



Introduction

Individual killer whales (*Orcinus orca*) are relatively easy to recognize, and their blows can be seen from quite a distance. Studies on respiration intervals, or apnoeas, of individuals are an important and reliable approach for ethological studies in their natural environment.

Respiration rate might be useful to distinguish different behaviours *in-situ*, where underwater-vision is not granted. Relatively few studies have been undertaken dealing with respiration of killer whales (Baird, 2000; Hooker & Baird, 2001; Kriete, 1995; Williams & Noren, 2008). The present study is a first descriptive on this topic in captivity thus far.

Results

The four whales showed a median apnoea of 29 sec for all three behaviours together, ranging from a minimum of a 2 sec apnoea during socializing to a maximum respiration interval of 3:36 min during resting. The interquartile range (IQR), representing 50% of the measured apnoeas per whale, was the smallest for whale 3 (24 sec), followed by whale 1 (25 sec) and whale 4 (33 sec). Whale 2 had the biggest IQR (46 sec).

The whales showed the lowest median apnoea for socializing (19 sec) and the biggest median apnoea for resting (43 sec). Swimming had a median apnoea of 34 sec (Figure 1). All behaviours showed a significant difference in apnoea distribution from one another (for all Mann Whitney U tests, $p = 0.000$). The IQR for socializing (16 sec) was remarkably smaller than for resting and swimming (33 sec and 34 sec respectively). For all whales there were significant differences in apnoea distribution for the different behaviours, except for one whale, who did not show a significant difference in apnoea distribution between socializing and swimming (Mann Whitney U test, $p = 0.067$) (Table 1).

Also there were significant differences in apnoea length between individuals displaying the behaviours. The oldest whale in the group showed the longest apnoeas for all behaviours.

Table 1. The median apnoea values (s) and the interquartile range (IQR) (s) of the apnoeas measured during the study period for all three behaviours per individual killer whale at Marineland Antibes, France.

Whale	Resting		Socializing		Swimming		In general	
	Median (s)	IQR (s)	Median (s)	IQR (s)	Median (s)	IQR (s)	Median (s)	IQR (s)
1	34.0	19.0	21.0	17.0	24.5	28.0	27.9	25.2
2	59.0	52.0	26.0	27.0	52.0	45.0	42.9	45.7
3	55.5	44.8	16.0	11.0	36.0	23.3	21.5	23.8
4	53.5	26.5	20.0	17.0	33.0	34.5	29.5	33.0

Conclusions

The main outcomes of this study are:

1. Apnoea values differ significantly between resting, socializing and swimming shown by the four killer whales studied.
2. The highest activity state coincides with the shortest median apnoea value, and *vice versa*, for all four whales studied.
3. Large individual differences in apnoea values exist.

Differences in apnoea length during different behaviours have been previously described in both wild and captive killer whales (Ford, 1989; Kriete, 1995; Williams & Noren, 2008). These same authors also confirmed, like the present study, that high activity state coincided with the shortest apnoeas. The large individual differences in apnoea length are not reported in previous studies.

We can conclude that apnoeas observed for the four individual study animals could be influenced by multiple aspects, such as weight, age, pregnancy, sex, bradycardia, and development of oxygen supplies. To be able to understand the impacts by these and other aspects, further studies, in both *in-situ* and *ex-situ*, are needed in the future.

Material & Methods

Apnoeas were collected by focal observations during 3 different behaviours: (1) swimming (moderate activity state), (2) (active) socializing (high activity state), and (3) resting (low activity state), for four killer whales held at Marineland Antibes. Statistical analyses were carried out to confirm if significant differences between different behavioural categories and apnoea distributions existed.

Observations were conducted from 19 April 2010 till 1 July 2010. During this study period a total of 2,045 apnoeas were recorded during 107 observations, spread out over 36 days, with a total duration of 20:18 hours.

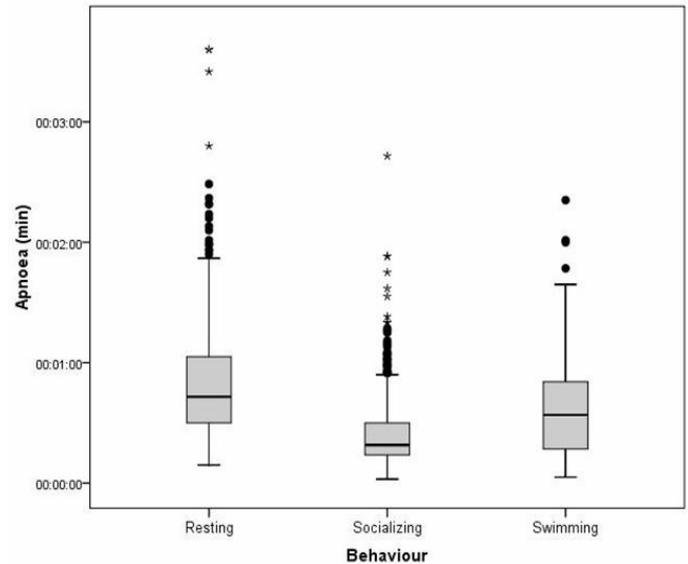


Figure 1. Box plot graphs of variability of the apnoeas found for the three studied behaviours during the study period on the four killer whales of Marineland Antibes together. The black line within the box shows the median, the boxes represent 50% of the apnoeas (interquartile range IQR) for that behaviour, the whiskers indicate the highest and lowest apnoea values within 1,5 IQR to both sides of the box. Outliers and extreme values are pointed out by • and * respectively.

References

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