

Towards non-invasive heart rate monitoring in free-ranging cetaceans: a unipolar suction cup tag measured the heart rate of trained Risso's dolphins

Kagari Aoki^{1*}, Yurie Watanabe², Daiki Inamori², Noriko Funasaka^{2,3}, Kentaro Q. Sakamoto¹

1 Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, 2778564, Japan

2 Taiji Whale Museum and Aquarium, Higashimuro, Wakayama, 2934-2, Japan

3 Cetacean Research Center, Graduate School of Bioresources, Mie University, Mie 514-8507, Japan

*Corresponding authors: aokikagari@aori.u-tokyo.ac.jp

Table S1. Summary of three swimming trials of a Risso's dolphin (ID: gg_mf) under operant conditions. Inactive periods, where the dolphin was motionless at surface, prior to each swimming trial are also shown. The dolphin followed a trainer who ran around the pen during swimming.

Trial date (dd/mm/yyyy)	Inactive		Swimming		Trial duration (min)
	Heart rate (bpm)	Range (bpm)	Heart rate (bpm)	Range (bpm)	
09/03/2019	48 ± 18	33-75	63 ± 24	28-111	13.8
12/03/2019	43 ± 9	32-81	52 ± 13	28-105	12.6
13/03/2019	47 ± 11	30-73	63 ± 21	28-108	12.7

Table S2. Instantaneous heart rates (f_H) of motionless delphinids at the surface when pronounced sinus arrhythmia patterns (PSA) were observed. Maximum and minimum f_H of inter-breath intervals (i.e. apneic periods) are shown (Mean ± S.D). See also Table 3 for summary of the experiments. Measurements were conducted from the end of October in 2019 until the beginning of November in 2019.

Species	ID	Fasting periods in the morning			Non-fasting periods in the evening		
		max. f_H (bpm)	min. f_H (bpm)	n*	max. f_H (bpm)	min. f_H (bpm)	n*
False killer whale	pc_km	50 ± 4	22 ± 2	5	70 ± 3	40 ± 3	8
Risso's dolphin	gg_sm	90 ± 2	53 ± 4	5	95 ± 5	62 ± 7	10
	gg_mf	70 ± 6	34 ± 4	10	78 ± 7	37 ± 6	10
	gg_nf	–	–	–	70 ± 24	38 ± 1	4
	gg_rm	93 ± 7	46 ± 3	19	97 ± 7	52 ± 3	12

* number of inter-breath intervals



Fig. S1. An example of past deployments of behavioural single-suction cup tag to a long-finned pilot whale. The size of tag was slightly larger than that used in this study. The tag was deployed using 6-m hand-pole.

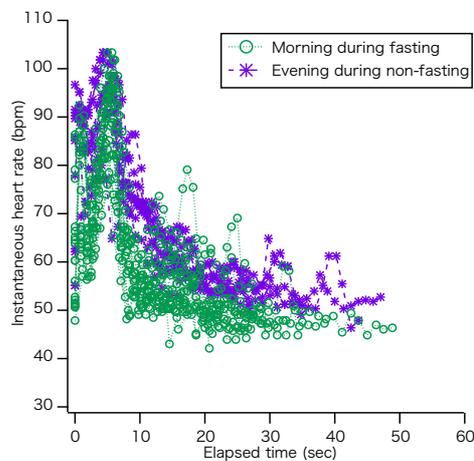


Fig. S2. An example of variations in the instantaneous heart rates with respiration in the morning during fasting and in the evening during non-fasting (ID gg_rm). The changes in heart rate from the end of each respiration to the next respiration when pronounced sinus arrhythmia patterns were observed.