Summary of stock structure research on the Bering-Chukchi-Beaufort Seas stock of bowhead whales 2003-2007

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ABSTRACT

This paper is a summary of research conducted over the past three years to investigate the stock structure of the Bering-Chukchi-Beaufort (BCB) population of bowhead whales (*Balaena mysticetus*), as requested by the International Whaling Commission Scientific Committee (IWC SC) during its 2004 meeting (Item 9.1.6 of SC.56 report). Research directed towards testing hypotheses concerning the stock structure of BCB bowhead whales was comprised of five elements: (1) Research Planning and Hypothesis Testing; (2) Genetics Sampling and Analysis; (3) Animal Mixing and Abundance; (4) Spatial Distribution and Abundance; and (5) Migration Patterns. Each of these elements was comprised of two to three projects including: photo-identification surveys, collection of tissues from harvested whales, traditional knowledge, biopsy sampling in Russia and Alaska, stable isotope analysis of baleen plates, analyses of catch data from the Yankee commercial whaling period, development of new microsatellite loci for bowheads, development of new SNPs genetic markers, analyses of the updated genetic datasets (SNPs, microsatellite and mtDNA), development of a models for pairwise microsatellite allele matching probabilities, simulation modeling of genetic and demographic population trajectories for comparison to empirical data, genetic modeling simulations, analyses of photo-identification data related to stock structure, estimation and classification of whale ages, estimation of abundance of whales seen in late spring in waters off Chukotka, collection and analyses of passive acoustic data, and satellite tracking of tagged whales. Collectively, these studies have resulted in over 80 research papers and contributed new information on BCB stock structure, but particularly the genetic structure of the BCB bowhead whale population. It should be recognized that these studies add to the baseline of over 30 years of research (resulting in >300 IWC SC submitted papers), including an intensive program in the 1970-80s when a similar suite of studies (e.g., aerial and ship based surveys, analysis of commercial whaling records, abundance estimation, harvest documentation, local knowledge, etc.) built the foundations of our current knowledge of BCB stock structure. These robust research programs demonstrate that the US has made a major effort to determine if the BCB bowhead whale stock has significant population sub-structuring. Collectively, results of roughly three decades of research have established that while the BCB population is out of genetic equilibrium, there is no compelling evidence of a multi-stock condition within its range, nor compelling evidence of conservation risk under the current single-stock management regime.

INTRODUCTION

At the annual meeting of the International Whaling Commission (IWC) in 2004, the US committed to conducting bowhead whale stock structure research. Through the efforts of the Alaska Eskimo Whaling Commission (AEWC), US research groups were able to secure funding through a Congressional Appropriation for stock structure studies[1]. Additional research was conducted independently by scientists at various institutions throughout the US and internationally.

Elements of the stock structure program were discussed during the 2004 meeting of the IWC Scientific Committee (SC). During that session the SC recommended (Item 9.1.6 of the Report of the SC):

[1] Senate Bill No. 2809, "Departments of Commerce, Justice and State, the Judiciary, and Related Agencies Appropriation Bill, 2005"

"that a report on the progress of the research programme (see Item 9.1.2) be provided each year to the Scientific Committee and it encourages cooperative research amongst the various interested research groups."

Accordingly, this paper provides a summary of the bowhead stock structure research program coordinated and administered through the North Slope Borough (NSB) Department of Wildlife Management and the Alaska Fisheries Science Center (AFSC) and the Southwest Fisheries Science Center (SWFSC) of the National Marine Fisheries Service (NMFS). Collaborators include: the Alaska Eskimo Whaling Commission, Association of Traditional Marine Mammal Hunters of Chukotka (ATMMHC), Savoonga Whaling Captains Association, Barrow Whaling Captains Association, Texas A&M University (TAMU), Colorado State University (CSU), University of Washington (UW), New Bedford Whaling Museum, University of Alaska Fairbanks, LGL Ltd., the Russian Academy of Sciences, Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), Alaska Department of Fish and Game (ADFG), Minerals Management Service (MMS), and Canadian Department of Fisheries and Oceans (DFO).

Background

A five-part plan for studying stock structure of bowhead whales in the Bering, Chukchi and Beaufort (BCB) seas was developed by US researchers prior to and during the 2004 IWC Scientific Committee (SC) meeting. The study plan included techniques such as: increased tissue sampling during the harvests, initiation of a long term non-lethal biopsy sampling program, development of additional genetic markers, photo-identification, satellite tagging, isotopic analysis of baleen, acoustic detection of whale calls and statistical modeling (Table 1). A list of SC research papers resulting from the 4-year program is provided in Appendix 1.

Table 1. Five BCB bowhead whale stock structure research elements identified during planning phase.

