Are Behavioral Data from Whalewatch Boats Biased?

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Abstract

Data collected aboard whalewatch boats have been used in a variety of cetacean studies, including behavioral studies. While it has been hypothesized that behavioral data collected from a whale watch vessel may be biased, this has not been tested. We used a data set of 30-min focal samples on humpback whales on their feeding grounds in the southern Gulf of Maine collected from 1982 to 2007 to test whether data collected from a research vessel was comparable with that from a whalewatch boat. Standard residuals from χ^2 tests were used to determine where differences existed between data sets. Whalewatch boats were found to over-sample juveniles, and to have more samples of whales that engaged in aerial behaviors, deep feeding, and social/milling activities. Research vessel samples had proportionately more samples with logging/resting and travel-only behaviors. Combined, these results suggest that whalewatch boats were more likely to spend greater periods of time with younger whales that are more likely to be active. Some methods to compensate for this bias in behavioral studies are suggested.

Introduction

Whalewatch boats have been suggested as platforms that are ideal for witnessing rare or unusual events, or for studies based on individually-based data using photo-identification (Clapham and Mayo, 1990; Clapham et al. 1993; Weinrich et al. 1992; Robbins 2000). Recent efforts have also shown that whalewatch boats can be used as platforms to examine marine mammal distribution and habitat use patterns, as long as some of the constraints of the platform are accounted for in analysis (Dahood 2009; Kaslovsky et al. 2008). In some cases, these data have been used for important management decisions, including zoning of human activities such as shipping and fishing (US Dept of Commerce, 2008).

One type of data that is typically collected from whalewatch vessels, with differing degrees of rigor, describes the behavior of the whales that are the focus of the observations. These data can be in the form of simple behavioral classifications, or contain more quantitative data on respiration rates and other behaviors. Publications on whale behavior which include, or are largely based on, whalewatch data describe ventilation patterns (Schilling et al. 1992; Kopelman and Sadove 1995), feeding behavior (Hain et al. 1982; Weinrich et al. 1992; Hain et al. 1995), mother-calf interactions (Sardi et al. 2005) and social grouping patterns (Weinrich 1991; Leaper et al. 1997; Hamilton and Mayo 1990; Scott and Sadove 1997; Ritter and Brederlau 1999; Weinrich et al. 2006).

However, until now, there have been no analyses done on potential biases in these data. Robbins and Mattila proposed that whales that spend more time on the surface, and individuals performing the most interesting behaviors (such as surface feeding, courtship/mating, and play) would be preferentially selected, but did not test for this preference. Similarly, the presence of the whalewatch operation itself may cause behavioral changes which result in a data set which would be non-representative of unaffected behavior (Williams et al. 2002; Avila and Correa 2009; Schaffar et al. 2009). However, over time, it is also possible that if such a bias in either "focal group" selection or recording of disturbed behavior is merely sporadic or infrequent, it may not lead to results different from those from any other platform if the sample size is sufficiently large.

The analysis presented herein grew out of a larger study to assess the behavior of humpback whales (*Megaptera novaeangliae*) on their feeding grounds in the Southern Gulf of Maine at different age classes. Previous work has shown that juvenile and adult whales often have different feeding strategies (Hain et al. 1995; Weinrich et al. 1997) and may even feed at different trophic levels (Sean Todd, pers. comm.). Initial results from this work were presented at the 17th Biennial Conference on the Biology of Marine Mammals (Weinrich and Corbelli 2007) and will not be presented here. However, a comparison of data from both

whalewatch and dedicated research vessel platforms allows a comparison of the results from each platform to see where differences, if any, may occur.

Methods

Humpback whales were observed from 1982-2007 in the southern Gulf of Maine on Stellwagen Bank or Jeffreys Ledge (Fig 1). Two types of observation platforms were utilized: whalewatch vessels and dedicated research vessels. Whalewatch boats ranged in length from 20 to 40 m, and were powered by 1-4 diesel engines. Whalewatch cruises were typically 3.5 – 4 hours in length, with 1 to 1.5 hours of whale observation time (the remainder of the cruise duration consisting of transit between port and the whale sighting areas). Research vessels were smaller (a 6.5 m vessel with a 115-140 hp outboard engine was used from 1983-1992, and an 8.5 m vessel with a 210 hp diesel engine was used from 1993-2007). Research cruises typically lasted for most of the day, departing 0600-0700 local time and returning in the same afternoon. While whalewatch cruises left from Gloucester, Salem, Boston, and (to a lesser extent) Provincetown, MA, all research cruises departed out of Gloucester MA.

