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2017 health report for the Bering-Chukchi-Beaufort Seas

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INTERNATIONAL WHALING COMMISSION

2017 HEALTH REPORT FOR THE BERING-CHUKCHI-BEAUFORT SEAS BOWHEAD WHALES – PRELIMINARY FINDINGS

Raphaela Stimmelmayr[1], J. Craig George[1], Amy Willoughby[2,4], Amelia Brower[2,4], Janet Clarke[3], Megan Ferguson[4], Gay Sheffield[5], Kate Stafford[6], Andy Von Duyke[1], Todd Sformo[1], Brian Person[1], Leandra Sousa[1], and Robert Suydam[1]

[1] North Slope Borough Department of Wildlife Management, Utqiaġvik (Barrow) Alaska
[2] Joint Institute for the Study of the Atmosphere and Ocean, University of Washington/NOAA Fisheries, Seattle, Washington
[3] Leidos, Arlington, Virginia
[4] Cetacean Assessment and Ecology Program, Marine Mammal Laboratory, Alaska Fisheries Science Center NOAA Fisheries, Seattle, Washington
[5] Alaska Sea Grant–Marine Advisory Program, University of Alaska Fairbanks, Nome, Alaska
[6] Applied Physics Lab, University of Washington, Seattle, Washington

ABSTRACT

At the 2016 IWC Scientific Committee meeting, it was agreed that an annual or bi-annual report on the Bering-Chukchi-Beaufort Seas (BCB) bowhead whale stock would be submitted that summarizes various health-related data (George et al. 2016). This summary is intended to be helpful for providing ancillary but pertinent information for informing management recommendations and tracking the status of the BCB population. This report is the 2nd of the series (George et al. 2017a) and summarizes general information on population indices, whale health and hunter observations of bowhead whales. We provide new information on *(1) population size and trends, (2) adult survival rate, (3) acoustic index of relative abundance of migrating whales, (4) calf production (aerial surveys), (5) pregnancy rates of landed adult females, (6) body condition and whale lice burden of landed whales, (7) proportion of landed whales showing evidence of feeding, (8) proportion of landed whales with injuries consistent with line entanglement, killer whale attacks and/or ship strikes, (9) non-harvest related mortality of bowhead whales, (10) pathological findings from postmortem examinations and disease screening surveys of landed whales, and (11) hunter observations.* Important population metrics such as population size and trend, calf production and crude pregnancy rates continue to show positive or stable trends for this stock. While climate warming is a major concern, the various metrics described in this review (in particular population size and trend; calving rate; body condition) suggest that to date, bowheads are not being harmed by sea ice retreat.

INTRODUCTION

At the 2016 IWC Scientific Committee meeting, it was agreed that an annual or bi-annual report on the Bering-Chukchi-Beaufort Seas (BCB) bowhead whale stock would be submitted by the North Slope Borough that summarizes various health-related data (George et al. 2016). This summary is intended to be helpful for providing ancillary but pertinent information for informing management recommendations and tracking the status of the BCB population. This report is the 2nd of the series (George et al. 2017a) and summarizes general information on population indices, whale health and hunter observations of bowhead whales.

Population Size and Trend, Adult Survival Rate

Bowhead whales migrate during spring along Alaska's northeastern Chukchi coast where a long time series of abundance estimates dating from 1978 to 2011 exists. Givens et al. (2016) provides the most recent abundance estimate for BCB bowhead whales at 16,820 (95% CI: (15,176, 18,643) in 2011), and a long-term (1978-2011) estimated annual rate of population increase of 3.7% (2.9%, 4.6%) (Figure 1). This survey used an ice-based visual and acoustic design. Analysis of a fully independent aerial photoID-based survey conducted in 2011 is underway where preliminary results are quite consistent with the ice-based abundance estimates (Givens et al., 2018).

Of all the "health parameters" presented here, arguably the population size and rate of increase provides some of the best evidence that the BCB bowhead stock is "healthy." These statistics strongly suggest that anthropogenic mortality (including hunting) is having little effect on the current status and recovery of BCB bowhead whales from commercial Yankee whaling.

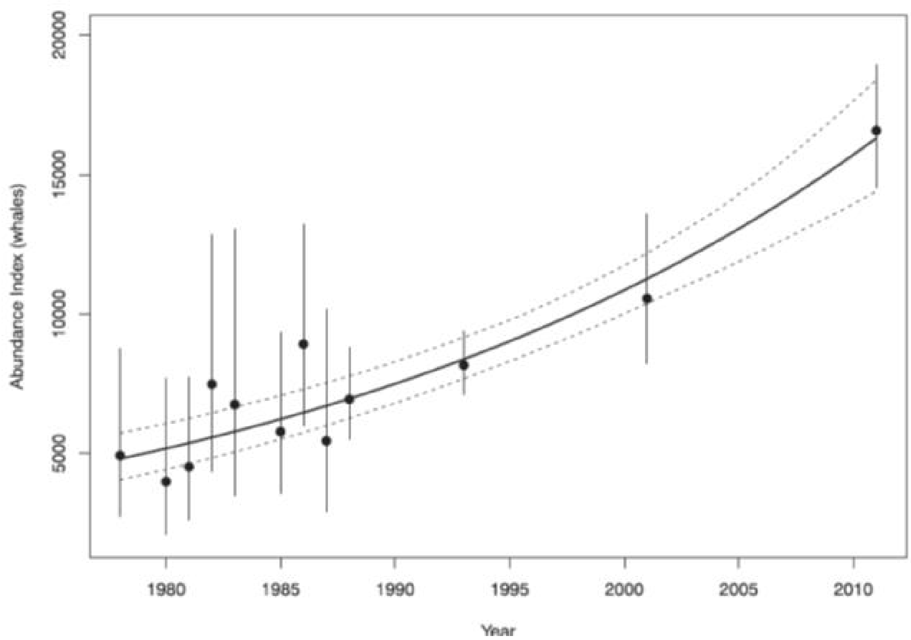

Figure 1. Estimated abundance indices, fitted curve, and pointwise 95% confidence band for the trend estimate using the time series from 1978 to 2011 (Givens et al. 2016). For 2011, only the ice-based estimate is shown as analysis is still underway on the photoID mark-recapture estimate.

Adult Survival Rate

An estimate of adult survival rate is also available from the 2011 photoID analysis that uses photo matches of re-identified whales as far back as 1985. The estimated survival rate was 0.996 (with an approximate lower confidence bound of 0.976). This estimate is consistent with previous ones and with other research showing that bowhead lifespans can be very long (George et al. 1999; Rosa et al. 2013; Borchman et al. 2017).

Acoustic Index

Spring migration
Bowhead whale abundance surveys have been conducted since 1978. Since 1984, a combined visual-acoustic survey was conducted at various intervals. The acoustic aspect of the survey provided, among many other metrics, whale locations and call counts through most of the spring migration used for abundance estimation (e.g., Clark et al. 1996; Givens et al. 2016).

In order to assess whether a count of recorded bowhead calls might provide a useful index of relative abundance of migrating bowhead whales, a single hydrophone package was moored off the ice edge west of Barrow (Utqiaġvik), Alaska, in 2015, 2016, and 2017. We wanted to compare counts of “calls,” “sequences” and “songs” with analogous acoustic data from 1984 to 2011 to determine if the relative number of signals recorded has changed over time and can be correlated with increasing population abundance. These data are still being analyzed; however, based on an apparent change in acoustic behavior over this period whereby more "songs" have been recorded in recent years, we suspect that counts of the typical up-sweep calls (common in the 1980s and 1990s) may not be a reliable abundance metric.

