SELECTED RESEARCH RELEVANT TO THE 2012 BOWHEAD IMPLEMENTATION REVIEW

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ABSTRACT

This paper lists publications and information relevant to the IWC Scientific Committee's 2012 Implementation Review (IR) of Bering-Chukchi-Beaufort Sea (BCBS) bowhead whales and data that was provided under the Scientific Committee's Data Availability Agreement. Since the last IR in 2007 major studies ranging from molecular biology to broad-scale distribution/relative abundance have been conducted on BCB bowheads by the local, state, and federal government and the oil and gas industry in Alaska Of particular relevance are: a) the last abundance estimate accepted by the Scientific Committee of 12,631 with CV 0.2442 (Koski *et al.*, 2010), b) subsistence harvest totals from recent years (Suydam and George, 2012) and, c) recent stock structure investigations (Givens *et al*., 2010). We also review selected publications (e.g., satellite telemetry, health status, etc.) relevant to the status of BCB bowheads.

INTRODUCTION

Bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock (BCB) provide an important nutritional and cultural resource for several Native communities in northern and western Alaska (US) and eastern Chukotka (Russia). The Alaska Eskimo Whaling Commission (AEWC) locally manages the Alaskan harvest through an agreement with the National Oceanic and Atmospheric Administration (NOAA). The quota and level of allowable harvest is determined by the documented subsistence need, the population size and trend of BCB bowheads, Implementation Reviews (IR) by the IWC Scientific Committee, and ultimately the bowhead SLA (IWC 2003, p. 22.).

In 2007, the SC conducted an extensive *IR* of BCB bowheads with a major emphasis on stock structure, catch and life history information. The SC concluded that the bowhead SLA performs "adequately for all stock structure hypotheses and all trials (IWC 2008a; p 77)." It was further stated after extensive discussion: "The Chair closed by concluding that the available evidence best supports a single stock hypothesis for BCB bowhead whales" (IWC 2008b, Annex F, p.158).

Active bowhead whale research has continued in the five years since the previous IR (see George *et al.* 2007), with local, state, and federal support. Here we list some of the research conducted that may be relevant for the 2012 Implementation Review of BCB bowheads. This list is not exhaustive. A complete list of available data has been provided to the SC in accordance with its DAA procedures (http://www.iwcoffice.org/sci_com/data_availability.htm). In some cases, we refer to published papers and/or other literature that was not included in the DAA listing and are identified herein. Many relevant research papers have been published in peer-reviewed journals where access is straightforward; also, copies of unpublished papers submitted to annual SC meetings are available from the IWC (website or email).

REVIEW OF RELEVANT RESEARCH

Abundance and Trend of BCB Bowhead Whales

Abundance has been estimated using ice-based surveys and aerial photo capture-recapture techniques since 1978. The last published estimate based on a combined ice-based visual and acoustic survey was conducted in spring 2001. The results were published in George *et al.* (2004) with some refinements in Zeh and Punt (2005). These data were archived, along with the entire bowhead abundance survey data series from 1978 to 2001, with the IWC Secretariat in 2007 under the auspices of the Data Availability Agreement (DAA). Those records remain with the IWC as a permanent record. These papers include the last accepted trend analysis of the population rate of increase (3.4%, 95% CI 1.7% to 5%). A reanalysis of the trend estimate including the 2004 abundance estimate is presented in Figure 1 (George and Zeh 2012).

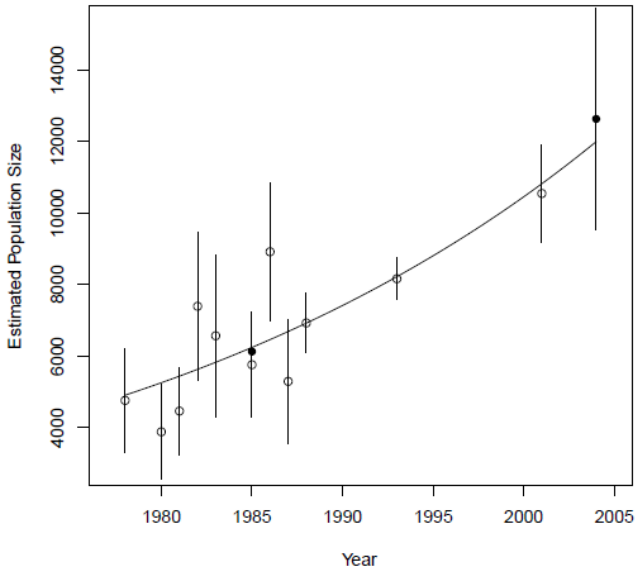

Figure 1. Abundance estimates with standard errors (SE) for the full time series of abundance estimates of the BCB population of bowhead whales from 1978 to 2004 shown with a fitted trend line (Zeh and George, 2012).. Open circles are estimates from ice-based surveys and filled circles estimates from aerial photography surveys. The vertical line through each estimate extends from one SE below it to one SE above it. The 1985 estimates have been offset slightly to show that the estimate from the photography surveys is more precise

In 2009, an ice-based survey was attempted but entirely failed due to very poor ice conditions (George *et al.*, 2009). Most of the second half of the survey period was obscured by heavy ice in the lead system totally precluding any chance of seeing whales.