Project
1. Research Planning and Hypothesis Testing
a. Planning and coordination
b. Modeling and hypothesis testing
2. Genetics Sampling and Analysis
b. Tissue sampling: Russian & US biopsy
c. Genetics analysis methods & application
3. Animal Mixing and Abundance
a. Photo-identification surveys
b. Photographic analysis: Alaska Coast
c. If possible, photographic survey: Chukotka
4. Spatial Distribution and Abundance
a. Traditional knowledge
b. Historical catch data reanalysis
c. Collaboration with Russian Scientists
5. Migration patterns
a. Analysis/acquisition of acoustic data
b. Satellite tracking
c. Isotopic analysis of baleen

1. Research planning an Hypothesis Testing

1.a. Planning and Coordination

The five research themes and supportive projects were reviewed, refined and endorsed during the course of the first Workshop on BCB bowhead whale stock structure, held 23-24 February 2005 in Seattle, Washington, USA (SC.57.For Information 11). Subsequently, progress on individual projects during 2005 was summarized in (IWC, 2006; SC/58/Rep2) and presented at the 57th Scientific Committee meeting in Ulsan, Korea. As a continuation of these planning and coordination efforts, and to provide specific advice

to the BCB Bowhead Whale AWMP *Implementation Review*, a second workshop focused on bowhead stock structure studies was convened in Seattle from 21-22 March 2006 (George et al., 2006). Workshop reports in both years included a brief summary of the meeting, with the agenda, workshop participants and short reports on research projects.

Teleconferences with the bowhead whale researchers (in the US) have been held monthly through 2005-2007. During these meetings, the group discussed coordination and preliminary results of the research.

The Aboriginal Whaling and Management Procedure (AWMP) meetings and intersessional workshops have also played a key role in planning and coordination of the bowhead stock structure research. Since the 2004 IWC meeting, the AWMP group has met six time (intersessionally and pre-meetings) , the most recent of which was the March 20-24 2007 workshop in Copenhagen

1.b. Modeling and Hypothesis Testing

We used a multifaceted approach to exploring the stock structure of BCB bowhead whales, as was done in early studies on population abundance and basic life history of the bowhead whale in the 1970-80s (e.g. NOAA 1978; Braham et al. 1980). At that time very little was known about the status of western arctic bowhead whales (e.g., Marquette et al., 1982, Rugh et al., 2003). These early studies included research on distribution and abundance (aerial, acoustic, ship-based in both Alaska and Russia), genetics (e.g., karyotype), population estimation, acoustics and some local knowledge.

As outlined above, current studies incorporate many of the same scientific methods and build on those time series. These data are then coupled with ongoing study of life-history information on age, morphometrics, abundance, reproduction, growth, contaminants, etc. New scientific tools applied to the stock structure program include: satellite telemetry, biochemistry (isotopic studies of baleen), and advanced genetic techniques (e.g., microsatellites).

The hypotheses were posited as a series of stock structure archetypes, and genetic hypotheses (George and Moore, 2006 (SC/58/BRG27). These are summarized in Table 2.

Table 2. Summary of archetypes, scenarios and hypotheses set up for modeling by the AWMP SWG.

ARCHETYPE	**Scenario**	**Hypothesis**
(1) SINGLE STOCK	**BCB Basic (Table 2)**	**Baseline** (H_1) Generational Gene Shift (H_2) Social Structuring (H_3) Feeding Site Fidelity (H_4)
(2) TWO STOCKS	Chukchi Circuit Temporal Segregation Spatial Segregation	**Mixed** (H_5) Segregated (H_6) 'Delayed' Baseline (H_7) St. Lawrence Mixed (H_8) St. Lawrence Segregated (H_9)

These hypotheses were reduced to 4 basic archetypes at the January 2007 2nd Intersessional Workshop to Prepare for the 2007 Bowhead Whale Implementation Review (IWC, 2007). After considerable discussion and review of new data and analysis, the archetypes were revised as follows:

1. Hypothesis A: Single stock, no feeding ground site fidelity.
2. Hypothesis B. Single stock, with feeding ground site fidelity.
3. Hypothesis C. Two stocks, spatial segregation.
4. Hypothesis D. Two stocks, spatio-temporally mixed migration.

See the Draft Report of the 2nd Intersessional Workshop to prepare for the 2007 Bowhead Whale *Implementation Review* for details on the archetypes (*In Prep*.).

2. Genetics Sampling, Analysis and Modeling

2.a Tissue collection: US harvest sampling

DNA samples were collected from nearly all bowheads landed in Alaskan villages in 2005 and 2006. Basic data associated with the tissue collection included: harvest date, length, sex, village, a skin sample (in DMSO salt-solution) for DNA and a baleen plate from St. Lawrence Island whales. At Barrow and Kaktovik a series of samples have been consistently collected including (at a minimum): morphometric measurements, blood, blubber, kidney, liver, muscle, stomach prey samples, an eyeball, and reproductive organs.

NSB and St. Lawrence Island personnel collected bone samples from 33 bowhead whale skulls from Savoonga and Gambell and 12 baleen samples. Most were from unique or unknown animals (whale ID not matched with skull materials). Of these, mtDNA extraction was successful for bone (n = 27) and baleen (n = 12).