Other methods to examine changes in bowhead relative abundance during the spring migration that use passive acoustic data include: a) documenting the beginning and end of the migration based on first and last dates of calls recorded; b) estimating the number of singers and distinct songs by year (following Johnson et al. 2015); and c) measuring the acoustic energy in the frequency band used by bowhead whales, similar to the "fin index" described by Nieukirk et al. (2012).

In 2017, the NSB purchased a new, much smaller recording package to make ice edge deployments easier. The SoundTrap 300 is a small (200 mm x 60 mm), light (0.5 kg) hydrophone package that is calibrated and capable of recording continuously for up to 70 days and much longer on a duty cycle. The shorefast ice in spring 2017 was extensive (see TK section) and very rough, we were *unable* to deploy the mooring far enough offshore to be in acoustic range of the majority of migrating bowheads. The use of a helicopter was not possible since whaling was underway. Therefore, while the instrument recorded throughout the deployment period (13 April – 14 July), it did not acoustically record the bowhead migration. Only a few bearded seal trills, faint bowhead whale calls, and walrus knocks were recorded.

The trend towards increased singing during spring since the 1980s appears to be continuing based on various data sources; however, the reasons remain unknown. We will provide additional results and analyses in future health reports describing the acoustic character of the migration and any implications to the health of this stock.

Calf Production

Summary of Bowhead Whale Calf Sightings from the Aerial Surveys of Arctic Marine Mammals Project (ASAMM)

ASAMM surveys are flown annually during summer and fall in the western Beaufort and eastern Chukchi seas by the U.S. National Marine Fisheries Service (NMFS), with funding from the U.S. Bureau of Ocean Energy Management (BOEM). These surveys provide data on the calf ratio (number of calves/number of total whales seen) and sighting rate (number of calves/km flown) during summer and fall in the northeastern Chukchi and western Beaufort seas. The ASAMM project (and its precursors) spanned over 35+ years and provide a good long-term indicator of bowhead whale calf production, distribution, relative abundance, frequency of feeding, and other metrics. The database (1979-2016) and annual reports dating back to 2006 are available at: https://www.afsc.noaa.gov/nmml/cetacean/bwasp/index.php.

Survey effort in the ASAMM study area (67°-72°N and 140°-169°W) has varied by year and month. In the western Beaufort Sea (140°-157°W) surveys were conducted during fall (September-October) every year since 1982, but summer (July-August) effort has varied. In many years there was no summer survey effort at all. Starting in 2012, surveys were consistently conducted in the western Beaufort Sea in summer. In the eastern Chukchi Sea (157°-169°W), surveys were conducted in 1982-1991 and 2008-2017; survey effort per month varied by year until 2009, when surveys were consistently conducted from July to October. Additional survey design, protocol, and analysis information can be found elsewhere (e.g., Monnett and Treacy 2005; USDOI, MMS 2008; Clarke et al. 2011, 2012, 2013, 2014, 2015a, 2017a,b).

Circling effort over cetacean sightings serves to verify species, group size, and presence or absence of calves. Most calves (75%) sighted from 2009-2017 were observed after circling was initiated and likely would not have been seen if circling had not commenced. Prior to 2009, circling occurred but was not specifically designated in the data, so it is difficult to determine the impact of circling on historical calf ratios. Calf detection probabilities may have been lower due to lack of circling, resulting in an underestimate of the number of calves present. Calf detection probabilities may also be lower in areas where bowhead whales aggregate in large groups (e.g., feeding aggregations). For example, some calves were probably undetected in 2016 on one day in late August when several hundred bowhead whales were seen in <15 minutes.

From 1982 to 2017, 789 bowhead whale calves were sighted out of a total of 16,691 bowhead whales in the ASAMM study area (Ljungblad et al. 1987; Moore and Clarke 1992; Clarke et al. 2011, 2012, 2013, 2014, 2015a, 2015b, 2017a,b; MML unpublished data) (Figure 1). Most bowhead whale calves (73%) were seen in the Beaufort Sea in fall. In summer, bowhead whale calves were not sighted in the Chukchi Sea but were seen in the Beaufort Sea. The majority of summer calves were broadly distributed on the continental shelf and slope, out to approximately the 200-m isobath. In fall, most of the bowhead whale calves were sighted on the continental shelf in the Beaufort and Chukchi seas and in Barrow Canyon (Figure 2). During both seasons, there were a few sightings in waters deeper than 1000 m in the western Beaufort Sea. Calf distribution was similar to the distribution of all bowhead whales sighted.

Calf ratios (number of calves/total whales) were calculated using whales and effort on transect only, which limits data to those collected systematically with the least degree of bias. Limiting to transect only also allows us to include results extending back to 1982. Annual calf ratios for the Beaufort and Chukchi seas combined were highest in 2017 (0.113), followed by 1991 (0.105), 2013 (0.097), 2001 (0.087), and 2009 (0.083) (Figure 4). High summer calf ratio was recorded in 2017 (31 calves, 219 total bowheads, calf ratio=0.142); summer calf ratios were high in 2011 (0.200) and 1985 (0.100) when single calves were observed out of a total of five and ten whales, respectively (Figure 3). As noted above, calves were likely underreported in summer 2016 due to the very high density of whales observed on one day in August. Fall calf ratios were highest in 2013 and 2016 (0.118), and 1991 (0.105) (Figure3).

Using data collected since 2009, calf sighting rates (calves/km) for the western Beaufort Sea (140°W-157°W) were calculated using kilometers and calf sightings from transect and circling from transect effort (Figure 4). Calf sighting rates were highest in summer 2017 compared to 2012-2016 (summer surveys in the western Beaufort Sea started in 2012). Calf sighting rates in fall 2017 were almost double those in 2009 to 2016. Although some of the calves observed in 2017 may have been seen more than once, the high sighting rates suggest that calf production was high during the year. Calf sighting rates were also high in summer and fall 2013 and 2016. A more detailed examination of bowhead whale calf distribution, relative density, and calf ratio resulting from ASAMM surveys in the western Beaufort Sea from 2012-2017 is included in Clarke et al. (2018).