Regardless of platform, observation techniques were similar. Two people teamed to gather data on a focal whale or group of whales. One person would be primarily responsible for the photo-identification of whales using natural variability on the flukes or dorsal fin of the focal whale(s) (Katona and Whitehead, 1981; Blackmer et al. 2000). The second observer recorded in sequence all surface behaviors of the focal whales, using an 82-behavior ethogram developed since the late 1970's by The Whale Center of New England, along with the time (to the second) of the behavior. Additional information (e.g. the position of the whale (using LORAN or GPS), presence of prey, associated seabirds, and other relevant information) were collected on an ad hoc basis. For this analysis, I only used behavioral data from focal samples (Altmann 1974; Mann 1999) with a predetermined focal sample period of 30 minutes of uninterrupted, complete information. The identity of focal whales was determined by matching their photographs against a computerized identification catalog of individuals with associated sighting data housed at The Whale Center of New England in Gloucester, MA, from which the identity, age class, sex, and other life history information on the individual was obtained.

Whales were classified into one of four age classes, based on either the known age of the individual, the visually estimated size of the individual in the first year it was seen (see Weinrich et al. 1997 for more details of this classification), or the number of years since the animal's first sighting. Whales were classified as calves (animals in their first year of life); juveniles (ages 1-4), sub-adults (ages 5-7), and adults (either known to be eight years old or greater, or had been first seen as a non-calf at least seven years prior to the sighting). Individuals who could not be classified into a discrete age class were not considered in this analysis.

Behavioral data for each focal sample were stored in a Microsoft Access database that included information on the sighting (date, location, time, and vessel); the whale being sampled (identity, age, age class, sex, etc.), the social environment of the sampled whale (group size at start and end of sample, identity of associates, and whether a calf was present in the group), and the number of times each behavior in the ethogram was expressed in the focal sample. I also coded whether each of the following behavioral categories was present in the focal sample: surface feeding, sub-surface feeding[1], travel, travel only[2], aerial – flipper behaviors (e.g. flipper slapping), aerial – tail behaviors (e.g. lobtailing, tail breaching), aerial – breaching, aerial - all[3], close to boat/inquisitive, social/milling, logging/resting, and probable nursing (calves only). These variables were treated as binary (present or absent) and analyses for this paper were based on the frequencies of samples with each behavioral mode.

[1] Sub-surface feeding was inferred by relatively long dives and little directional movement, often substantiated by echosounder traces of prey

[2] A focal sample where none of the other behavioral categories was expressed or inferred during the data collection period.

[3] Expression of one or more of the sub-categories of aerial behavior

For this analysis, comparisons were made between focal samples collected in two aggregate groups: those from whalewatch vessels (n=2,608) and those from research vessels (n=657). I tested whether there were differences in both the whales that were sampled and the behavioral results using χ^2 analyses, with standard residuals (SR) for each cell used to determine which cells contributed to the significance of the test (a cell with an SR of 1.7 or higher suggesting the cell was significant, and the direction of the significance indicated by a positive (over-represented) or a negative (under-represented) value). All analyses were done using SPSS v.15.0 statistical software.

Results

Animals sampled

When the proportion of samples of whales of different age classes were compared, there was a significant difference between the two vessel types (Table 1; χ^2=41.82, df=3, P<0.001). Juveniles were significantly over-represented in the whalewatch sample, and adults were significantly over-represented in the research vessel sample. When specific ages were examined, the whalewatch data set had over-representation of 4 year-olds (SR=2.3), while the research vessel data set had an over-representation of 15-year olds (SR=2.2) and under-representations of 2 (SR= -1.8), 4 (SR= -4.5), and 5 (SR=3.0) year-olds. There was no significant difference between the platforms in the proportion of focal samples with calves present (Table 2; χ^2=2.02, df=1, P=0.085).

Group sizes were also significantly different between vessel types (Table 3; χ^2=120.67, df=6, P<0.001). Single animals were significantly over-represented on whalewatch vessels and underrepresented on research vessels, while groups of 2, 3, 4, and $\geq$6 were over-represented on research vessels.

Behavioral Results

The proportion of samples containing each of the behavioral categories listed above is shown in Table 4, and were found to be significantly different between the two vessel classes (χ^2=57.48, df=7, P<0.001). Among whalewatch samples, deep feeding was significantly over-represented, and logging was significantly under-represented. On research vessels, samples containing logging/resting and travel-only were significantly over-represented, and samples containing aerial behavior, deep feeding, and social/milling behavior were significantly under-represented.

I also examined the three components of aerial behaviors. There was no significant difference in the proportion of samples from the different vessel types regarding flipper behaviors (χ^2=2.16, df=1, P=0.082), but there were in both tail-behaviors (χ^2=6.97, df=1, P=0.004) and breaching behaviors (χ^2=10.93, df=1, P<0.001); in both cases, the behaviors are significantly under-represented on research vessels.

Discussion

The findings presented here suggest that behavioral data from whalewatch boats have some significant and notable differences from those recorded from a research vessel.

