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# Bowhead Whale Carcasses in the Eastern Chukchi and Western Beaufort Seas, 2009-2017

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## ABSTRACT

Bowhead whale (*Balaena mysticetus*) carcass data and imagery provide insights into the health of the species. The Aerial Surveys of Arctic Marine Mammals (ASAMM) project surveys large areas of otherwise inaccessible offshore bowhead whale habitat in a relatively short period of time. ASAMM offers a long time series of consistent information on floating and beach-cast bowhead whale carcasses detected during standardized line-transect surveys. A total of 27 carcasses identified as bowhead whale were documented from 2009 to 2017. Twenty-one carcasses (78%) were found floating and six were beach-cast (22%). Highest number of carcasses were observed in 2015 (10/27), followed by 2013 (6/27), and 2016 (5/27). Carcasses were distributed across the eastern Chukchi (EC) and western Beaufort (WB) sea study areas from 141.6°W to 168.1°W and 68.9°N to 72.0°N. More bowhead whale carcasses were seen in the EC study area; September had the highest number of bowhead whale carcass sightings in both EC and WB study areas; and September had the most survey effort, but October had the highest bowhead whale carcass sighting rates. Bowhead whale carcasses having injuries consistent with killer whale predation were photo-documented in one carcass in 2017, two carcasses per year in 2012, 2013, and 2015, and three carcasses in 2016. Three of the bowhead whale carcasses documented by ASAMM were likely calves or yearlings: one each in 2013, 2015, and 2017. Each of the calf/yearling carcasses was photographed and showed signs of killer whale interactions. Prior to 2012, evidence of killer whale predation on bowhead whales was not recorded in the ASAMM database or carcass imagery. Two carcasses, one in 2013 and one in 2015, were likely whales struck and lost during aboriginal subsistence hunting activity; this is based on timing, proximity to known struck and lost whales, and image review of those carcasses. One carcass in 2015 had gear attached (orange buoy and attached line) that was consistent with commonly used subsistence whaling equipment.

**KEY WORDS: BOWHEAD WHALE, CARCASS, ARCTIC, SURVEY-AERIAL, LINE-TRANSECT, KILLER WHALE, PREDATION**

## INTRODUCTION

The Aerial Surveys of Arctic Marine Mammals (ASAMM) project provides information on marine mammal distribution, behavior, and relative abundance in the western Beaufort and eastern Chukchi seas. Bowhead whale (*Balaena mysticetus*) carcass imagery provide insights into natural and anthropogenic mortality causes of the species. ASAMM effectively surveys large areas of otherwise inaccessible offshore bowhead whale habitat in a relatively short period of time. ASAMM offers a long time series of consistent information on floating and beach-cast bowhead whale carcasses detected during standardized line-transect surveys. ASAMM bowhead whale carcass sighting and imagery data from 2009 to 2017 are presented here. For an overview of bowhead whale carcass sightings from 1982-2017 see George *et al.* (2018).

## METHODS

The study area in 2009 to 2013 comprised the area between 68°-72°N and 140°-169°W, and in 2014 was expanded south to 67°N. This area consists of 23 survey blocks, encompassing 242,000 km<sup>2</sup> (Fig. 1). Starting in 2016, survey effort also included areas inshore of the barrier islands north of Deadhorse, Alaska. Also in 2016, surveys were

extended north of the central western Beaufort Sea study area to target Eastern Chukchi Sea beluga habitat (for full details see Clarke *et al.* 2017). Line-transect aerial surveys were flown in De Havilland Twin Otters in 2009 and 2010 and Turbo Commanders from 2009 to 2017. All aircraft were equipped with left- and right-side bubble windows for a complete view of the survey trackline. Surveys were conducted daily, weather permitting, from approximately 2 July through 30 October. Survey flights were flown at a targeted speed of approximately 213 km/hr, altitudes of 365-457 m, and Beaufort wind force < 6. The marine mammal observer team consisted of one primary observer stationed in each bubble window and one dedicated data recorder who entered data into a laptop computer outfitted with specialized data entry software. Data collected at regular intervals during surveys included date, time, location, and environmental conditions; additional data were recorded during sighting events or changes in weather. For full survey methods and materials, see Clarke *et al.* (2017).