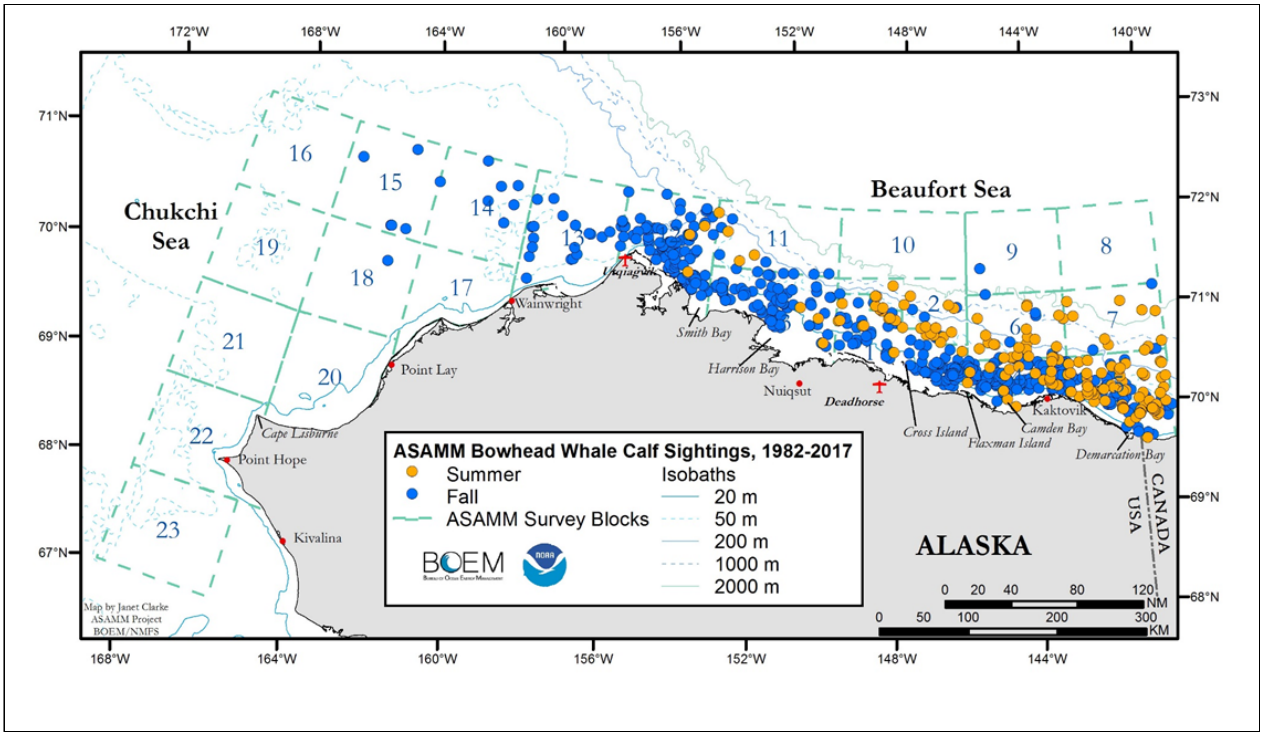

Figure 2. ASAMM bowhead whale calf sightings by summer (July-August) and fall (September-October) seasons, 1982-2017

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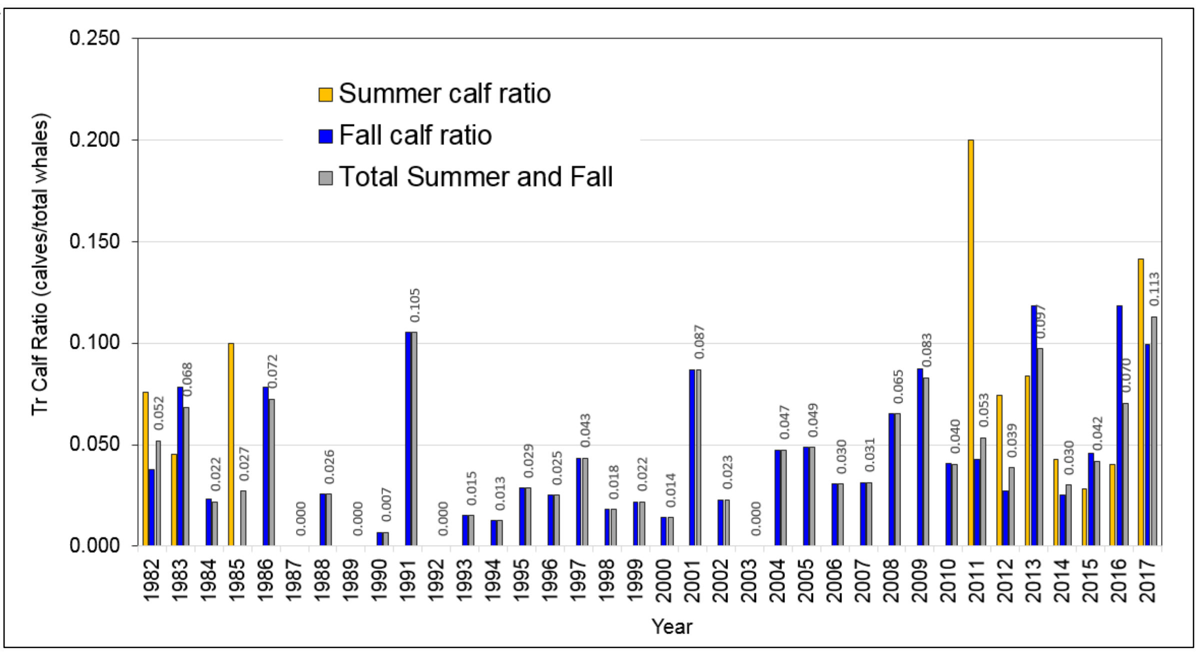

Figure 3. ASAMM bowhead whale annual calf ratios (number of calves on transect (Tr) relative to total whales on transect) in summer (July-August pooled) and fall (September-October pooled), 1982-2017, in the Beaufort and Chukchi seas

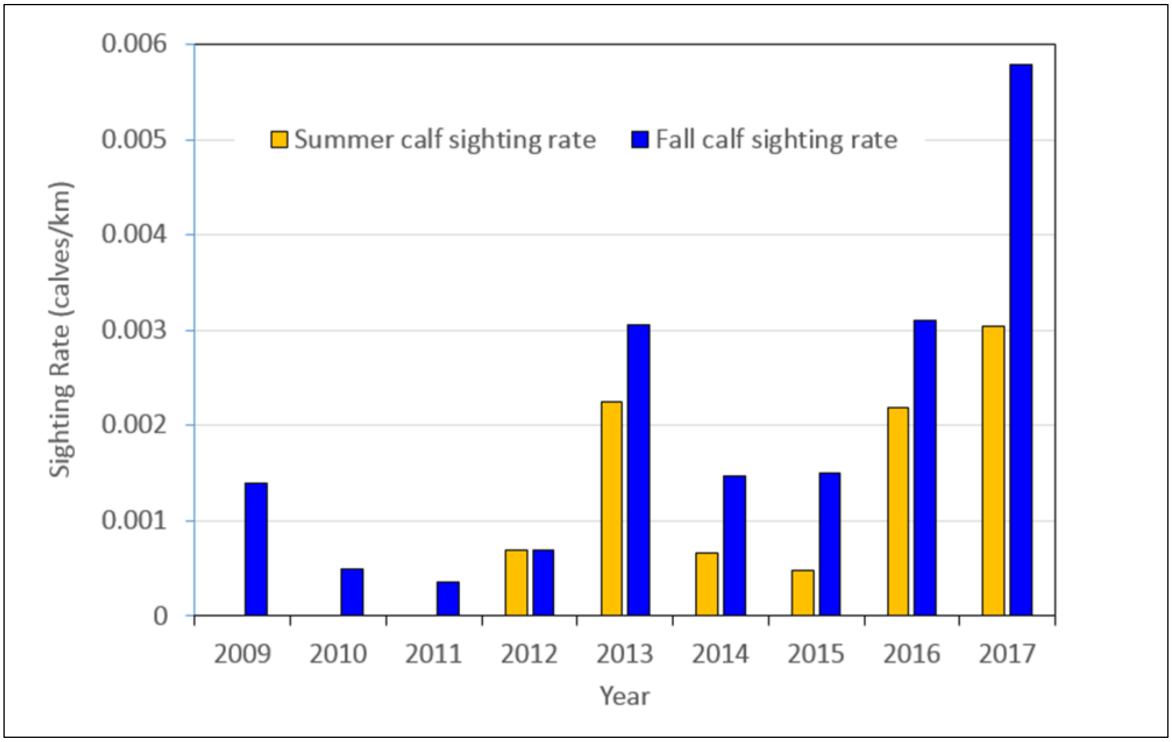

Figure 4. ASAMM bowhead whale calf sighting rates (number of calves on transect and circling from transect (Tr+TrC) relative to Tr+TrC kilometers (km)) in summer (July-August pooled) and fall (September-October pooled), 2009-2017, in the western Beaufort Sea (140°W-157°W)