There was an inherent difference in how focal samples were obtained from the two platforms. In the case of the research vessel, it was pre-determined that the whale would be observed for exactly 30 minutes, regardless of its activity. Whalewatch boats, on the other hand, often spend shorter periods with individual whales or groups of whales because of their more limited observation time. I would predict that the times that whalewatch boats would likely stay with a whale or group of whales long enough for 30 minutes or more would be at times where a) density of whales is low, and so there are limited animals for the boat to choose from, and b) when the focal animal(s) are being “spectacular” or interesting enough so that the vessel would be less likely to leave them for other whales.

When findings from both the animals sampled and the behavior recorded are combined, clear trends emerge that support this contention. Whalewatch boat data were biased towards juvenile whales rather than adults. Previous work has shown that juvenile whales, especially 2- and 3-year olds, are the most

"active" whales. These animals are more likely to engage in aerial activities and, when they do so, to engage in them for longer periods (Whitehead 1985; Weinrich and Corbelli 2007). On the other hand, adults are less likely to engage in such activities, and if they do, the displays are shorter in both duration and the number of events (unpublished data). Further, focal samples from research vessels over-represented less "interesting" behaviors to watch, such as logging/resting or those in which the whales only traveled.

Along the same lines, it was notable that both solitary whales and were deep feeding were over-represented on whalewatch boats. Juvenile whales are more solitary than adults (Clapham 1994), so the predominance of solitary whales may be an artifact of their disproportionately active behavior. Similarly, juvenile whales may be more likely to deep feed than adults, especially during daylight hours (Hain et al. 1995; Weinrich et al. 1997).[4]

The under-representation of younger whales in the research vessel data set may more accurately reflect the real proportion of adults to juvenile humpback whales in the habitat. While Stellwagen Bank is a habitat that is of importance to juvenile whales, it is also heavily used by adults (especially females; Robbins et al. 2001; Robbins 2007). The proportion of adult to juvenile samples may therefore be more representative of the population at large. Further, since the research vessel undertook longer cruises, they may have been able to access areas with adult aggregations that may be more distant. Because of time constraints, however, whalewatch boats may be limited to a temporarily sub-optimal habitat that contains prey suitable for juveniles (who have lower energetic needs – Lockyer 1981) but not adults.

In summary, the results presented here substantiate the contention of Robbins and Mattila (2000) that behavioral data collected from whalewatch boats may contain a bias caused by the nature of the observation platform. They will tend to over-represent active animals, and under-represent behaviors that may actually make up a substantially larger portion of an animal's time budget, including resting or traveling. Potential ways to deal with this bias is to also record the behavior of non-focal animals, to use a shorter focal sample period, or to use an alternative method to sample behaviors (e.g. scan samples). However, using the protocol employed during this study, results from whalewatch boats would not be likely to give a clear picture of an animal's natural time-energy budget.

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Table 1. Results of a χ^2 comparison of the number of focal samples of each age class recorded on research and whalewatch vessels, including standard residuals.

			Age class				Total
			1 - calf	2 - juv	3 - subad	4 - adult	1 - calf
Research Vessel?	Research Vessel	Count	115	119	63	360	657
		Std. Residual	.6	-4.7	-.2	3.3	
	whalewatch	Count	424	785	259	1140	2608
		Std. Residual	-.3	2.3	.1	-1.7	
Total		Count	539	904	322	1500	3265

Table 2. Results of a χ^2 comparison of the number of focal samples of each age class recorded on research and whalewatch vessels, including standard residuals.

			Calf Present?		Total
			No	Yes	No
Research Vessel?	Research Vessel	Count	450	207	657
		Std. Residual	-.7	1.1	
	whalewatch	Count	1860	748	2608
		Std. Residual	.3	-.5	
Total		Count	2310	955	3265

Table 3. Results of a χ^2 comparison of the number of focal samples of different group sizes recorded on research and whalewatch vessels, including standard residuals.

			Group size start							Total
			0	1	2	3	4	5	6	0
Research Vessel?	Research Vessel	Count	0	130	371	117	28	4	7	657
		Std. Residual	-.9	-6.5	3.0	3.3	3.2	-1.1	4.7	
	whalewatch	Count	4	1005	1207	313	49	30	0	2608
		Std. Residual	.5	3.3	-1.5	-1.6	-1.6	.5	-2.4	
Total		Count	4	1135	1578	430	77	34	7	3265

Table 4. Results of a χ^2 comparison of the number of focal samples containing different behavioral categories recorded on research and whalewatch vessels, including standard residuals.

			Binned_beh								Total
			Aerial	CTB	Deep feeding	Logging	Social - Milling	Surface feeding	Travel	Travel only	
Research Vessel?	Research Vessel	Count	77	21	28	76	20	40	157	238	657
		Std. Residual	-3.1	-.6	-3.4	3.5	-1.7	-.3	.3	3.0	
	whalewatch	Count	468	97	232	178	126	168	606	733	2608
		Std. Residual	1.6	.3	1.7	-1.7	.9	.1	-.1	-1.5	
Total		Count	545	118	260	254	146	208	763	971	3265