Can you see me now? Evaluating the detectability cetaceans during line-transect surveys in the SE U.S.

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Introduction: Shipboard line-transect surveys are used to estimate the abundance and density of cetaceans using Distance sampling techniques. The relative bearing and the radial distance of cetaceans from the trackline are recorded, which combined allow for the calculation of perpendicular sighting distances (Figure 1). The distribution of calculated perpendicular sighting distances allow for the estimation of the probability of detections of animals within the surveyed strip (Thomas et al, 2010). Sea state and, potentially, scientific echosounders (EK) are two of the factors that may affect visual detections during these surveys (Barlow et al, 2001; Cholewiak et al, 2017).

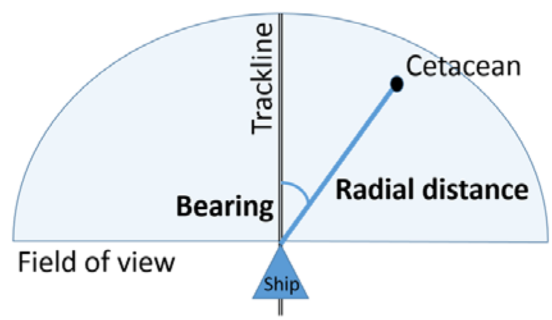

Figure 1: Schematic of survey design and measurements.

Objective: The goal of this study was to calculate the radial distances of Delphinid, Kogiid and Ziphiid visual detections and evaluate whether they varied by ocean basin, sea state, and EK status.

Methods: Between 2009 and 2017, the SEFSC conducted four line-transect surveys onboard the *NOAA Ship Gordon Gunter* (Table 1; Figure 3B). Marine mammal observers recorded the radial distance from the ship to the cetacean (s) by reading a reticle scale on the big-eye binoculars (25x150); the relative bearing was read using an azimuth ring at the base of the big-eyes (Figure 3A).

For this study, detections were categorized as Delphinids (small dolphins and blackfish), Kogiids (Pygmy or Dwarf sperm whales) and Ziphiids (beaked whales). Radial distance (direct animal-observer distance; Figure 1) was calculated in meters for each detection and the values were compared using boxplot, Wilcoxson Mann Whitney rank sum test (U) and Spearman's rank correlation test to examine the relationship between distances and the variables: ocean basin (Atlantic vs. Gulf), sea state (Beaufort scale 0-6, also further categorized as “low” 0-2 and “high” 3-6) and EK status (on vs. off).

Ocean Basin	Year	EK Status	Survey	Method	Effort (km)	Ave SS*	Total Detections	Detection rate x 100 km
Gulf	2009	On	GU0903	2 big-eye obs.	3,584.8	2.2	105	2.93
	2017	Off	GU1703	4 big-eye obs.	6,343.1	2.6	189	2.98
Atlantic	2013	On	GU1304	4 big-eye obs.	5,667.5	2.0	438	7.73
	2016	Off	GU1605		4,874.5	2.7	413	8.47
Total	**4**	**2 each**	**4**	**2**	**10,542.0**	**2.4**	**851**	**8.07**

Table 1: Schedule, effort, sea state and total detections for all line-transect surveys.
* Average sea state during detections.

Results: No significant differences in the detections' radial distances were found for ocean basin. Significantly larger distances were found in lower sea states for Delphinids and Ziphiids ("low" vs. "high") and with the EK on for Delphinids only (on vs. off). Kogiids showed no significant differences for all variables (Figure 2, Table 4,). In addition, strong correlations between radial distance and sea state (0-6) and EK status (on/off) were found for all species combined (Table 2).

Figure 2: Boxplot for medians, ranges and outliers of radial distances for species categories by ocean basin, sea state category and EK status.

Variables	Spearman's rank correlation for radial distance
Sea state	- 0.30, **p<0.001**
EK Status	0.25, **p<0.001**

Table 2: Spearman's rank correlation results for radial distances evaluated by sea state and EK status; significant correlations are in bold.