During survey effort, all marine mammal sightings, including carcasses, were recorded. When survey parameters and flight safety allowed, sightings of large whale carcasses were further investigated by diverting to circle the carcass to verify species, level of decomposition, and, when possible, obtain photographs. Immediately following a flight, bowhead whale carcasses located along the shore or within 18 km of shore were reported to the North Slope Borough (NSB) Department of Wildlife Management (DWM). Within approximately 24 hours, NOAA Marine Mammal Stranding Report - Level A Data forms were compiled for every new bowhead whale carcass sighted, and disseminated with photos (when applicable) to the appropriate authorities, including the National Marine Fisheries Service Alaska Stranding Network Coordinators, and biologists/veterinarian with the NSB DWM and Alaska Sea Grant.

Bowhead whale carcass sighting rates (number of bowhead whale carcasses per 1000 km of effort) were computed to evaluate the variability in carcass sightings between the eastern Chukchi (EC; 67-72°N and 157-169°W) and western Beaufort (WB; north to 72°N and 140-157°W) sea study areas. Bowhead whale carcass sighting rates were calculated using sightings during transect (Tr) and circling from transect (TrC) survey modes, which were considered “on effort”. Carcasses sighted during search and circling from search modes were considered “off effort.” Sighting rates were calculated monthly and annually for the WB study area and the EC study area.

## RESULTS

A total of 27 carcasses identified as bowhead whale were documented from 2009 to 2017 (Fig. 2, Tables 1 and 2). Twenty-one carcasses (78 %) were found floating and six were beach-cast (22%). Bowhead whale carcasses were seen in all years except 2011 and 2014 (Tables 1, 2, and 3). Highest percent of carcass sightings was 37% observed in 2015 (10/27), followed by 22% in 2013 (6/27), and 18.5% in 2016 (5/27) (Table 2). In both study areas, more carcass sightings occurred in September than in other survey months (Fig. 3, Tables 1, 2, and 3). Carcasses were distributed across the EC and WB study areas from 141.6°W to 168.1°W and 68.9°N to 72.0°N (Fig. 2). The majority 77.7% (21/27) of carcass sightings occurred in the EC study area, of which 57% (12/21) were in September (Table 1 and 2). Six bowhead carcasses were seen in the WB study area, of which three were in September (Tables 1 and 2).

In the ASAMM study area, there were a total of 19 bowhead whale carcasses recorded on effort (Tr+TrC): 14 in the EC study area and 5 in the WB study area (Table 3). Even though the WB study area had similar and, in some years (2016 and 2017), more, annual effort than the EC study area, the WB area accounts for only 26% of on-effort carcass sightings (Table 3). In summary, more bowhead whale carcasses were seen in the EC study area; September had the highest number of bowhead whale carcass sightings in both EC and WB study areas; and September had the most survey effort, but October had the highest bowhead whale carcass sighting rates (Table 3).

The cause of death is difficult to determine on free-floating or beach-cast whales seen during aerial surveys and, due to the remoteness of the Alaskan Arctic, only few reported beach-cast carcasses are investigated and forensic necropsies performed. Nevertheless, based on scarring and injury evidence from landed whales, Alaska stranding and necropsy data on beach-cast bowhead whales, examination of images of bowhead whale carcasses and traditional ecological knowledge from Alaskan and Canadian aboriginal whaling communities, killer whale attacks, ship strikes, and entanglement in commercial fishery gear have been identified as potential non-harvest related causes of morbidity and mortality of bowhead whales (for example Hay *et al.* 2000; Ferguson *et al.* 2012, George *et al.* 2017; Shpak and Stimmelmayer 2016; NSB DWM unpubl.data). Beginning in 2009, efforts to collect imagery of bowhead whale carcasses were implemented. Imagery review of carcasses by bowhead whale specialists and marine mammal

veterinarians have provided insight into the probable cause of death for 12 (44%) of the 27 carcasses recorded since 2009.

Bowhead whale carcasses having injuries consistent with killer whale predation were photo-documented in one carcass in 2017, two carcasses per year in 2012, 2013, and 2015, and three carcasses in 2016 (Fig. 4, Table 1). Three of the bowhead whale carcasses ASAMM documented were likely calves or yearlings: one each in 2013, 2015, and 2017. Each of the calf/yearling carcasses was photographed and showed signs of killer whale interactions, including flesh missing from heads and ventral “chins”, suggesting death was likely due to predation, and one had resolved rake marks on its right pectoral flipper (Fig. 5). Prior to 2012, evidence of killer whale predation on bowhead whales was not recorded in the ASAMM database or carcass imagery.