In 2010, the NSB conducted another ice-based visual and acoustic survey but again, failed because of closed ice during a critical period of the migration. No abundance estimate was calculated using these data, but the survey methods were described by George *et al.* (2011) and the data have been available in accordance with the SC DAA. Givens *et al.* (2011) estimated visual detection probabilities using the 2010 data.

For the 2011 field season, sufficient data were collected during the ice-based survey to compute an abundance estimate. Data are currently being analyzed and an updated ice-based population estimate should be available by 2013.

The most recent abundance estimate accepted by the IWC was photo capture-recapture survey conducted in 2003-2004 of 12,631 with CV 0.2442 (Koski *et al.*, 2010) (IWC, 2010).

The following is a review of abundance estimates conducted over the past 10 years.

Ice-based Visual/Acoustic Surveys

George, J. C., J. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of western arctic bowhead whales surveyed near Barrow, Alaska. Marine Mammal Science 20 (4):755-773.

In spring 2001 an ice-based survey was conducted near Barrow, Alaska. This is the most recent *ice-based* estimate. Visual observers recorded a total of 3,295 'new' and 532 'conditional' whales in 1,130 hours of watch effort, including 121 new calves (3.7% of the new whales). Passive acoustic surveillance was conducted concurrently. The abundance estimate (N4/P4) for 2001 is 10,470 (SE =1,351) with a 95% confidence interval of 8,100 to 13,500. The estimated annual rate of increase (ROI) of the population from 1978 to 2001 is 3.4% (95% CI 1.7% to 5%).

Zeh, J.E. and Punt, A.E. 2005. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. JCRM 7(2):169-175.

The method of Cooke (1996) and Punt and Butterworth (1999) was applied to 2001 survey data. The resulting 2001 abundance estimate was 10,545 (95% confidence interval 8,200 to 13,500), very close to the 2001 N4/P4 abundance estimate of 10,470 (95% confidence interval 8,100 to 13,500) (George *et al.*, 2004).

George, J.C., Givens, G.H., Herreman, J., DeLong, R.A., Tudor, B., Suydam, R., and Kendall, L. 2011. Report of the 2010 bowhead whale survey at Barrow with emphasis on methods for matching sightings from paired independent observations. Paper SC/63/BRG3 presented to the Scientific Committee of the International Whaling Commission, June, 2011.

In 2010, the NSB conducted another ice-based visual and acoustic survey but again, failed because of closed ice during a critical period of the migration. No abundance estimate was calculated using these data, but the survey methods were described in detail. The raw data were made available in accordance with the SC DAA in December 2011. Givens *et al.* (2011) presented preliminary visual detection probabilities using the 2010 data.

George, J.C., J. Herreman, G. H. Givens, R. Suydam, J. Mocklin, C. Clark, B. Tudor, K. Stafford, R. DeLong. 2012. Brief review of the 2010 and 2011 bowhead whale abundance surveys near point Barrow, Alaska. Report to the IWC SC SC/64/AWMP7.

During 2011, the NSB conducted another ice-based visual and acoustic survey, since weather conditions precluded sufficient hours of visual watch in 2010 to make an abundance estimate. The 2011 ice-based bowhead whale survey was successful as much of the field season had acceptable visibility. Currently analysis of the visual and acoustic data from this survey are underway.

Aerial Photo Capture-Recapture Estimate

Koski, W.R., J. Zeh., J. Mocklin, A.R. Davis, D.J. Rugh, J.C. George and R. Suydam. 2010. Abundance of Bering-Chukchi-Beaufort bowhead whales (*Balaena mysticetus*) in 2004 estimated from photoidentification data. J. cetacean Res. Manage. 11(2): 89–99.

Aerial photo-identification surveys were flown in 2003, 2004, and 2005. Between-year matching of photos has been completed for 2003-2005. In 2009, the SC **agreed** on an abundance estimate of 11,800 (CV 0.255; 95% IC 7,200-19,700) based on these data (IWC, 2010, p. 22). The analyses and results are given in (Koski *et al.*, 2010). However, in the published paper the abundance of the B-C-B bowhead population in 2004 (excluding calves) was estimated to be 12,631 with CV 0.2442, 95% bootstrap percentile confidence interval (7,900; 19,700) and 5% lower limit 8,400. These data were made available in accordance with the DAA in November 2011.