Radial distances (m)									
	n	Min.	1stQu.	Median	Mean	3rdQu.	Max.	W	p
Delphinids	**892**	**total detections**							
Atlantic	635	25.0	1,723.0	3,046.0	3,445.0	4,937.0	12,205.0	87220	0.107
Gulf	257	0.0	1,721.0	2,824.0	3,260.0	4,439.0	13,207.0		
SS Low	479	5.0	2,322.0	3,814.0	4,048.0	5,588.0	13,207.0	60211	**0.000**
SS High	413	0.0	1,306.0	2,195.0	2,631.0	3,614.0	9,213.0		
EK on	444	10.0	2,289.0	3,943.0	4,036.0	5,588.0	13,207.0	65626	**0.000**
EK off	448	0.0	1,557.0	2,322.0	2,753.0	3,772.0	9,292.0		
Kogiids	**106**	**total detections**							
Atlantic	86	475.2	1,477.1	1,859.3	2,314.3	2,969.5	6,427.0	762	0.431
Gulf	20	877.9	1,580.7	2,293.1	2,478.8	3,614.3	4,259.8		
SS Low	104	475.2	1,477.1	1,883.0	2,350.9	3,115.9	6,427.0	104.5	1.000
SS High	2	1,721.0	1,889.0	2,057.0	2,057.0	2,225.0	2,393.0		
EK on	52	747.2	1,605.0	1,859.3	2,363.7	3,029.8	6,427.0	1375	0.857
EK off	54	475.2	1,305.4	1,906.3	2,327.8	3,357.4	6,059.9		
Ziphiids	**147**	**total detections**							
Atlantic	130	200.0	1,421.0	2,548.0	3,083.0	4,364.0	8,393.0	1275	0.306
Gulf	17	757.5	1,585.8	2,725.2	2,397.3	3,046.3	4,259.8		
SS Low	111	200.0	1,742.0	2,780.0	3,220.0	4,399.0	8,393.0	1426	**0.010**
SS High	36	757.5	1,306.4	1,906.3	2,336.4	2,962.8	8,178.3		
EK on	47	695.5	1,565.4	3,005.3	3,462.0	4,688.3	8,392.9	1968	0.113
EK off	100	200.0	1,408.0	2,385.0	2,788.0	3,614.0	8,178.0		

Table 4: Wilcoxson Mann Whitney rank sum test (U) results for radial distances for species categories by ocean basin, sea state category and EK status; significant differences are in bold and highlighted.

Potential confounding between sea state and EK status in the Delphinid detections was found as 64% of the dolphin detections recorded with the EK on were also recorded in "low" sea states, whilst only 44% of the dolphin detections with EK off were seen at "low" sea states (2-sample test for equality of proportions test , X^2=37, df=1, **p<0.001**). In addition, the average sea state (0-6) for Delphinid detections with the EK on was lower than with the EK off (2.3 vs. 2.9; Table 3).

To further investigate potential confounding of sea state and echosounder status in the radial distances of Delphinid detections, we held the sea state variable constant by analyzing only the sea state 2 dolphin detections. Again, significantly larger distances were found with the EK on than off even when sea state was constant (Table 3).

	Delphinid detections			
	Sea state		Radial distance Ss 2	
	EK off	EK on	EK off	EK on
n	448	444	183	162
Min.	1	0	5.0	100.0
1stQu.	2	1	1,883.0	2,641.0
Median	3	2	2,725.0	3,943.0
Mean	2.9	2.3	3,283.0	3,978.0
3rdQu.	4	3	4,488.0	5,179.0
Max.	6	5	9,292.0	9,213.0
W	131580		11448	
p	**0.000**		**0.000**	

Table 3: Wilcoxson Mann Whitney rank sum test (U) results for Delphinid detections only. Sea state for EK On vs. Off and radial distances (m) at sea state 2; significant differences are in bold and highlighted.

Conclusions: Not surprisingly, sea state was found to be a strong factor affecting the radial distance of cetacean detections. There are indications that echosounder noise is also a factor driving detections of Delphinids away from the ship. Yet, it remains to be better understood as there are other variables that could be affecting radial distances that were not evaluated here, such as group sizes, haze distorting the horizon, observer experience and animal behavior (e.g. cryptic surfacing, proneness to bow riding).

Further studies should be done utilizing analysis tools that take into account confounding factors between variables, such as generalized additive models. Field studies conducted under different environmental conditions and systematically alternating the use of echosounders during visual line-transect surveys are also encouraged.

Figure 3: A- Marine mammal observer scanning with big-eyes; B- *NOAA Ship Gordon Gunter* with pilot whales (Delphinidae, *Globicephala* spp.).

It is worth emphasizing that the cetacean detections utilized here were visual events; for acoustic detections, echosounder noise has been shown to have a marked effect for Ziphiids (Cholewiak et al., 2017).

References:

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