

# Observations of Bowhead Whale Foraging Near Barrow, Alaska, in 2015 Support the Krill Trap Model

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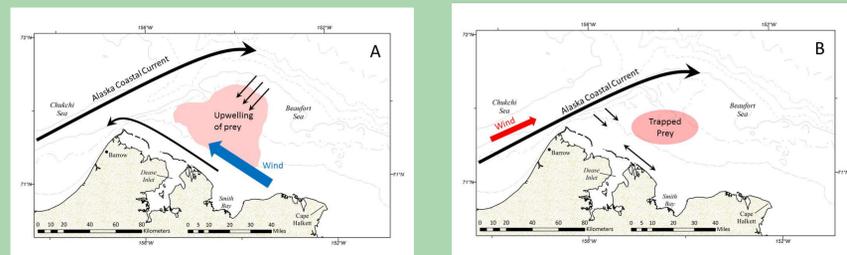


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## Abstract

The density, behavior, and group size distribution of bowhead whales over Barrow Canyon and the Beaufort Sea shelf near Barrow, AK, during late summer and fall exhibit interannual variability that may be partially explained by the presence of dense patches of euphausiids (krill) and copepod prey. The “krill trap” model theorizes that moderate to strong easterly winds cause upwelling that advects prey onto the shelf, which then become aggregated (“trapped”) when wind speed decreases or direction changes to westerly or southwesterly. Furthermore, the model predicts that during upwelling periods bowhead whales will be found in smaller groups, often in Barrow Canyon, whereas during krill trap active periods bowhead whales will be found in larger groups over the shelf. Between 26 August and 4 October 2015, the Aerial Surveys of Arctic Marine Mammals (ASAMM) project (funded and co-managed by BOEM, conducted by NOAA) found historically high densities of feeding bowhead whales on the shelf south of 72° N, between Pt. Barrow and Cape Halkett (152°-157° W). During this period, ASAMM conducted 8 surveys totaling over 40 hrs and observed 672 total bowhead whales, 454 of which were either feeding or milling. The ratio of feeding/milling to total bowhead whales in 2015 (0.676) was second only to 2009 (0.732) in a time series of annual surveys beginning in 1989. Seven ASAMM surveys were conducted on 6 of 8 krill trap active periods in 2015; feeding/milling bowhead whales were observed on 5 of those surveys. During the active krill trap phase, the observed mean and maximum bowhead whale group sizes were larger than at other times. A single survey was conducted during the upwelling phase and moderate numbers of bowhead whales were observed, none of which were feeding/milling. Comparison of bowhead whale group sizes on krill trap active days with data from surveys conducted 5 days prior showed that krill trap group sizes were larger, implying that the bowhead whale congregation response was rapid. All of the fall bowhead whales harvested near Barrow in 2015 had been feeding on euphausiids. ASAMM bowhead whale observations in 2015 support the krill trap model.