Pregnancy Rates of Landed Adult Females

A crude pregnancy rate of adult females is presented annually in harvest reports (e.g., Suydam et al. 2017). This metric is computed as the number of pregnant females/number of presumed mature females (>13.4m; George et al. 2004). While the crude pregnancy rate of landed whales is not necessarily representative of the entire population for a specific year because of low sample sizes, the long-term dataset does provide a useful index of reproduction and is consistent with a reproductively healthy population (George et al. 2018).

For 2017, Suydam et al. (2018), reported the following:

“Twenty-eight (56%) of the landed whales were females. The longest female was 17.6 m, and the shortest was 8.0 m. Based on a length >13.4 m (George et al. 2004), 13 of the females were sexually mature. Six of those were examined for pregnancy. Two were pregnant, one with a mid- and another with a term fetus (2.1 to 3.0 m long), and one female was lactating. The pregnancy rate is similar to the long-term average of 33% (George et al. 2004; George et al. 2011).

Sightings from ASAMM surveys (see above) and the crude pregnancy rate of landed whales suggest that 2017 calf production was excellent, with calf sighting rates being almost double those in 2006 to 2016.

Body Condition of Landed Whales

A simple bowhead body condition index (BCI) has been computed for harvested whales using axillary girth and body length (BCI = axillary girth/body length), and dates back to the 1970s. George et al. (2015) determined that it is important to compare specific cohorts to each other in BCI analyses because different growth stages have quite different physiologic characteristics. For example, freshly weaned yearlings are quite rotund but largely reflect the condition of their mother rather than conditions for a specific feeding season. Therefore, George et al. (2015) did not include yearlings in their long-term BCI analyses. However, all BCI data are useful when considered in the proper context.

Table 1 shows the estimated BCI for harvested whales in 2017 compared with the long-term mean BCI for 1990-2016. Body condition indices for subadult and all whales in 2017 were somewhat lower than the long-term average. Caution is advised in interpreting a single year because of the small sample sizes generally and in 2017 specifically.

Bowhead BCI has varied but increased during the period 1990-2012 (George et al. 2015). Results for <u>fall</u> landed whales indicate that summer 2017 conditions in the Beaufort Sea feeding grounds were likely "good" based on: a) the finding that all (100%) examined stomachs indicated feeding and, b) the BCI of whales taken in fall at Kaktovik and Utqiaġvik-Barrow, while lower, are within the range of the long-term averages (Table 1).

A full statistical analysis of all BCI data with environmental covariates (e.g. ice density) using the methodology in George et al. (2015), is scheduled for 2019.

Table 1. Preliminary statistics on bowhead body condition for 2017 and historical values (1990-2016).

Index	1990-2016	2017
"Subadult" Body Condition Index (fall)	$\bar{X}$= 0.671; SD = 0.042; N = 150	$\bar{X}$=0.656, SD= 0.031; n = 13
Body Condition index (all whales)	$\bar{X}$= 0.686; SD = 0.077, N = 560	$\bar{X}$= 0.633, SD=0.099; n = 22

Proportion of Landed Whales carrying Cyamid spp. (Whale lice)

Von Duyke et al. (2016) describe a methodology for examining bowheads for the prevalence of cyamid lice and analyzing the factors related to their presence. Based on the examinations of 673 landed bowheads between 1973 and 2015, overall prevalence of individuals carrying cyamids was determined to be ~20%. Over the last 12 years, prevalence was at 14.3%. In 2017, only two of 29 bowheads (6.9%) had cyamids present on the skin, which is the lowest percentage in the past 12 years and among the lowest percentages in the full record. Nevertheless, the observed variation among years and the relationships between cyamid presence and whale age and length suggest that low percentages of cyamid prevalence are not unusual (Table 2). Observed low prevalence is consistent with the high proportion of immature bowhead whales landed in 2017 (75.9% immature).

The continued monitoring for cyamid presence among subsistence-harvested bowheads is important as departures from established baseline prevalence and long-term trends serve as signals for an evolving host x parasite relationship under a changing Arctic ecosystem. Further investigations into the roles of environmental and anthropogenic variables on cyamid prevalence are recommended.

Table 2. Harvested bowhead whales examined for cyamids, 2006-2017, for Gambell, Savoonga, Kaktovik, Nuiqsut, and Utqiaġvik, Alaska.

Year	Whales examined	Whales with cyamids present	Percentage of Whales examined with Cyamids
2006	24	2	8.3%
2007	23	4	17.4%
2008	28	3	10.7%
2009	23	3	13.0%
2010	24	6	25.0%
2011	21	3	14.3%
2012	27	6	22.2%
2013	23	2	8.7%
2014	19	2	10.5%
2015	27	7	25.9%
2016	24	2	8.3%
2017	29	2	6.9%
$\bar{x}$	24.3	3.5	14.3%

Proportion of Landed Whales Showing Evidence of Feeding

Several publications and reports (Lowry et al. 2004; Moore et al. 2010; Sheffield and George 2013) on bowhead whale feeding provide a good framework for reporting the frequency of bowhead whales feeding and diet in several areas across the BCB range (Saint Lawrence Island to Kaktovik, Alaska). This dataset now spans 40 years of stomach contents collections from harvested whales. One metric is the proportion of examined whales that were found to be feeding or not feeding during the spring and fall seasons. The prevalence of examined whales with signs of *Anisakis* spp. infestation in the stomach (i.e., worms, gastric nodules, gastric ulcers, etc.) was also tallied and reported here (see section Pathological findings).

During 2017, the stomachs of 25 harvested whales (20 in spring and 5 in fall) from the Beaufort Sea were examined for evidence of feeding. Overall, 20 examined whales (89%) showed evidence of feeding. During the spring hunt in the Beaufort Sea, none of the examined whales (0%) indicated feeding prior to death. All whale stomachs (100%) examined from the autumn hunt presented evidence of feeding. Of note, one whale near Saint Lawrence Island in the northern Bering Sea showed strong evidence of feeding when taken mid-January 2017 (e.g. gallons of prey/stomach liquid issued from the throat concurrent with feces spilling from the anus); however the stomach was not examined. The frequency of feeding during the fall 2017 hunt was higher than in 2016 (77%) in the Chukchi and Beaufort seas. This pattern is consistent with Lowry et al. (2004) and Sheffield and George (2013) for the years 1969-2013, in which the majority of fall whales examined were feeding, whereas the majority of whales examined during the spring were not. Nevertheless, significant feeding events do occasionally occur during spring migration (Carroll et al. 1987). Sheffield and George (2013) found that the majority of whales examined during spring and fall near Saint Lawrence Island were feeding.