Two carcasses, one in 2013 and one in 2015, were likely whales struck and lost during aboriginal subsistence hunting activity; this is based on timing, proximity to known struck and lost whale, and image review of those carcasses (Fig. 4, Table 1). One carcass in 2015 had gear attached (orange buoy and attached line) that was consistent with commonly used subsistence whaling equipment but not commercial fishing gear (C. George, pers. comm. to J. Clarke on 28 October 2015). This carcass was >250 km west of Utqiagvik so close examination was not possible and cause of death could not be determined.

## DISCUSSION

The fact that there were more bowhead whale carcass sightings in the EC compared to the WB cannot be accounted for using the differences in survey effort between the two areas. It is possible that offshore currents and winds in the Beaufort Sea are carrying carcasses westward into the Chukchi Sea or farther north of the ASAMM survey area. Satellite-tracked sea drifter data collected during a study conducted in 2014 (<http://mather.sfos.uaf.edu/drifters/Chukchi2014/>) support this idea, but do not account for other factors such as body mass or wind variations. In contrast to the drifters’ westward track, ASAMM documented a floating bowhead whale carcass sighted three times in 2016, moving progressively eastward in the WB. The carcass was initially sighted on 27 August, resighted on 8 September, and again on 21 September, having drifted southeasterly nearly 330 km (Clarke *et al.* 2017). This may be an anomaly driven by predominately westerly winds during the sighting period. Carcasses sighted in the Chukchi Sea may include whales that died in the Chukchi and perhaps also whales that died in the Beaufort and then were transported west by currents and winds. Once in the Chukchi, carcasses might get caught in the various eddies and currents that flow around Hanna and Herald shoals (see Pickart *et al.* 2016), increasing the likelihood of being found by ASAMM.

Carcass imagery was reviewed to rate the level of decomposition. “Fresh to moderate” decomposition was assigned to 81% of floating carcasses. Skin intact, with little to no visible signs of bird scavenging (e.g., tufted appearance of black skin), was considered to be fresh. Some to most skin sloughed off, with visible bird scavenging, was considered to be moderate. Although it is unknown how quickly free-floating bowhead whale carcasses decompose and when they sink, it is plausible that if bowhead whale carcasses were remaining afloat in the study area for long periods of time (e.g., >10 days), we would have more intra-annual repeat sightings of individual carcasses, or we would see more carcasses with advanced levels of decomposition than we do.

The apparent increase in killer whale predation on bowhead whales beginning in 2012 may be associated with the dramatic sea ice reduction during summer and fall that may allow killer whales to hunt in areas, like the northeastern Chukchi Sea, that were previously ice covered, similar to conditions occurring in the eastern Canadian Arctic (Reinhart *et al.* 2013). The increase in killer whale predation as cause of death in bowhead whale carcass sightings is intriguing and consistent with results reported in George *et al.* (2017) on increasing prevalence of injuries/scars from killer whale predation attempts in landed bowhead whales. Similar results have been reported for Eastern Canadian Arctic bowheads by Reinhart *et al.* (2013) and for Okhotsk Sea bowheads by Shpak (2016). Higdon and Ferguson (2009) hypothesized that, in the eastern Canadian Arctic, decreased sea ice presence might allow killer whales to access the Arctic through areas that were previously “choke points”, created by sea ice blockages in waterway straights and between islands. Review of ASAMM gray whale carcass imagery could provide further insight into the presence and extent of killer whale predation within the ASAMM study area.

Documentation of bowhead whale carcasses is an important factor in monitoring the effects of climate change in the Arctic and implementing effective management and conservation of the species. Nearly all of the bowhead whale carcasses ASAMM detects would have gone undocumented in the absence of these aerial surveys.

## ACKNOWLEDGMENTS

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Table 1. Chronological listing of ASAMM bowhead whale carcass sightings, all months, Beaufort (B = Longitude > -157°W) and Chukchi (C = Longitude < -157°W) seas, 2009-2017. Intra- and inter-annual resighting dates are referenced in the notes for the original sighting.