International Whaling Commission. 2010. Aboriginal subsistence whaling management advice (Annex F). Vol 11, Supplement 2, April 2010. (p. 22).

"The Committee agrees that the 2004 abundance estimate of 11,800 is an acceptable estimate of the abundance of the BCB stock of bowhead whales. This estimate is suitable for use in the *Bowhead SLA*."

Telemetry Studies, distribution, and migration

Pioneering bowhead telemetry studies were conducted in the late 1980s and 1990s but the overall sample sizes were relatively small (Mate *et al.*, 2000). These studies added incrementally to a broader understanding of bowhead movements. Following the serious concerns about bowhead stock structure at IWC 2002 (Shimonoseki) a major program was developed as summarized in George, Moore and Suydam (2007). Telemetry studies were strongly recommended as part of this overall program which was endorsed by the Alaska Eskimo Whaling Commission.

Telemetry studies suggest that overall BCB bowhead distribution has not significantly departed from what was known and presented at the last bowhead IR in 2007 (IWC, 2008b, Annex E). However, there have been many important new findings. These include: 1) intra-season movements within summering range indicate far more mobility than previously reported. 2) An incidence of "range-overlap" has been reported between BCB and eastern Canada/western Greenland whales (Heide-Jorgensen 2011), however the tagged whales did not join the other stock or winter in areas not previously identified (Citta *et al.* 2012). 3) One whale showed variation in summering areas. It was tagged in the western Beaufort Sea in summer; however, the following summer it did not migrate NE during spring migration but instead summered along the Chukotka coast (Quakenbush *et al.* 2010). This anomaly is consistent with reports from Russian observers that low number of whales summer in this region (Zelinsky and Melnikov, 1997). 4) All tagged whales spent some time along the Chukotka coast apparently feeding, before entering the Bering Sea (Quakenbush *et al.*, 2012, this meeting).

Mate, B.R., Krutzikowsky, G.K., Winsor, M.H. 2000. Satellite-monitored movements of radio-tagged bowhead whales in the Beaufort and Chukchi seas during the late-summer feeding season and fall migration. Can J. Zool. 78 1168-1181.

"Twelve juvenile bowhead whales were satellite taged in the Canadian Beaufort Sea off the Mackenzie River Delta. The whale with the longest record traveled 3886 km to Siberia in 32.5 d, averaging 5.0 km/h. Its westerly route through the Beaufort and Chukchi seas was between 70° and 72°N and primarily in heavy ice (90% coverage), which was continuous west of 151°W. This whale's speed was faster, though not significantly, in heavy ice than in more open water. This is the first detailed documentation of the route and speed of a bowhead whale during its fall migration from Canadian to Russian waters."

Citta, J.J., Quakenbush, L.T., George J.C., Small, R.J., Heide-Jorgensen M.P., Brower H., Adams, B. and Brower, L. 2012. Winter movements of bowhead whales (*Balaena mysticetus*) in the Bering Sea. ARCTIC, Vol. 65:1.

Twenty one satellite tagged bowhead whales were followed during winter 2008-09 (11 whales) and 2009-10 (10 whales). All whales over-wintered in the Northern Bering Sea, although distribution varied between years. Whales were most likely to be found in areas with 90-100% sea-ice concentration, generally far from the ice edge and polynyas.

Heide-Jorgensen, M.P., Laidre K.L., Quakenbush L.T. and Citta J.J. 2011. The Northwest Passsage opens for bowhead whales. Biol. Lett. published online 21 September 2011. (DOI: 10.1098/rsbl.2011.0731)

This paper reports the first observation of distribution overlap between single bowhead whales tagged with satellite transmitters offshore West Greenland and Alaska in August 2010. The two whales entered the Northwest Passage from opposite directions and spent approximately 10 days in the same area.

Quakenbush, L. 2007. Preliminary satellite telemetry results for Bering-Chukchi-Beaufort bowhead whales. Paper SC/59/BRG12 presented at IWC 59, Anchorage, Alaska, June 2007.

This very brief paper was provided to the SC during the 2007 bowhead IR. It reports early results of the BCB bowhead tagging program of two whales tracked from 12 May to 29 October 2006. These animals moved into previously known summer feeding areas and returned along the Beaufort Sea coast.