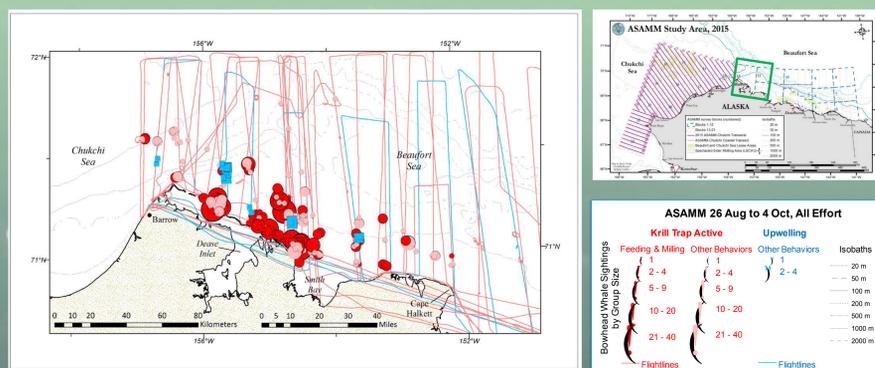
## Krill Trap Model



**Figure 1.** The “krill trap” model theorizes that moderate to strong easterly winds cause upwelling that advects prey onto the shelf (A), which then become aggregated (“trapped”) when wind speed decreases or direction changes to westerly or southwesterly (B). Black arrows show schematized currents. The model predicts that during upwelling periods bowhead whales will be found in smaller groups, often in Barrow Canyon, whereas during krill trap active periods bowhead whales will be found in larger groups over the shelf.

## Methods

- Line-transect aerial surveys for marine mammals were conducted by observers in high-wing twin engine turboprop aircraft
- Focal study area: 152° to 157° W, from the coast to 72° N (Figure 2)
- Focal survey dates in 2015: August 26; September 1, 7, 16\*, 21, 26, 27; October 4 (Table 2). \*Survey conducted during upwelling period.
- Survey effort and sightings were recorded as one of four flight types: deadhead, circling, search, or transect
- Similar survey protocols were used from 1989 to 2015



**Figure 2.** ASAMM Bowhead whale sightings (including circling, search, and transect) and survey effort (including deadhead, circling, search, and transect) in the focal study area near Barrow, Alaska, during krill trap active and upwelling periods, 26 August to 4 October 2015.

## References

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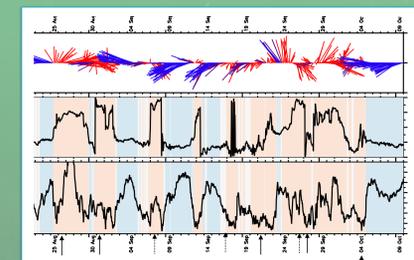
## Winds and Whales

- In 2015, the total number of bowhead whales and the number of feeding and milling bowhead whales were high, resulting in the second-highest feeding ratio (# feeding and milling whales / total # whales) since 1989 (Table 1).

**Table 1.** Number of feeding or milling and total bowhead whales observed during all flight types, by month, near Barrow during ASAMM surveys, 1989-2015. Feeding ratios were calculated as the number of feeding or milling bowhead whales divided by total bowhead whales. Black cells identify periods with no survey effort.

Year	JUL			AUG			SEP			OCT			TOTAL		
	Feed & Mill	Total	Feeding Ratio	Feed & Mill	Total	Feeding Ratio	Feed & Mill	Total	Feeding Ratio	Feed & Mill	Total	Feeding Ratio	Total	Feeding Ratio	
1989	0	0		0	0		0	0		3	9	0.333	3	9	0.333
1990	0	0		0	0		0	0		3	32	0.094	3	32	0.094
1991	0	0		0	0		0	0		0	1	0.000	0	1	0.000
1992	0	0		0	1	0.000	37	77	0.481	37	78	0.474	78	0.474	
1993	0	0		0	9	0.000	6	32	0.188	6	41	0.146	41	0.146	
1994	0	0		0	6	0.000	0	2	0.000	0	8	0.000	8	0.000	
1995	0	0		0	1	0.000	0	8	0.000	0	9	0.000	9	0.000	
1996	6	18	0.333	0	0		0	0		0	6	0.18	6	0.18	
1997	55	105	0.524	127	204	0.623	182	309	0.589	182	309	0.589	309	0.589	
1998	243	385	0.631	9	45	0.164	252	440	0.573	252	440	0.573	440	0.573	
1999	3	24	0.125	57	109	0.523	60	133	0.451	60	133	0.451	133	0.451	
2000	38	57	0.667	0	7	0.000	38	64	0.594	38	64	0.594	64	0.594	
2001	0	2	0.000	0	0		0	0		0	2	0.000	2	0.000	
2002	0	1	0.000	3	13	0.231	4	15	0.267	4	15	0.267	15	0.267	
2003	0	12	0.000	0	1	0.000	0	13	0.000	0	13	0.000	13	0.000	
2004	138	200	0.690	0	23	0.000	138	223	0.619	138	223	0.619	223	0.619	
2005	28	37	0.757	1	8	0.125	29	45	0.644	29	45	0.644	45	0.644	
2006	37	75	0.493	6	17	0.353	43	92	0.467	43	92	0.467	92	0.467	
2007	0	0		0	0		0	0		0	0		0		
2008	0	0		0	0		15	89	0.169	12	60	0.200	12	60	0.200
2009	0	0		0	0		2	11	0.182	266	355	0.749	268	366	0.732
2010	0	0		0	0		22	34	0.647	0	13	0.000	22	47	0.468
2011	0	0		0	0		0	13	0.000	0	6	0.000	0	19	0.000
2012	0	8	0.000	24	37	0.649	1	29	0.034	20	91	0.220	45	165	0.273
2013	0	0		24	45	0.533	54	105	0.514	0	35	0.000	78	185	0.422
2014	0	14	0.000	0	8	0.000	69	129	0.535	40	78	0.513	109	229	0.476
2015	0	0		24	48	0.500	322	461	0.698	108	163	0.663	454	672	0.676