Date	Latitude °N	Longitude °W	Survey Area	Notes
8/20/2009	70.917	157.607	C	
7/27/2010	68.856	165.718	C	
9/17/2010	71.146	157.986	C	
9/26/2012	71.151	157.682	C	Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 1/21/2018
10/1/2012	71.353	158.861	C	Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 1/29/2018
9/11/2013	71.172	162.642	C	Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 1/21/2018
9/16/2013	70.605	147.825	B	Likely struck whale from subsistence activities that was lost in this area
9/19/2013	70.486	160.431	C	
9/24/2013	70.873	157.765	C	
9/26/2013	70.878	159.103	C	
9/30/2013	71.623	167.994	C	Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 1/21/2018
8/18/2015	70.875	159.174	C	
9/21/2015	70.789	168.724	C	
9/23/2015	70.828	146.731	B	
9/27/2015	71.415	159.031	C	Small whale; whale was resighted on 9/28/2015
10/4/2015	71.281	158.512	C	
10/4/2015	71.388	155.454	B	Confirmed via photos to be struck and lost whale from subsistence activities several days prior
10/4/2015	71.331	153.749	B	Appears to be calf; Resolved rake marks on right pec; fresh injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 1/21/2018
10/27/2015	70.992	162.354	C	
10/27/2015	71.460	164.172	C	Carcass with orange float attached
10/27/2015	72.017	165.377	C	Possible calf or yearling, based on size, per conversation with C.George (NSB) 4/30/2017; Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 1/21/2018
7/13/2016	70.845	160.018	C	Whale resighted 9/10/2016; matched using lesions on jaw and aft of pec; Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 1/29/2018
8/27/2016	71.499	150.158	B	Carcass was resighted on 9/8 & 9/21 2016
9/11/2016	71.311	165.809	C	Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 2/1/2018
9/11/2016	71.486	163.339	C	Injuries consistent with killer whale predation; R.Stimmelmayer (NSB DWM) on 2/1/2018
9/14/2016	70.334	141.614	B	
9/30/2017	71.742	166.701	C	C. George (NSB DWM) reviewed photo: small male, flipper size consistent with a calf or < 1.5 years old; injuries consistent with killer whale predation R.Stimmelmayer (NSB DWM) on 1/29/2018

Table 2. ASAMM bowhead whale carcasses, all survey modes, for the eastern Chukchi Sea study area (EC; 2009-2013: 68°-72°N, 157°-169°W; 2014-2017: 67°-72°N, 157°-169°W), western Beaufort Sea study area (WB; 2009-2017: south of 72°N, 140°-157°W), and both areas combined (A), tallied by month and year.

	JUL			AUG			SEP			OCT			Total by Year
	EC	WB	A	EC	WB	A	EC	WB	A	EC	WB	A	
2009	0	0	0	1	0	1	0	0	0	0	0	0	1
2010	1	0	1	0	0	0	1	0	1	0	0	0	2
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	1	0	1	1	0	1	2
2013	0	0	0	0	0	0	5	1	6	0	0	0	6
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	1	0	1	2	1	3	4	2	6	10
2016	1	0	1	0	1	1	2	1	3	0	0	0	5
2017	0	0	0	0	0	0	1	0	1	0	0	0	1
Total by Area & Month	2	0	2	2	1	3	12	3	15	5	2	7	Grand Total 27

Table 3. Sighting rates of bowhead whale carcasses in the eastern Chukchi Sea study area (EC; 2009-2013: 68°-72°N, 157°-169°W; 2014-2017: 67°-72°N, 157°-169°W) and western Beaufort Sea study area (WB; 2009-2017: south of 72°N, 140°-157°W), on effort, by month, per year. Bowhead Whale Carcass Sighting Rate: Number of bowhead whale carcasses (*n*) per 1000 kilometers flown on effort (Tr+TrC). Note that dedicated Beaufort Sea surveys in 2009-2011 did not begin until September.