Quakenbush, L.T., Citta, J.J., George, J.C., Small, R.J., and Heide-Jørgensen, M.P. 2010. Fall and winter movements of bowhead Whales (Balaena mysticetus) in the Chukchi Sea and within a potential petroleum development area. ARCTIC Vol. 63 (3): 289-307.

Nineteen mostly immature bowhead whales were tagged with satellite-linked transmitters between May 2006 and September 2008. From Point Barrow, Alaska, most whales moved west through the Chukchi Sea between 71˚ and 74˚ N latitude; nine whales crossed in six to nine days. Three whales returned to Point Barrow for 13 to 33 days, two after traveling 300 km west and one after traveling ~725 km west to Wrangel Island, Russia; two then crossed the Chukchi Sea again while the other was the only whale to travel south along the Alaskan side of the Chukchi Sea. Seven whales spent from

one to 21 days near Wrangel Island before moving south to northern Chukotka. Whales spent an average of 59 days following the Chukotka coast southeastward. Kernel density analysis identified Point Barrow, Wrangel Island, and the northern coast of Chukotka as areas of greater use by bowhead whales that might be important for feeding. All whales traveled through a potential petroleum development area at least once. Most whales crossed the development area in less than a week; however, one whale remained there for 30 days.

Genetics and Stock Structure

The population genetics of BCB bowheads, which impacts estimates of population structure, migration rates, and effective population size, have been investigated using mitochondrial DNA (mtDNA; LeDuc *et al.*, 2008), microsatellites (Givens et al., 2010), and Single Nucleotide Polymorphisms (SNP; Morin *et al.* 2010) loci.

In the 2007 implementation review of the BCB stock of bowhead whales, stock structure was a central issue based in part on the results of studies ultimately published in Jorde *et al.* (2007) which showed evidence for potential temporal structuring of the population during the Fall migration based on individual genetic distance and days apart during migration. Evidence for a single stock of BCB bowhead whales was presented in studies ultimately published by Givens *et al.* (2010). In the Chair's Report of the 59th Annual Meeting, the results of the implementation review for the BCB stock of bowhead whales (IWC 2008a, Annex D, page 77), it was concluded: *"After extensive discussions of the genetic and other information, the Committee agreed that the evidence supports a single-stock hypothesis (the one originally used to develop the Bowhead SLA).*"

In the five years since the 2007 IR, the BCB bowhead genetics have continued to be investigated and no further evidence of substructure has been presented. Analyses regarding genetic stock structure since the 2007 IR include:

Morin P.A., V. L. Pease, B. L. Hancock, K. M. Robertson, C. W. Antolik, and R. M. Huebinger. 2010. Characterization of 42 single nucleotide polymorphism (SNP) markers for the bowhead whale (*Balaena mysticetus*) for use in discriminating populations. Marine Mammal Science 26: 716–732.

This study characterized 42 SNP loci using two discovery approaches: random locus (using the microsatellite-enriched cloned DNA segments from which Huebinger *et al.* (2008) described microsatellite loci, and a targeted gene approach that used an intron spanning method with primers anchored in the exons of known genes. According to Morin *et al.* (2010) empirical and theoretical results from previous studies have shown SNPs to have equal or greater statistical power as compared to microsatellites for some applications. Other benefits to SNPs include cost-effective genotyping, they can be used on historical and poor-quality samples whereas microsatellites cannot, and SNPs provide a data type that can be compared and combined across time and from different laboratories regardless of the technology used to generate genotypes. The study validates the SNP assay by genotyping 97 individuals from two populations, the Sea of Okhotsk and eastern Canada, Davis Straight stock). Their data indicated an Fst = 0.037 with a highly significant ($p < 0.0001$) differences between stocks.

Givens, G. H., R. M. Huebinger, J. C. Patton, L. D. Postma, M. Lindsay, R. S. Suydam, J, C. George, C. W. Matson, and J. W. Bickham. 2010. Population genetics of bowhead whales (Balaena mysticetus) in the western Arctic. ARCTIC VOL. 63, NO. 1 (MARCH 2010) p. 1–12

This remains one of the most comprehensive papers to test for population structure within and between three bowhead whale stocks using microsatellite loci. The study used 414 whales and 22 microsatellite loci. Widespread departures from Hardy-Weinberg equilibrium were identified but clear structuring within western arctic bowheads (or BCB) was not detected. There was conclusive evidence of genetic differentiation among the three stocks or regions. The statistical rejection of panmixia within the BCB stock improves our understanding of bowhead whale biology. The lack of evidence for multiple populations within the BCB enables risk-averse management of aboriginal hunting of Western Arctic bowhead whales.