Based on examinations of harvested bowhead whales at several villages, there appeared to be good foraging opportunities during autumn 2017 throughout the range of BCB bowheads.

Proportion of Whales with Line Entanglement, Killer Whale, and Ship Strike Injuries

As logistics allowed, biologists, veterinarians, and hunters examined bowhead whales harvested in 2017 for line entanglement, ship strike, and killer whale injuries following methods in George et al. (2017b). Baseline statistics for these injuries were estimated for the period 1990-2012 in George et al. (2017b) (see Table 3).

During 2017, landed whales carried injuries for line entanglement (13.8%) and killer whale attacks (6.7%), but not for ship strikes (0.0%) (Table 3). These percentages for line entanglement and killer whale injuries percentages were slightly lower than 2016 but quite consistent with the 1990-2012 baseline. Two whales were landed at Utqiaġvik in spring 2017 actively carrying line/pot gear. Both animals had severe entanglement injuries to the tongue, flippers and peduncle (Figure 5). Body condition index for both animals fell within the lower range for 2017 examined landed whales. Reduction in body condition is frequently found in North Atlantic right whales carrying gear (Cassoff et al. 2011).

In a collaborative effort to mitigate line entanglement events involving bowhead whales, the NSB-DWM, the Alaska Eskimo Whaling Commission (AEWC), and Alaska Bering Sea Crabbers, a professional organization consisting of Bering Sea commercial crabbers, have begun a dialogue. Initial contact included meeting with the AEWC Commissioners during a February 2018 meeting in Utqiaġvik. First discussions included a general understanding of the types of commercial fishing gear, commercial pot fishery locations in the U.S. Bering Sea, and an examination of line gear (1992-2017) recovered from harvested or beach cast dead bowhead whales and archived at the NSB-DWM.

Table 3. Proportions of whales with entanglement scars/injuries in 2017, with baseline information for 1990-2012 and 2016. Past analyses showed scarring rates increase sharply with whale length and age; the point estimates presented here are approximations for all landed whales (George et al. 2017b).

Year	**Entanglement**	**Killer Whale**	**Ship Strike**
Percentage of scarring on whales from 1990-2012 baseline (George et al., 2017)	~12%	~8 %	~2%
Percentage of scarring for 2016	20.7%	11.4%	0.0%
Percentage of scarring for 2017	13.8%	6.7%	0.0%
No. of whales examined in 2017	29	30	30

Figure 5. Photograph of the peduncle of whale 17B6. Wound depth was 10 cm, with gear having penetrated into the blubber layer. There were 6 full wraps of the 3/4" line around the peduncle.

Number of Dead Floating and Beach cast Bowheads

Marine mammal aerial surveys have been flown in the eastern Chukchi and western Beaufort seas since 1979 (ASAMM and precursor projects). A brief summary of ASAMM methods is included in the **Calf Production** section, above. In addition to documenting live marine mammals, ASAMM also collects data on all bowhead whale carcasses seen. Sightings of carcasses that were previously documented by ASAMM (both intra- and inter-annually) were flagged as repeat sightings and are not discussed further. Since 2009, most of the carcasses in the ASAMM database have been photographed and images subsequently analyzed for species identification, possible cause of death, and age and sex class.

A total of 49 carcasses identified as bowhead whales were sighted by ASAMM during all survey modes (e.g., transect, search, and circling) from 1982-2017 (Figure 6, Table 4). Bowhead whale carcasses were distributed across the Chukchi and Beaufort seas from 141.6°W to 168.7°W and 68.9°N to 72°N. Seven carcasses were sighted on the beach, and 36 were sighted floating in open water (six sightings did not include habitat information but were likely floating, based on location). Two carcasses, one in 2013 and one in 2015, were likely struck and lost whales related to aboriginal subsistence activity; this is based on timing, proximity to known struck and lost whale, and image review of those carcasses (Figure 6, Table 4). One carcass in 2015 had gear attached (orange buoy and attached line) that was consistent with commonly used subsistence whaling equipment (C. George, pers. comm. to J. Clarke on 28 October 2015).

From 2013 to 2017, 22 unique bowhead whale carcasses were sighted during all survey modes (Clarke et al. 2014, 2015, 2017; MML unpublished data); this is almost half of the total number of unique bowhead whale carcasses from all years combined. The apparent increase in bowhead whale carcasses may be attributable to the increased amount of survey effort compared to earlier years. However, most carcasses were observed in the eastern Chukchi Sea in 2013-2017, and annual survey effort there was similar to annual survey effort in 2009-2012 when only five bowhead whale carcasses were seen. Of the 22 carcasses observed from 2013 to 2017, 45.5% occurred in 2015 (10/22), which is twice the number observed in any other single year since 1982. An increase in bowhead whale abundance (see: Population Size and Trend) and sea ice reduction may also affect the number of carcasses documented in the ASAMM study area.

It is nearly impossible to closely examine and determine the cause of death of floating or beach cast whales seen from aerial surveys in the Arctic; however, cause of death due to killer whale attacks, ship strikes, entanglement in fishing gear/longline, or natural causes are all possibilities (George et al. 2017b). 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 (Figure 6, Table 4).

Since 1982, four of the bowhead whale carcasses documented by ASAMM were calves: one each in 1991, 2013, 2015, and 2017. Three of the four calf carcasses were photographed and showed signs of killer whale interactions, including rake marks on pectoral flippers or flesh missing from heads and lower jaw, suggesting death was likely due to predation. Prior to 2012, evidence of killer whale predation on bowhead whales was not recorded in the ASAMM database. However, there are no images of bowhead whale carcasses prior to 2009 and possible killer whale predation may have gone undetected. The dramatic sea ice reduction during fall could allow killer whales to hunt in areas like the northeastern Chukchi Sea that were previously ice covered. A more detailed examination of bowhead whale carcasses recorded during ASAMM surveys from 2009 to 2017 is included in Willoughby et al. (2018).

Floating Bowhead Carcass Reports - Non-ASAMM
Two bowhead whale carcasses were documented in the Bering Sea, and were included in Table 5 (denoted with *) (Sheffield and SWCA, 2015, Sheffield et al. 2016*a*). Both carcasses were adult females, one of which was discovered floating and entangled in commercial crabbing gear near Saint Lawrence Island in the Bering Strait (Sheffield and Savoonga Whaling Captains Association, 2015).

In 2015, hunters found a floating bowhead carcass ~15-20 km east of Point Barrow. The whale was in good enough condition that it was towed back to Barrow (Utqiaġvik), the maktaq (i.e., the black skin and outer blubber) utilized for human consumption, and the baleen salvaged for other purposes. The cause of death was unclear. There were obvious fresh killer whale rake marks on the flukes and flippers indicating killer whale predation; however, its lips and tongue were still intact. There was also a large “tear” along the ventrum (belly), consistent with blunt trauma. We carefully looked for wounds or injuries associated with harvest activities but found none (Suydam et al. 2016).

On 3 October 2015, Dr. Humfrey Melling onboard the Canadian Coast Guard Cutter *Sir Wilfrid Laurier* reported two intact bowhead whale carcasses sighted west northwest of Barrow (Utqiaġvik), Alaska, and were included in Table 5 (denoted with **) (H. Melling, pers. comm. to J. Clarke on 3 October 2015).