EC		July			August			September			October			Annual		
Year	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	
2009	5.17	0	0.00	3.88	1	0.26	7.09	0	0.00	4.47	0	0.00	20.61	1	0.05	
2010	7.53	0	0.00	4.19	0	0.00	4.90	0	0.00	3.04	0	0.00	19.65	0	0.00	
2011	5.24	0	0.00	7.07	0	0.00	8.63	0	0.00	2.98	0	0.00	23.92	0	0.00	
2012	9.96	0	0.00	5.71	0	0.00	8.07	0	0.00	7.62	1	0.13	31.36	1	0.03	
2013	5.45	0	0.00	9.01	0	0.00	9.30	3	0.32	0.96	0	0.00	24.73	3	0.12	
2014	7.42	0	0.00	6.42	0	0.00	7.43	0	0.00	5.58	0	0.00	26.84	0	0.00	
2015	5.72	0	0.00	8.12	1	0.12	9.39	1	0.11	6.74	3	0.44	29.97	5	0.17	
2016	7.50	1	0.13	8.55	0	0.00	8.82	2	0.23	5.80	0	0.00	30.67	3	0.10	
2017	8.32	0	0.00	6.99	0	0.00	10.18	1	0.10	4.59	0	0.00	30.07	1	0.03	
Totals	62.30	1	0.02	59.94	2	0.03	73.81	7	0.09	41.78	4	0.10	237.83	14		

WB		July			August			September			October			Annual		
Year	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	T+TrC per 1000km	<i>n</i>	SR	
2009	0.06	0	0.00	0.07	0	0.00	5.52	0	0.00	3.80	0	0.00	9.46	0	0.00	
2010	0.06	0	0.00	0.04	0	0.00	4.79	0	0.00	3.40	0	0.00	8.29	0	0.00	
2011	0.03	0	0.00	1.76	0	0.00	9.62	0	0.00	1.70	0	0.00	13.11	0	0.00	
2012	4.80	0	0.00	11.12	0	0.00	7.08	0	0.00	5.97	0	0.00	28.97	0	0.00	
2013	4.62	0	0.00	7.36	0	0.00	5.87	0	0.00	2.29	0	0.00	20.14	0	0.00	
2014	3.59	0	0.00	8.38	0	0.00	7.34	0	0.00	4.89	0	0.00	24.20	0	0.00	
2015	3.27	0	0.00	7.23	0	0.00	12.82	1	0.08	5.23	2	0.38	28.55	3	0.11	
2016	6.79	0	0.00	10.56	1	0.09	11.17	1	0.09	5.60	0	0.00	34.13	2	0.06	
2017	7.22	0	0.00	10.86	0	0.00	9.82	0	0.00	6.09	0	0.00	33.99	0	0.00	
Totals	30.46	0	0.00	57.37	1	0.02	74.04	2	0.03	38.96	2	0.05	200.83	5		