LeDuc, R. G., K.K. Martien, P.A. Morin, N. Hedrick, K.M. Robertson, B.L. Taylor, N.S. Mugue, R.G. Borodin, D.A. Zelenina, D. Litovka, and J.C. George. 2008. Mitochondrial genetic variation in bowhead whales in the western Arctic. Journal of Cetacean Research and Management 10:93–97.

This study examined mtDNA control regions sequences from 382 BCB bowheads to test for potential population subdivision and temporal division. No significant differences were detected in spatial comparisons or in temporal comparisons along Alaska's North Slope. However, the authors found evidence of genetic heterogeneity among age cohorts. Animals estimated to have been born prior to 1918 (n=8) differed significantly from those born after 1979 (n=34) (p=0.030). Animals estimated to have been born between 1918 and 1949 (n=13) were significantly different from those born after 1979 (p=0.050). And the two older cohorts together were significantly different from whales born after 1979 (p=0.009). The authors also demonstrated a significant Fst between whales harvested in the autumn (n=13) and spring (n=11) hunts from St. Lawrence Island (p=0.049).

Jorde, P. E., T. Schweder, J. W. Bickham, G. H. Givens, R. Suydam, D. Hunter, and N. C. Stenseth. 2007. Detecting genetic structure in migrating bowhead whales off the coast of Barrow, Alaska. Molecular Ecology 16:1993-2004.

Using a method the authors developed to measure genetic distance between pairs of individuals, a pattern of elevated genetic differences among whales caught about a week apart was detected and shown to be statistically significant for the autumn migration. The authors discussed possible explanations for the pattern, including population substructuring, demographic consequences from historical overexploitation, and social structuring during the migration.

Philips, C. D., J. I. Hoffman, J. C. George, R. S. Suydam, R. M. Huebinger, J. C. Patton and J. W. Bickham. 2012. Molecular insights to historical demography in Bowhead whales. SC/64/AWMP1.

This study investigated the demographic history of BCB bowheads using approximate Bayesian computation, extended Bayesian skyline analysis, and classical bottleneck and

demographic tests. The approximate Bayesian computations support a pre-depletion ancestral population size of 10,000 to 20,000 individuals. A signal for a historical population expansion having begun approximately 75,000 years before present was supported by multiple analyses. A subsequent, non-anthropogenically driven, population reduction, that ensued about 15,000 years ago, was also detected. No genetic signature for the recent population depletion caused by commercial whaling was recovered; the suggested reason for this was that the bottleneck was of short duration in relation to the long generation time of the bowhead, which served to minimize erosion of variability through genetic drift.

IWC, 2008b. Cetacean Research and Management. Supplement, Vol 10, April 2008. Annex E. Report of the standing working group on the aboriginal whaling management procedure (AWMP).

This annex summarizes the intersessional workshops regarding several stock structure hypotheses, design of trials, development of a multi-stock SLA (AWMP-lite) and its performance results and related matters. The SWG *strongly recommended* that the bowhead SLA continued to be used to provide management advice.

IWC, 2008c. Cetacean Research and Management. Supplement, Vol 10, April 2008. Annex F. Report of the subcommittee on bowhead, right, and gray whales.

This Annex summarizes the BRG discussions of: hypothetical stock archetypes, the results and interpretation of genetic studies, historical distributions of bowheads, isotopic evidence for multiple stocks, aerial PhotoID comparisons between regions, and other related information. After full consideration of the stock structure discussions, the BRG echoed the advice of the AWMP SWG that it "*strongly recommended* that the bowhead SLA remains the best tool for giving management advice."

Basic Biology and Health Assessment

Bowhead basic biological and health assessment studies have been underway since the 1970s (Willetto et al., 2002). Postmortem examinations of harvested whales take place each spring and autumn in at least Barrow, Kaktovik, Savoonga and Gambell (Suydam *et al.*, 2012). Samples from these examinations have also provided the basis of many basic biological and physiological studies and publications as well as genetic investigations.

Literature review of bowhead whale health assessments:

Since 1982, at minimum of 22 peer reviewed papers have been published on biomedical aspects of bowhead whales (*Balaena mysticetus)*. These health assessment studies (toxicological pathology, general pathology; infectious disease agents have been primarily based on sample collection of subsistence harvested bowhead whales during annual Inupiaq spring and fall bowhead whale hunts. Only a few case reports on pathological findings (i.e. lipoma, Migaki and Albert 1982; ecto and endoparasites, Migaki *et al.* 1982; Heckmann *et al.* 1987; Hughes –Hanks *et al.* 2005; trauma, Philo *et al.* 1990; intestinal volvulus, Heidel and Albert 1994; epidermal lesions, Shotts *et al.* 1990; Henk and Mullan 1996; pseudohermaphrodism, Tarpley *et al.* 1995; eye disease, Zhu Qian 1997) have been published indicating a generally very low level of pathological conditions in bowhead whales.