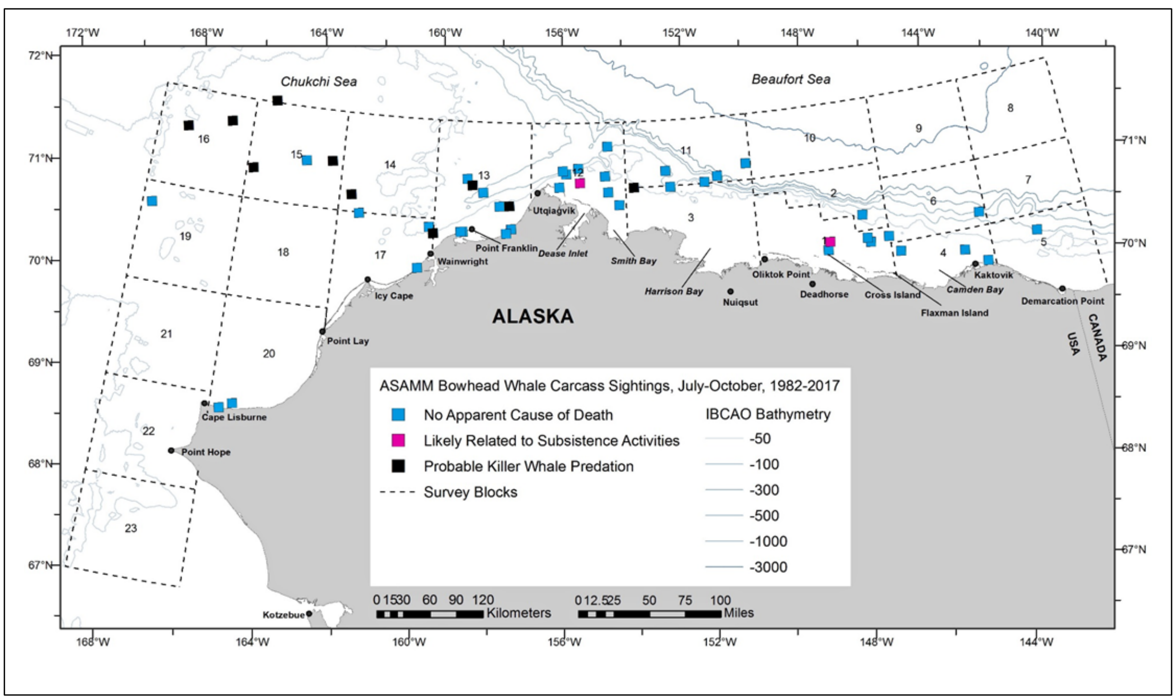

Figure 6. ASAMM bowhead whale carcass sightings (all survey modes) listed by apparent cause of death, July-October, 1982-2017

Pathological Findings from Postmortem Examinations and Disease Screening Surveys of Landed Whales

Similar to previous years (Stimmelmayr 2015; Suydam et al. 2015; George et al. 2017b), a number of unusual findings (abnormal; pathological) were observed in several subsistence-harvested bowhead whales in 2017. Briefly, abnormal findings included: (1) multiple fatty tumors in the liver of several immature whales; (2) multiple gastric parasitic nodules in the stomach of an immature whale; and (3) kidney worm infection with renal lesions in 10/13 immature bowhead whales.

Fatty tumors: Neoplastic lesions in bowhead whales continue to be rare. However, benign fatty masses (lipomas; myelolipomas) of the liver, first seen in 1980 (Migaki and Albert 1982a), have been annually observed in 1-2 landed bowhead whales per year since 2012 (Stimmelmayr et al 2017). Observed hepatic lesions are not associated with extensive atrophy and/or destruction of hepatic parenchyma. Furthermore, lesions are not associated with other significant disease in examined bowhead whales. The pathogenesis and exact cell origin of these benign fatty tumors in bowhead whales are undetermined. Assessment of further cases is warranted to better define the tissue distribution and pathogenesis of these tumors in bowhead whale liver. We systematically screened for these hepatic lesions during our general post mortem viscera examination.

Gastric nodules and *Anisakis* "whale or herring worm": Although bowhead whale diet consists mostly of krill and copepods, *Anisakis* round worm infection (presence of larvae and/or adults) in bowhead whale stomach contents occurs at a prevalence of around 17 % (Sheffield et al. 2016b). In contrast, observations of gastric nodules caused by *Anisakis* larvae remain rare with only a few cases observed (n=7; 1980-2017). As "systematic screening for gastric lesions was not an identified objective during past stomach post-mortem examinations" (Sheffield et al. 2016b), we cannot exclude that observed low incidence is an artifact. Nevertheless, on the basis of our currently available case material with overall few cases with few lesions, we continue to agree with Migaki and Albert (1982b) who, in their initial case reports (n=2), concluded that "adverse effects of these gastric nodules on the health of the bowhead whale remain undetermined." Screening for gastric nodules in the forestomach has been incorporated in the post-mortem examination of viscera and stomach content sampling of landed bowhead whales in Utqiaġvik, Kaktovik, Gambell, and Savoonga.

Crassicauda spp: We previously reported on kidney worm infection (*Crassicauda* spp.) in two bowhead whales (Stimmelmayr 2015; Suydam et al. 2015; George et al. 2017a). A variety of *Crassicauda* species have been documented in various baleen whales, including the southern right whale and the bowhead whale (Delyamure 1955; Skrjabin A. S. 1969). The ascribed presence of *Crassicauda crassicauda* in Atlantic bowhead whales however, has been contested by Baylis and others due to marked inconsistencies between subsequent authors as to the species of whale from which the original specimen was obtained. . Integrated morphological - molecular comparison of collected worm specimens from the two 2016 BCB bowhead whales with previously described *Crassicauda* spp. specimens were inconclusive (Stimmelmayr et al. 2018). Additional morphological and molecular studies on worm specimens collected in 2017 are ongoing to further refine *Crassicauda* species identification. Gross pathology associated with kidney worm infection (2016 versus 2017) was similar, however worm burden was greater (2017 >2016) and more renal lesions were observed in 2017 case material.

Arctic climate change (e.g., diminishing sea ice, increased sea surface temperature, opening of the Northwest Passage, range overlap with seasonal southern baleen whale migrants known to carry kidney worms, prey shifts) may be setting the stage for an evolving host x parasite relationship in BCB bowhead whale stock. Research on *Crassicauda spp.* infection among BCB bowhead whales is ongoing with a multi-disciplinary diagnostic research team (e.g., veterinary medicine, wildlife disease ecology, parasitology, genetics, and biology) addressing the biomedical and ecological aspects of this emergent disease.

Contaminant Trends in Bowhead Whales

We previously presented preliminary findings on long-term declining trends of organic contaminant concentration in various body tissues in bowhead whales (George et al. 2017a). The next tissue analysis for legacy and emerging contaminants in landed BCB bowhead whales is scheduled to occur in a 5-10 year time interval. Long-lived marine mammals that feed at a low trophic level like the bowhead whale are important and unique sentinels to monitor global pollution and long-term ocean health trends.