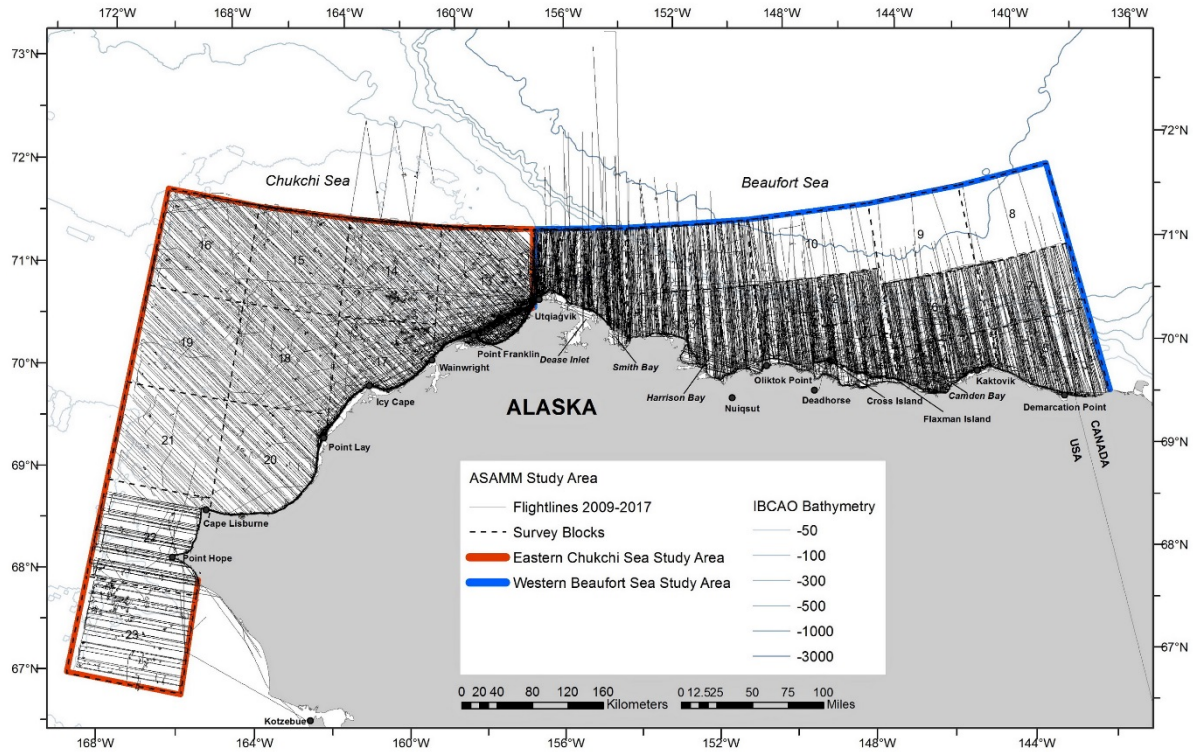


Figure 1. ASAMM study area, including the eastern Chukchi Sea study area (EC; 2009-2013: 68°-72°N, 157°-169°W; 2014-2017: 67°-72°N, 157°-169°W) and western Beaufort Sea study area (WB; 2009-2017: south of 72°N, 140°-157°W), showing survey blocks, and 2009-2017 combined survey flight tracks.

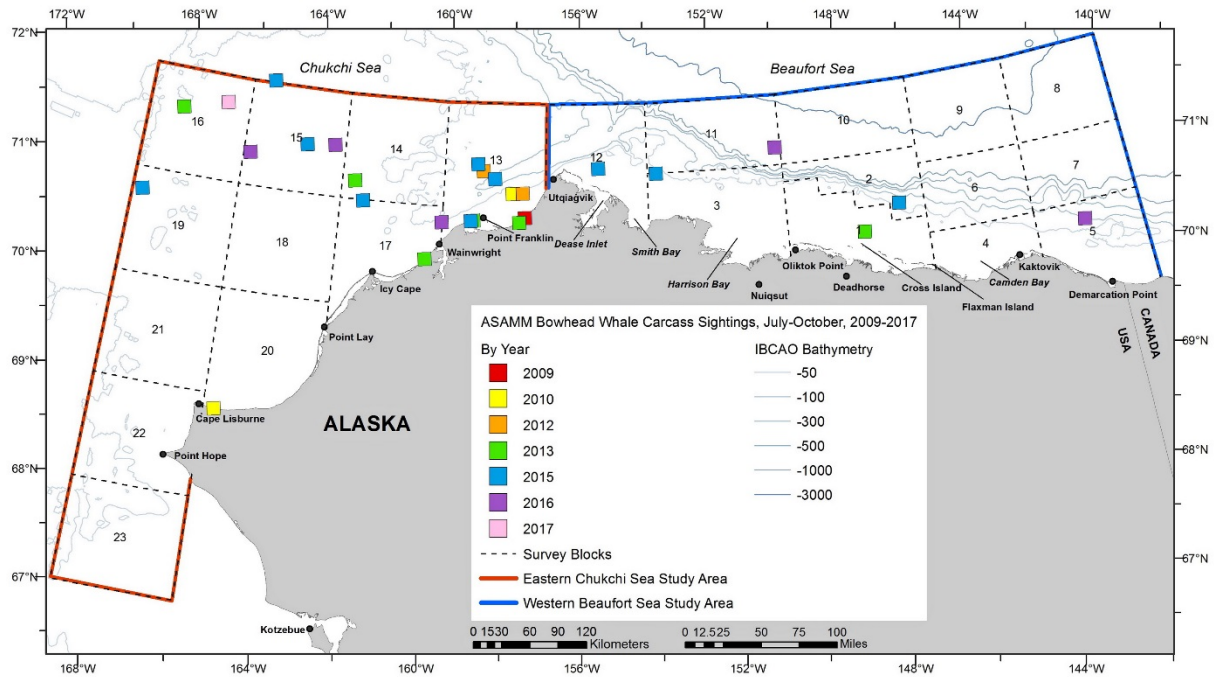


Figure 2. ASAMM bowhead whale carcass sightings, all effort, by year, 2009-2017.