Other pathological conditions observed in individual harvested bowhead whales (NSB-DWM unpubl.data) include myocardial abscess, Sarcocystis spp, and oral lesions. With respect to the presence of infectious disease agents in bowheads several serological studies have been conducted (Smith *et al.* 1987; O'Hara *et al.* 1998). These studies indicate that bowhead whales similar to other marine mammals are exposed to some important marine mammal viral agents such as Calici virus, VESV vesicular exanthema of swine virus (VESV), San Miguel sea lion virus (SMSV), and pox virus (Bracht *et al.* 2006), but prevalence rates are generally low and no clinical apparent cases have ever been documented in bowhead whales. Thus infectious disease-related risks appear low for bowhead whales.

Toxicological assessment of contaminant concentrations and heavy metals in bowhead has over the last 30 years demonstrated that bowheads similar to other marine mammals accumulate contaminants and heavy metals, albeit at much lower rates (Rosa *et al.* 2007; O'Hara *et al.* 1999; Hoekstra *et al.* 2005, 2003, 2002; Muir *et al.* 1999; Ponce *et al.* 1998; NSB-DWM unpubl.data). Since 1999 contaminant levels in bowheads have either remained stable or decreased with the exception of contaminant levels in bowhead whale meat, as indicated by a recent study of subsistence harvested whales from St. Lawrence Island (Welfinger-Smith *et al.* 2011). However, similar to other marine mammals there is a lack of data to assess the biological significance of these low level chronic exposures to bowhead whale health. Only one study has been published that has looked at correlation between histopathological findings and heavy metal concentrations in bowhead whales. Statistical associations between concentrations of Cd in kidney and liver and scored histopathological changes indicated significant relationships between cadmium concentration, age and observed degree of lung fibromuscular hyperplasia and renal fibrosis. These moderate histopathological changes most likely do not adversely affect organ function or health of older bowhead whales.

In conclusion, based on the review of historical and current biomedical data available on the health status of bowhead whales, no new data has been provided that indicate that bowhead whale health is declining.

Reviews of some selected papers:

Philo, L.M., Shotts, E.B., Jr. and George, J.C. 1993. Chapter 8. Morbidity and mortality. In: J.J. Burns, J.J. Montague and Cowles, C.J. (eds.) The Bowhead Whale. Special publication No. 2 of the Society for Marine Mammalogy. 787 pp.

This chapter reviewed mortality and morbidity in bowheads and concluded "there is limited information on causes of natural morbidity and virtually none on causes of natural morality of bowheads". They noted that bowheads "suffer from the problems typical of other cetaceans" but at lower levels. These include: parasites, pathogenic microbes, predation, human-caused non-hunting trauma, etc.

Suydam *et al.*, 2007, 2008, 2009, 2010, 2011). Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos Report to the IWC SC.

Mature females are uncommon in the harvest but the pregnancy rates are at levels consistent with the last 30 years. Despite some hunter selection for small whales, the high percentage of young whales in the harvest is indicative of stable long-term reproduction and a growing population. Crude pregnancy rates are also reported annually. Pregnancies over the past 5 years (since 2007) appear consistent with earlier years indicating ~4 pregnancies from 10 presumably mature females (> 13.4 m; ~40% pregnant).

O'Hara, T.M., Krahn, M.M., Boyd, D., Becker, P.R., and Philo, LM. 1999. Organochlorine contaminant levels in Eskimo harvested bowhead whales of arctic Alaska. J. Wildl. Dis. 35(4):741-52.

Most organochlorine contaminants are at low concentrations in bowhead whale tissues compared to other cetaceans-especially Odontocetes. The researchers expect no adverse effects related to these contaminants to occur in bowhead whales or consumers of the tissues. They recommended continued investigations to confirm their findings.

Reeves, R., Rosa, C., George, J.C., Sheffield, G. Moore, M. 2012. Implications of Arctic industrial growth and strategies to mitigate future vessel and fishing gear impacts on bowhead whales. Marine Policy 36 (2012): 454–462.

[See review under *Shipping and Commercial Fishing*]

Rosa, C. 2009. A summary of dead, stranded bowhead whales reported in the Chukchi and Beaufort Seas over the last twenty-five years. Paper presented to the IWC Scientific Committee SC/61/E12

Bowhead strandings are relatively uncommon. However, five dead-stranded bowhead whales were reported in the Chukchi and Beaufort Seas during the open water season of 2008. Prior to this, only five bowhead whales reported stranded dead in this area over the past 25 years. While a relatively small number, the cases in summer 2008 could be an artifact of increased sighting effort, an increase, or both. Few strandings have been reported since 2009.