Anthropogenic Radionuclides in Bowhead Whales

We previously presented preliminary findings from our monitoring program of radiocesium 137 and 134 in meat from bowhead whales (George et al. 2017a). Our study provided evidence consistent with previous studies (Cooper et al. 2000) that environmental contamination with cesium 137 from previous nuclear testing and/or nuclear accidents due to their long half-life time can be detected, albeit at generally low levels, in meat from Arctic subsistence species, including the bowhead whale. This is consistent with a previous study by Cooper et al. (2000) and similar studies from other Arctic regions (for example Andersen et al. 2006)

Marine Biotoxin Exposure in Bowhead Whales

Marine biotoxins, the focus of a recent IWC expert workshop (2017) have the potential to significantly impact health of marine mammals ranging from morbidity to mortality. Marine biotoxins can cause serious illness in humans and exposure from ingestion of contaminated fish and shellfish have been well documented (Visciano et al. 2016). We present preliminary results from our longitudinal marine biotoxin screening effort. To date feces from ~200 bowhead whales (2002-2016) have been analyzed using commercially available enzyme-linked immunosorbent assay for domoic acid. Occurrence rates of domoic acid in bowhead whales (% positive) varies by year and ranges between 0 to 100 % in examined whales (Lefebvre and Stimmelmayr unpubl.data). As discussed by Natsuike et al (2017) and others regional climate variability may be driving the interannual differences in harmful algae abundance in the Arctic and elsewhere. The complex interactions of multiple oceanic and climatic drivers underlying harmful algae bloom dynamics are just beginning to be understood. Bowhead whale biotoxin exposure data can serve as an early warning system for human health risk assessment under a changing Arctic as well as provide relevant general health information on bowhead whales. Continued monitoring of landed bowhead whales and other marine mammal subsistence species for biotoxin exposure is warranted.

Viral, Bacterial and Protozoal Disease Screening

The few infectious disease studies that have been conducted on bowhead whales indicate that few infectious agents are present that could impact bowhead health or pose a public health risk (Philo et al. 1992; O'Hara et al 1998; Hughes-Hanks et al. 2005; Stimmelmayr 2015). As the Arctic ecosystem is rapidly changing, updated surveys on prevalence of microbial agents among marine mammals are needed to provide current baseline health data. An infectious disease survey study was designed using an integrated molecular-pathology approach. Tissue samples of major visceral organs were collected during routine post mortem examination from 61 landed bowhead whales (2011-2015) and stored at ultra-low temperature (minus 80 degrees) until analyzed. Select tissue samples (liver, kidney, spleen, lung) reflecting the tissue tropism of the various agents were tested by polymerase chain reaction (PCR) for a suite of high priority marine mammal pathogens (Venn Watson et al. 2010). A subset of tissues were fixed in 10% formalin and processed for histopathology. The only viral agent detected in 9.8% (6/61) bowhead whales belonged to the group of adenoviruses. Adenoviruses were initially discovered in bowhead whales during the early 1980s using cell culture (Smith 1987). Sequencing of current isolates and comparison with National Center for Biotechnology Information (NCBI) Basic Local Alignment Search tool (Blast) databank revealed diverse genotypes with three of the adenoviruses detected being novel (Sanchez and Stimmelmayr unpubl.data). No histopathological lesions were observed in adenovirus-positive bowhead whales.

Previous surveillance for endoparasites in subsistence-harvested bowhead whales demonstrated a limited suite of internal parasites, most likely reflecting the dietary habits of bowhead whales, and the presence of potential zoonotic protozoa (for review Philo et al. 1992; Dailey and Brownell 1972; Hughes-Hanks et al. 2005). Parasites, like other infectious agents, are considered climate sensitive and thus their distribution, prevalence and host range in the Arctic is expected to change. A parasitology survey using archived and modern fecal tissue samples (n=159) collected from landed bowhead whales during 2002 to 2015 focused on detection and genetic characterization of protozoal disease agents (e.g., *Cryptosporidium* spp., *Giardia* spp.) and a general screening for helminths. *Cryptosporidium* spp. and *Giardia* spp. are well known protozoa implicated in infectious diarrheal episodes in a variety of mammals, including humans. We present preliminary results from this longitudinal parasite screening effort.

In contrast to previous work, no helminthes eggs were detected on sedimentation and flotation. Similarly *Cryptosporidium* spp. was absent. Previously, the latter had been detected at 5.1% (2/39) in feces from BCB bowhead whales (Hughes-Hanks et al. 2005). *Giardia* spp. was detected in 22% of examined bowhead whales and varied by age class and gender. Overall prevalence of *Giardia* spp. in our study was lower (22% versus 33%) than previously reported by Hughes-Hanks et al. (2005). However, marked inter-annual variation of Giardia prevalence (0 -50%) was noted in our longitudinal study. In contrast, the previous study by Hughes-Hanks et al. (2005) was limited in scope (1998–2001) and sample size (n=39). The differences in study design provides a possible explanation for the differing prevalence rates. Molecular characterization of several *Giardia* isolates identified them as belonging to the A assemblage, the most common type recovered from humans (Ballweber and Stimmelmayr unpubl.data). Marine contamination with human feces is recognized as a potential pathogen pathway for the introduction of these protozoa to marine mammal populations. Our findings implicate human to bowhead whale transmission via environmental marine contamination, e.g., ballast water, run off from land, and ship or land based sewage outflow.

Hunter Observations of Bowhead Whales

Over 150 whaling captains from 11 whaling communities annually organize bowhead whale hunting crews along the northern and western coast of Alaska. Astute observers of bowhead whale life history and the ocean, Inuit whale hunters have been instrumental in guiding and advancing scientific knowledge of bowhead whales. For over 40 years, whaling communities have shared in the successful management of bowhead whales through their collaborative efforts to integrate vast traditional and local knowledge with whale biologists and regulatory bodies (e.g., Albert 2000; Huntington et al. 2009; Noongwook et al. 2007; Wohlforth 2004). Summarizing all notable observations from 2017 is not within the scope of this report. However, Table 5 provides a few unusual or specific observations or statements relative to the changing Arctic environment, whale health, timing of bowhead migration, pregnancy, killer whale presence, and/or other aspects of bowhead ecology. These observations indicate that environmental change is proceeding faster than anticipated and that bowhead whales, similar to other Arctic keystone species, are responding with increased plasticity in timing of their seasonal migrations.

Table 5. Selected hunter-based observations on notable bowhead whale issues in northern and western Alaska during 2017. The villages are listed in geographic order along the Alaskan coast.

Location	**Observation**	**Significance**
Gambell	Lots of industrial maritime vessels this year. No sea ice this fall and winter.	Changes in frequency/amount of large vessel traffic. Sea ice reduction unprecedented.
Savoonga	Same issues as Gambell reported; no [sea] ice this fall and winter (2018), wondering about whale hunting success.	Sea ice reduction unprecedented. Food security concerns.
Little Diomede	No sea ice in fall 2017 and winter 2018.	Sea ice reduction unprecedented. Food security concerns.
Kivalina	22 years without harvesting a whale. For us to get to whales we'd have to go 20 miles offshore. Too dangerous. That is why no whales have been harvested.	Bowhead migration along the coast. Changing sea ice conditions.
Point Hope	Killer whales were observed chasing belugas at Pt. Hope during April. Conditions are different now; we have to pull out meat early, and we lost 6 meat cellars due to melting permafrost. Losing ice cellars is hard. Crews (families?) had to pile the catches together.	Killer whales present in the Chukchi Sea during April. Food security issue - Ice cellars, the traditional underground storage areas, are collapsing due to melting permafrost.