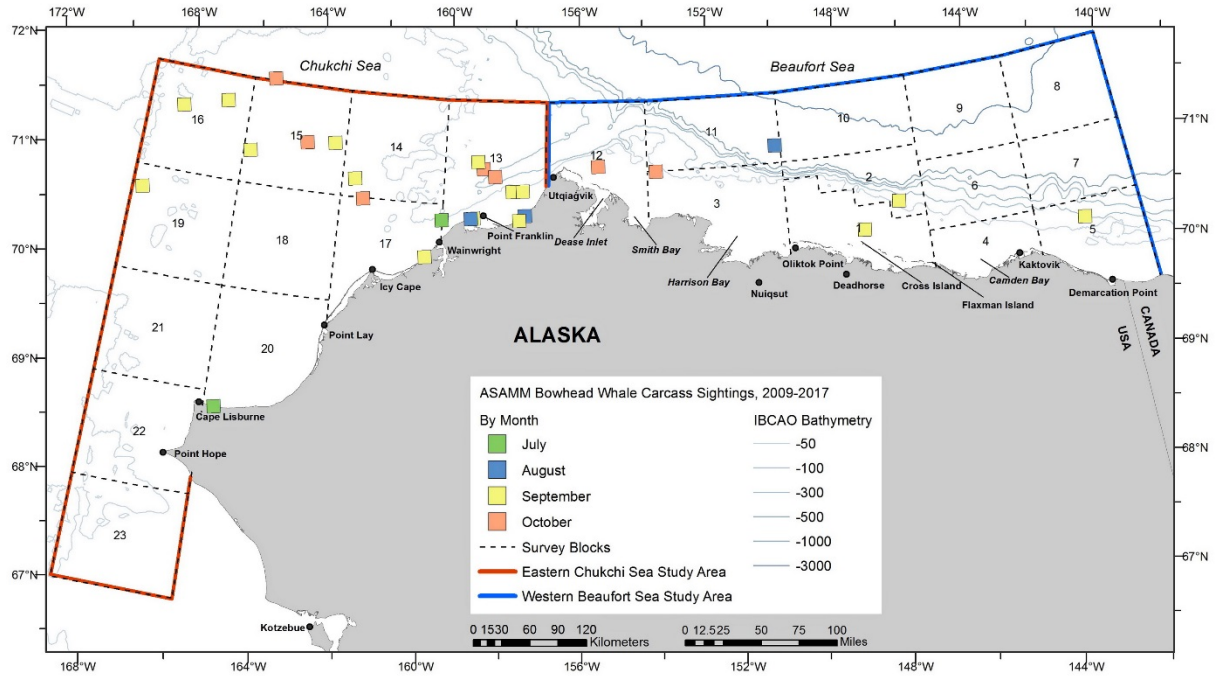


Figure 3. ASAMM bowhead whale carcass sightings, all effort, by month, 2009-2017.