Willetto, C.E., O'Hara, T.M., Rowles, T. 2002. Bowhead whale health and physiology workshop, October 2001. North Slope Borough, Department of Wildlife Management, Barrow, Alaska. 129 pp.

This report provides a summary of health assessment work conducted as of 2001 and suggestions/methodology for further research. It reviews contaminant levels, blubber efficacy as an indicator organ, physiology, morphology, age methods, etc. No major health issues were identified for BCB bowheads in the workshop.

Documentation of bowhead subsistence harvest

The North Slope Borough (NSB) annually reports harvest data to the SC (as a BRG paper), including information on strikes, landings, pregnancy status, calf status and other relevant data (e.g., Suydam *et al.* (2012). The harvest data in these papers provide the basis of the official catch records maintained by the IWC and used in the bowhead SLA. The AEWC is the ultimate source of these records, which are carefully reviewed and summarized by NSB biologists.

Harvest levels have been essentially stable since 1995-1998 when that year the 4-year strike limit was set at 68, 67, 66 and 65 respectively (Breiwick and Smith, 1995). The 5-year block quota was initiated in 1998 with 335 strikes or 280 landed (IWC 1999). The total available strikes within any of the 5-year quota blocks has never been exceeded.

Habitat Issues

Underwater Sound

Passive acoustic sampling of bowhead whale calling has been in common practice for decades (e.g., Wursig and Clark, 1993). During the International Polar Year (IPY) acoustic recorders were deployed on oceanographic moorings in Fram Strait and on the Chukchi Plateau. Of note, bowhead whale calls were recorded on the Chukchi Plateau (75.1°N, 168° W), initially in March-April and consistently from May through August 2009 (Moore *et al.* 2012). These data complement information on bowhead acoustic detections offshore Barrow, with earliest calls recorded on 25 March 2004, followed by much higher calling rates from mid-April through mid-May when the recorder failed (Moore *et al.* 2010).

Since 2006, bowheads have experienced a strong resurgence of anthropogenic sound from seasonal seismic surveys conducted in support of continental shelf mapping and oil and gas exploration. Airgun signals were recorded nearly continuously at the Chukchi Plateau site in September and October 2009 (Moore *et al.* 2012). Near Barrow, mean noise levels were elevated by 2-8 dB in September and early October due to the presence of seismic surveys in the Chukchi and Beaufort Seas (Roth *et al.* 2012).

Moore, S.E., Stafford, K.M., Melling H., Berchok, C., Wiig Ø., Kovacs K.M., Lydersen C., Richter-Menge, J. 2012. Comparing marine mammal acoustic habitats in Atlantic and Pacific sectors of the High Arctic: year-long records from Fram Strait and the Chukchi Plateau. Polar Biol 35: 475-480.

Moore, S.E., Stafford, K.M. and Munger, L.M. 2010. Acoustic and visual surveys for bowhead whales in the western Beaufort and far northeastern Chukchi seas. Deep Sea Res II 57: 153-157.

Roth E.H., Hildebrand J.A. ,Wiggins S.M. and Ross D. 2012. Underwater ambient noise on the Chukchi Sea continental slope from 2006-2009. J. Acoust Soc Am 131.

Climate Change Effects

Sea ice reductions have been significant in the last five years. In fact, Overland *et al.* 2008 suggests a "phase change" in sea ice extent occurred ~2007 where rebuilding extensive multiyear ice is unlikely. The effect of ice retreat on bowheads has not been intensively or directly studied; however, ancillary data are available. A BCB bowhead range expansion may have occurred including range overlap with East Canadian stock (Quakenbush *et al.* 2012; this meeting). In terms of overall population level effects, one of the best indicators that sea ice reduction has not seriously impaired BCB bowheads is their steady increase in population size of the BCB and stable calf production over the long-term.

One study examined the relationship between ice-densities on the Canadian summer feeding grounds and body condition (George *et al.*, 2009). They found a correlation between increased body condition and light sea ice cover within the Eastern Canadian Beaufort Sea.

George, J.C., C. Nicolson, S. Drobot, J. Maslanik, R. Suydam, and C. Rosa. 2009. Progress Report: Update on Sea Ice Density and Bowhead Whale Body Condition. Paper SC/57/E13 workshop on climate change and cetaceans.