Location	Observation	Significance
Wainwright	Jaw fracture in a beach cast mature bowhead whale. Initially hunters thought it to be a struck and loss. Maktak was taken. No harpoon or bomb was found; hunters noted jaw fracture and also observed that vertebrae/back was coming apart really easily.	This is the second report of bowhead whale with a complete jaw fracture. Blunt trauma from a collision with a ship is probable
Utqiaġvik (Barrow)	Spring whaling conditions were quite unusual with extensive highly fractured shorefast ice. By mid-April only a single trail was successfully cut to the lead-edge and all 8 spring whales were processed there. During fall whaling 2017, whales were generally closer to shore than the fall 2016, and many were feeding. Storms created large swells in some cases Several of the crews observed 8 killer whales while they were out hunting. One of the other crews reported seeing a tongue-less bowhead carcass, likely killed by the KWs. Ten whales were landed with kidney worms noticed by whaling captain wives who were processing the kidneys for sharing with the community (see Pathological findings). Small flocks of common eiders were seen in open water off Barrow in January 2018. Shorefast ice formation off Nuvuk was very late (Dec 31, 2017).	Unusually rough shorefast ice conditions in spring reduced harvest success at Utqiaġvik. Killer whales more common in autumn near Utqiaġvik? Hunter safety and efficiency (fall whaling) depends on whales being relatively close to shore, good weather and good communications. Fall 2017 had better conditions in that regard than 2016, and had 100% strike efficiency. New parasite (see Pathological findings section) Latest recorded freeze up for Utqiaġvik
Kaktovik	Whalers at Kaktovik reported several gray whales in September 2017; more than usual. The hunters have to assure whale is a bowhead and not gray whale; distracting and can lead to considerable extra effort. Note that ASAMM surveys have never observed gray whales in the Kaktovik area.	gray whale sightings near Kaktovik are rare but they show up every few years,

CONCLUSIONS

In 2017, several analytical approaches were used to document the health status of the BCB population of bowhead whales. Important health metrics such as population size and trend, calf production and crude pregnancy rates show positive or stable trends. Calf production was excellent in 2017, and feeding rates and body condition were consistent with past years. Incidence of non-infectious and infectious disease conditions in bowhead whales remain rare. The detection of *Crassicauda spp.* in landed whales during 2017, however, warrants further integrated morphological-molecular-pathological investigations to better understand this possibly new parasite-host relationship, implications to bowhead whale health, and the underlying ecological drivers. Sea ice reduction from climate warming is a major concern; however, the various metrics mentioned here (in particular, population size and trend; calving rate) suggest that to date, bowheads are not being harmed by sea ice retreat.

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Table 4. Bowhead whale carcass sightings from ASAMM in the eastern Chukchi and western Beaufort seas, July-October, 1982-2017, bowhead whale carcasses in the Bering Sea, 2015-2016 (denoted with *), and shipboard bowhead whale carcasses north of the ASAMM study area (denoted with **).

Date	Number of Carcasses	Age Class	Habitat	Latitude	Longitude	Notes
23-Sep-1982	1	Adult	open water	71.322	-152.600	
28-Sep-1982	1	Adult	open water	71.160	-154.232	
3-Oct-1982	1	Adult	open water	70.910	-160.162	
18-Jul-1984	1	Adult	beach	68.917	-165.367	
18-Sep-1984	1	Adult	open water	70.542	-146.605	
19-Oct-1984	1	Adult	open water	71.347	-151.517	
29-Sep-1991	1	Calf	open water	71.345	-156.115	
12-Sep-1992	1	Adult	beach	70.142	-143.230	
9-Sep-1993	1	Adult	open water	70.522	-147.910	
18-Oct-1997	1	Adult	open water	71.480	-155.890	
17-Sep-1998	1	Adult	open water	70.403	-145.750	
18-Sep-1998	1	Adult	open water	70.572	-146.030	
26-Sep-1998	1	Adult	open water	70.590	-146.680	
4-Oct-1998	1	Adult	open water	70.641	-143.205	
11-Oct-1998	1	Adult	open water	71.486	-152.732	
12-Sep-2000	1	Adult	open water	71.756	-154.556	
9-Sep-2003	1	Adult	open water	71.396	-151.100	
6-Sep-2004	1	Adult	open water	70.295	-143.847	
18-Sep-2004	1	Adult	open water	71.537	-155.501	
18-Sep-2004	1	Adult	open water	71.510	-155.997	
26-Sep-2004	1	Adult	open water	71.290	-154.574	
3-Oct-2007	1	Adult	open water	71.453	-154.664	
20-Aug-2009	1	Adult	beach	70.917	-157.607	
27-Jul-2010	1	Adult	beach	68.856	-165.718	
17-Sep-2010	1	Adult	open water	71.146	-157.986	

26-Sep-2012	1	Adult	open water	71.151	-157.682	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 21 Jan 2018
1-Oct-2012	1	Adult	open water	71.353	-158.861	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 29 Jan 2018
11-Sep-2013	1	Calf	open water	71.172	-162.642	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 21 Jan 2018
16-Sep-2013	1	Adult	open water	70.605	-147.825	Likely struck whale from subsistence activities that was lost in this area
19-Sep-2013	1	Adult	beach	70.486	-160.431	
24-Sep-2013	1	Adult	beach	70.873	-157.765	
26-Sep-2013	1	Adult	beach	70.878	-159.103	
30-Sep-2013	1	Adult	open water	71.623	-167.994	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 21 Jan 2018
7-Jul-2015 *	1	Adult	open water	63.32	-169.35	(Sheffield and SWCA 2015) Approximate location
18-Aug-2015	1	Adult	beach	70.875	-159.174	
21-Sep-2015	1	Adult	open water	70.789	-168.724	
23-Sep-2015	1	Adult	open water	70.828	-146.731	
27-Sep-2015	1	Adult	open water	71.415	-159.031	
3-Oct-2015 **	1	Unknown	open water	72.668	-164.894	H. Melling, pers. comm. to J. Clarke on 3 October 2015
3-Oct-2015 **	1	Unknown	open water	72.119	-164.338	H. Melling, pers. comm. to J. Clarke on 3 October 2015
4-Oct-2015	1	Adult	open water	71.281	-158.512	
4-Oct-2015	1	Adult	open water	71.388	-155.454	Confirmed via photos to be struck and lost whale from subsistence activities several days prior
4-Oct-2015	1	Calf	open water	71.331	-153.749	Resolved rake marks on right pec; fresh injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 21 Jan 2018
27-Oct-2015	1	Adult	open water	70.992	-162.354	
27-Oct-2015	1	Adult	open water	71.460	-164.172	Carcass with orange float attached
27-Oct-2015	1	Adult	open water	72.017	-165.377	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 21 Jan 2018
13-Jul-2016	1	Adult	open water	70.845	-160.018	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 21 Jan 2018

27-Aug-2016	1	Adult	open water	71.499	-150.158	
5-Sep-2016 *	1	Adult	beach	63.12	-162.45	(Sheffield et al. 2016*b*)
11-Sep-2016	1	Adult	open water	71.311	-165.809	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 1 Feb 2018
11-Sep-2016	1	Adult	open water	71.486	-163.339	Injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 1 Feb 2018
14-Sep-2016	1	Adult	open water	70.334	-141.614	
30-Sep-2017	1	Calf	open water	71.742	-166.702	Small male, calf-of-the-year to 1.5 y; injuries consistent with killer whale predation; R.Stimmelmayr (NSB DWM) on 29 Jan 2018