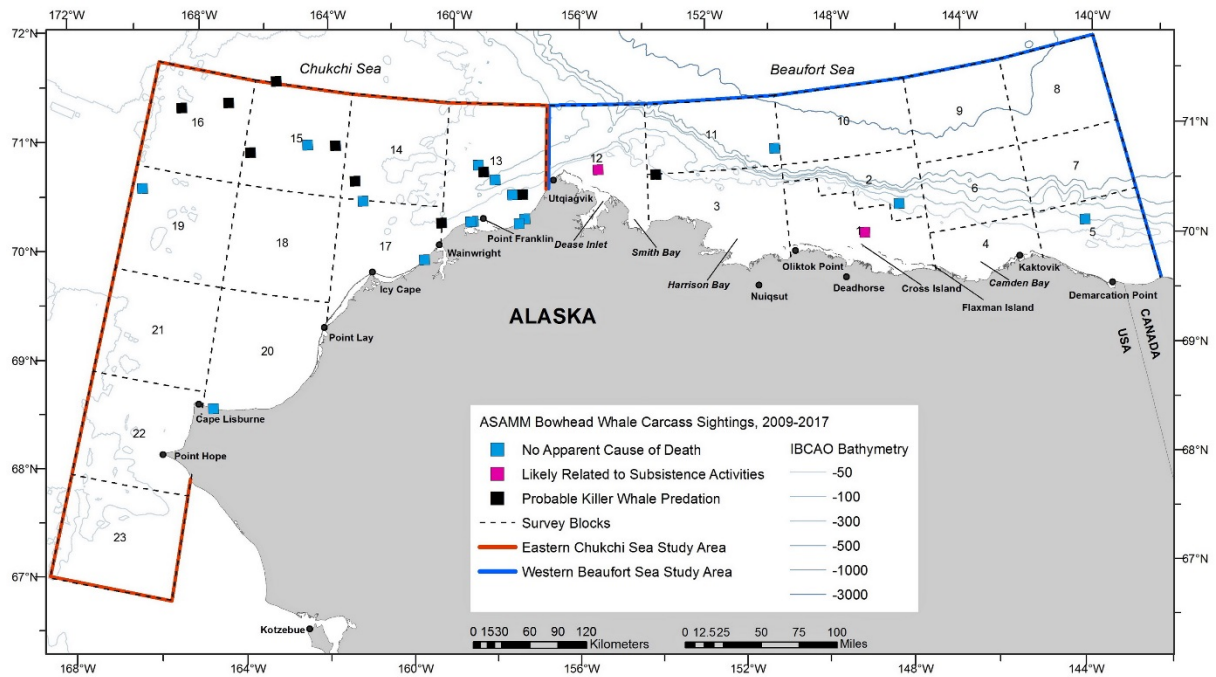


Figure 4. ASAMM bowhead whale carcass sightings by likely cause of death, 2009-2017.

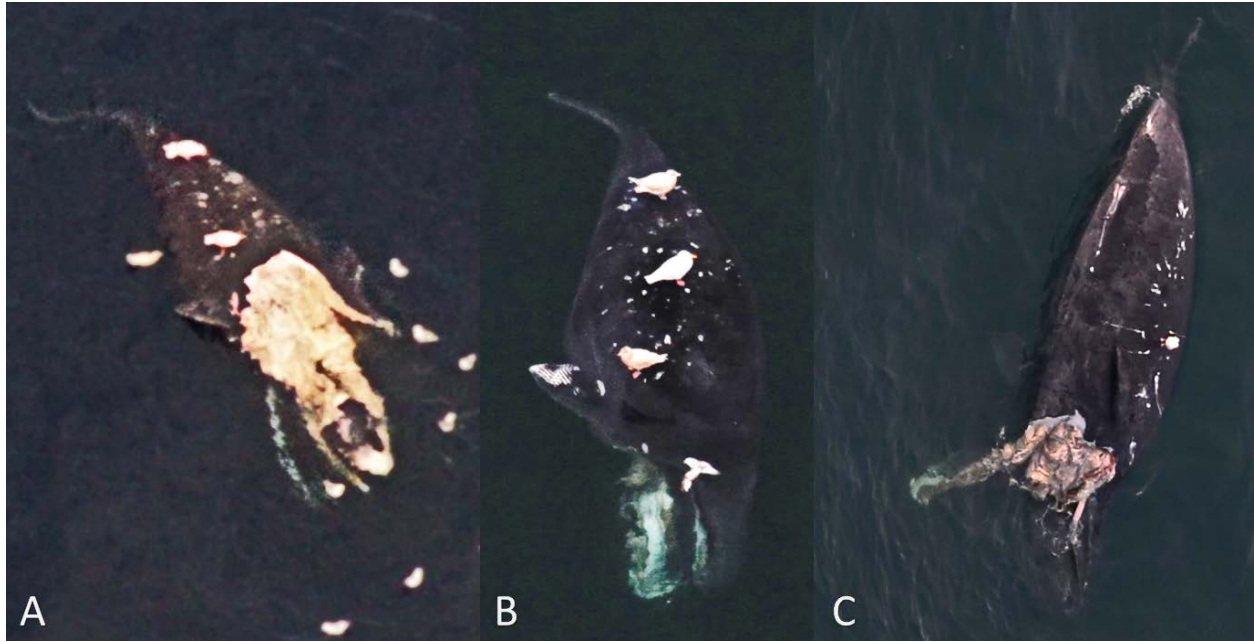


Figure 5. Examples of injuries consistent with killer whale predation on bowhead whale calf /yearling. Images A, B, and C show flesh missing from heads and ventral “chins”, and image B also shows rake mark scars on the whale’s right pectoral flipper.