Preliminary analysis indicates a negative correlation between bowhead body condition in a given year and the amount of "feeding habitat" in the Eastern Beaufort Sea that is covered by sea ice. While the exact mechanisms and reasons for the correlations are not well understood, the BCI is significantly different between years with heavy and light sea ice cover. Possible reasons include a longer feeding season and possibly higher primary production (Arrigo *et al.*, 2011).

Oil and Gas

Since 2006, there has been a resurgence of interest in offshore oil and gas in the U.S. Beaufort and Chukchi seas. Increased seismic, ship activity, and potential drilling activities have caused great concern about possible impacts to bowhead whales and subsistence hunting. These concerns are based on traditional knowledge and scientific studies that indicate bowheads are quite sensitive to low levels of anthropogenic sounds. Oil and gas companies are expending considerable effort to better understand impacts from oil and gas activities on bowhead whales.

The AEWC is working with the oil and gas and seismic companies to develop mitigation measures to help protect bowheads and the people that depend upon the whales for cultural and nutritional needs. A Conflict Avoidance Agreement is signed annually that helps mitigate impacts to whale hunters and whales.

Funk, D.W., Reiser, C.M., Ireland, D.S., Rodrigues, R. and Koski, W.R. 2011. Joint monitoring program in the Chukchi and Beaufort seas, 2006-2010. LGL Draft Report P1213-1 submitted to Shell Offshore Inc., ConocoPhillips Alaska Inc., Statoil USA E&P Inc. and other industry contributors. LGL Alaska Research Associates Inc., Anchorage, AK

This report summarizes information collected during vessel-based monitoring, aerial surveys, and acoustic monitoring in the Beaufort and Chukchi seas from 2006 to 2010. This and previous reports provide results and some analyses on impacts to oil and gas activities on bowhead whales and other marine mammals.

McDonald, T.L., Richardson, W.J., Greene, C.R., Blackwell, S.B., Nations, C.S., Nielson, R.M. and Streever, B. In press. Detecting changes in the distribution of calling bowhead whales exposed to fluctuating anthropogenic sounds.

This study documented the impacts of anthropogenic sounds created from activities at BP's production island, Northstar, in the central Beaufort Sea. The analysis indicate that bowheads are very sensitive to low levels of anthropogenic sounds. The sounds were primarily due to boats resupplying the island. Bowhead calls were located farther offshore and farther away from the island when anthropogenic sounds were loudest.

Shipping and Commercial Fishing

Mortality and morbidity from shipping and commercial fishing to BCB bowheads has been summarized in reports and papers and appears to be occurring at low levels (Philo *et al.*, 1993; Reeves *et al.*, 2012). Still, based on the experience of the closely related North Atlantic right whale, anthropogenic effects from these sources are significant concerns should shipping, fishing and industrial operations increase in the Arctic.

Reeves, R., Rosa, C., George, J.C., Sheffield, G. Moore, M. 2012. Implications of Arctic industrial growth and strategies to mitigate future vessel and fishing gear impacts on bowhead whales. Marine Policy 36 (2012): 454–462.

Vessel strike and fishing gear trauma has been documented in bowheads, but at a much lower rate than in North Atlantic right whales. Initiatives intended to mitigate the impacts of ship traffic on

North Atlantic right whales have included speed limits and routing changes. Those meant to reduce the incidence and severity of entanglements includes the modification of gear design and gear deployment practices. Management measures need to be considered in advance in the Arctic in order to minimize the risks to bowhead whales as shipping and industrial fishing expand in the Arctic with ice retreat.

Multidisciplinary Studies

Several multidisciplinary studies are underway in the US Arctic by the Federal Government, various Universities, and Industry to describe pre-industrial mechanisms and conditions in the US Arctic Ocean. The goals of these studies are to quantify ecosystem assemblages and linkages, study bowhead feeding areas, quantify the acoustic environment, quantify biological and physical oceanographic conditions and other investigations.

National Marine Mammal Laboratory. 2010. Bowhead whale feeding ecology study (BOWFEST) in the western Beaufort Sea, Bowhead Whale 2009 Annual Report. Alaska Fisheries Science Center, F/AKC4, 7600 Sand Point Way, NE, Seattle WA 98115-0070.

This study focuses on late summer oceanography and prey densities relative to bowhead whale distribution over continental shelf waters between mainly north and east of Point Barrow, Alaska. The study utilizes: aerial transects and photographic surveys, biological and physical oceanographic sampling, stomach sampling, bioenergetics, acoustics, current moorings, and local Inupiat knowledge/ boat surveys. A main focus is to understand the mechanisms that make the western Beaufort an atypical but important feeding area for bowheads. This information is needed to minimize potential impacts from shipping and petroleum development as well as possible future commercial fishing activities.

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