- In 2015, feeding and milling bowhead whales were observed only during krill trap active periods (Figures 2 and 3, Table 2).

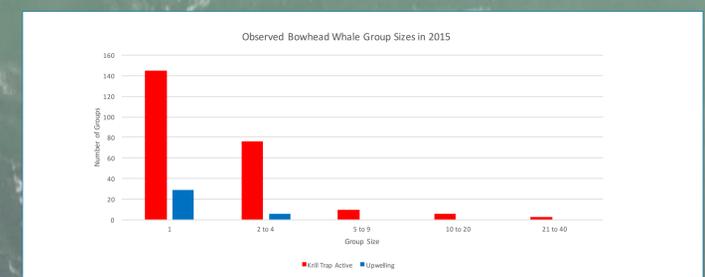


**Figure 3.** Wind speed and direction near Barrow from 20 August to 9 October, 2015. Upwelling periods, when easterly winds are stronger than 5.4 m/s, are shown as blue stripes. Red stripes depict krill trap active periods, which occur under westerly winds or when winds are weak from any direction. Feeding bowhead whales sighted during survey. No feeding bowhead whales sighted during survey.

**Table 2.** Summary of ASAMM survey flights and bowhead whales observed in the focal area between 26 August and 4 October 2015. Red = krill trap active period. Blue = upwelling period.

Date	Flight Time (hours) in Focal Area	Number of Bowhead Whales Observed			
		Total	Calves	Mill	Feed
8/26/2015	3.23	32	1	0	23
9/1/2015	1.33	57	2	0	9
9/7/2015	2.23	8	0	0	0
9/16/2015	6.62	46	3	0	0
9/21/2015	4.28	187	6	0	136
9/26/2015	2.55	10	1	0	0
9/27/2015	3.18	187	0	18	165
10/4/2015	6.93	164	8	36	79

- During krill trap active periods, the observed mean (2.43 whales) and maximum (40 whales) group sizes were larger than during the upwelling period (mean = 1.23 whales, maximum = 4 whales) (Figures 2 and 4).



**Figure 4.** Histogram of observed bowhead whale group sizes in the focal area in 2015, all flight types, during krill trap active and upwelling periods.

## Conclusions

- The ratio of feeding & milling bowhead whales in 2015 was second only to 2009 in records dating back to 1989
- During krill trap active periods, the observed mean and maximum bowhead whale group sizes were larger than at other times
- Comparison of bowhead whale group sizes on krill trap active days with data from surveys conducted 5 days prior showed that krill trap group sizes were larger, implying that the bowhead whale congregation response was rapid
- ASAMM bowhead whale observations in 2015 support the krill trap model