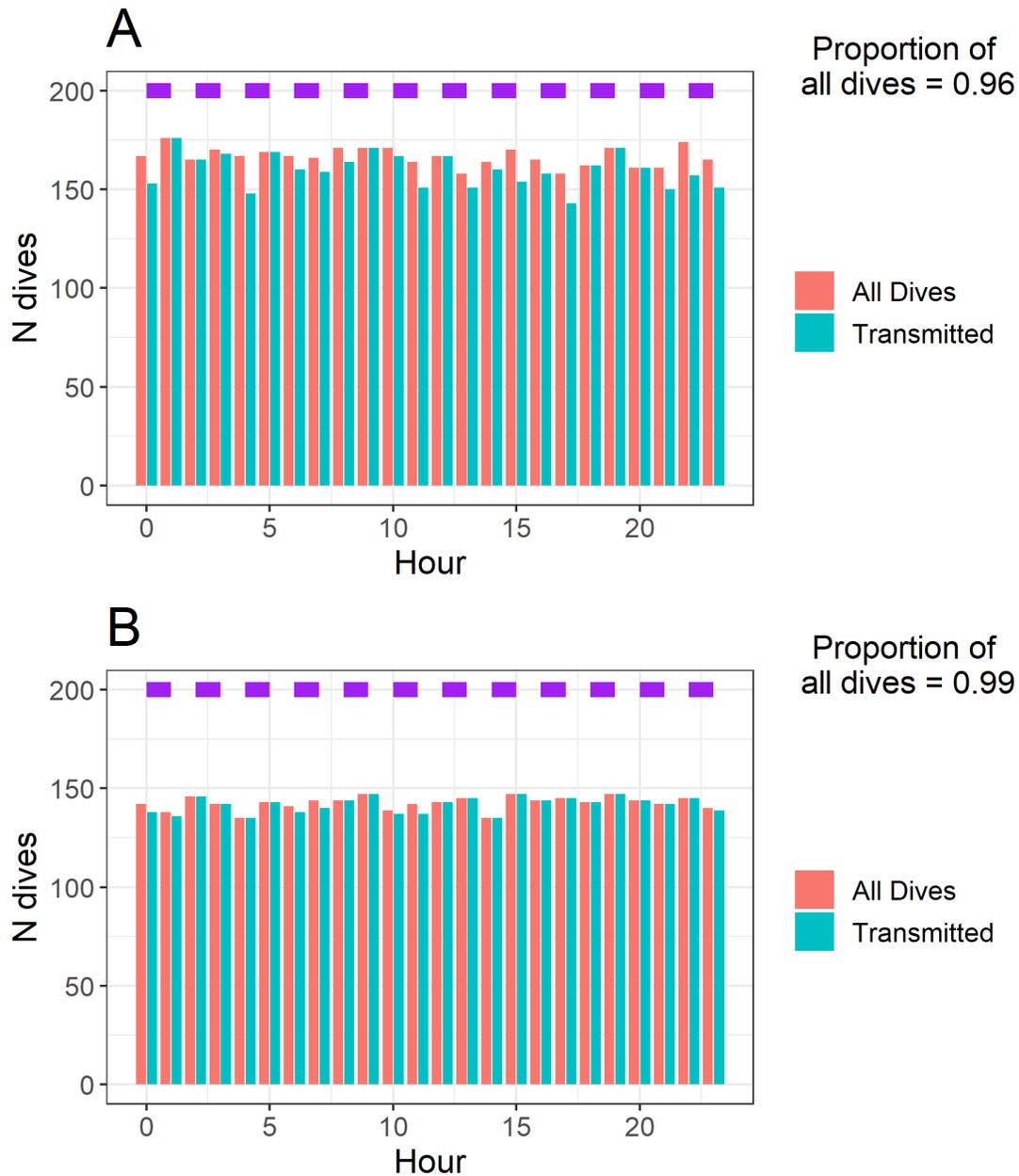


Figure S6. Simulation results to test the effect of RDW tag dive summary and transmission settings regimes on data recovery. Dives were simulated for an animal making relatively short- duration dives (e.g., humpback whales; A) and long-duration dives (e.g., blue whales; B). Dive summary messages were assumed to have been transmitted every 60 s during 12 1-h periods (purple horizontal bars) spaced evenly throughout the day. Dive summaries were assumed to have been received if a satellite was predicted to be overhead when the message was transmitted after accounting for a 44% empirically estimated message corruption rate.