2.b Tissue sampling: Russian & US biopsy

Following a training program in 2004 in Anadyr, which included hunters from various Chukotka villages, the ATMMHC (Association of Traditional Marine Mammal Hunters of Chukotka) successfully collected 17 biopsies during autumn 2005 in the Senyavin Strait region. Samples were divided and retained in Russia with half successfully imported to US laboratories under a CITES permit (NMFS Permit # 932-1489-08). In 2006, approximately 10 biopsy samples were collected near Syreniki; these samples have not yet been transferred to the US.

During autumn 2005 and 2006, nine non-lethal biopsies were collected at Barrow prior to and after the whale hunting season.

2.c Genetics analysis methods and application

Work under this theme was conducted by four principal laboratories [alphabetically]: Colorado State University (CSU), NOAA's Southwest Fisheries Science Center (SWFSC), Texas A&M University (TAMU), and Russian Federal Research Institute of Fisheries & Oceanography (VNIRO). Current research is summarized below.

2.c Microsatellite analysis

Bickham, Huebinger and others (see paper SC/58/BRG11 and SC/59/BRG14) continued work on new microsatellite loci specifically from bowhead whales. To allow a more accurate assessment of genetic variation in bowhead whales a new panel of microsatellite loci has been developed at TAMU. A small insert genomic library enriched for CA repeats was constructed and screened using standard protocols. A total of 196 identified clones were sequenced. A total of 61 loci were identified from among the sequences for further testing and appropriate primer pairs were designed for these loci. Of this group, 34 loci yielded PCR products that exhibited clear polymorphisms on agarose gels. These 34 loci were labeled with fluorescent dyes and run on the ABI 3100 to determine their quality of amplification and their ease of analysis. A final set of 24 loci was selected from among the 34 tested for their consistent amplification and their ease in determining allele calls. DFO Canada sent a technician to TAMU to work with Huebinger on the 3100 analyzer and sample calibration. The TAMU and DFO laboratories established same-sample calibration procedures to allow comparison of Canadian and US bowhead microsatellite data.

Samples were available from 457 bowheads. The vast majority of these were obtained from harvested whales. Some samples were obtained from biopsies in the field (6 Barrow, at least 13 Chukotka, 64 Sea of Okhotsk, and 48 Igoolik, Canada). Most were genotyped for the 24 microsatellite loci. TAMU collaborated with Geof Givens (CSU) and SWFSC on the analysis of the microsatellite dataset.

Statistical analyses of the microsatellite data are presented in Paper SC/59/BRG14. This paper is the culmination of several years of refinement and hypothesis testing of these data. The authors used both standard techniques for genetic analysis (e.g., Fst scores) and a new pair-wise microsatellite allele matching algorithms. Various forms of this analysis has been presented at SC and Intersessional AWMP workshops over several years; the most recent of which was presented at the March 2007 AWMP workshop in Copenhagen. The most current analysis of microsatellite loci for bowhead whales (using both new and old

markers) suggests Bering-Chukchi- Beaufort Seas bowhead whale exhibit strong and widespread departure from Hardy-Weinberg equilibrium, including some evidence of a historical bottleneck and patterns related to whale birth year that may be consistent with gene drift after commercial exploitation or thousands of years earlier. However, BCB bowheads are clearly genetically distinct from thee Sea of Okhotsk bowheads. As in past studies, migratory pulses of bowheads passing Barrow in the fall are evident, however these differences are extremely small compared to known separate stocks and possible familial lineages. When the bowhead-specific (i.e., most trusted) markers are used, most of the differences appear to be attributable to scoring errors, familial relations, and birth year. SC/59/BRG14 concludes that: "*Bering-Chukchi- Beaufort Seas bowheads may comprise a complex spatio-temporal aggregation of animals with mixed and variable ancestry with an unknown degree of nonrandom mating, whose degree of genetic inhomogeneity is significantly less than what is seen between spatially isolated stocks but found no evidence that BCBS bowheads should be "managed as more than one stock"*.

Paper SC/59/BRG8 presents efforts to develop a new class of genetic markers, single nucleotide polymorphisms (SNPs), for bowhead whale genetic studies. These genetic markers were examined for the temporal patterns (i.e., the "Oslo bump" feature), spatial patterns and Hardy-Weinberg and linkage disequilibrium. Preliminary analysis of these data show no evidence of population structure for various strata analyzed previously with mtDNA and microsatellite analysis.

Early analysis of BCB bowhead microsatellite data by Schweder, Givens, Pastene and others (eg., SC/56/BRG36, SC/56/BRG17) indicated departures from Hardy Weinberg Equilibrium (HWE), and temporal and spatial genetic differences. The most well-known of these features was the "Oslo bump" which indicated pulses of related individuals passing Barrow in autumn. In an attempt to help explain these findings, Archer and colleagues at SWFSC (SC/59/BRG17) conducted a simulation of bowhead whale population dynamics and genetics. The model attempted to mimic aspects of bowhead whale demography, genetics, and whaling history and simulated datasets were generated and used for testing hypotheses. Their analysis reproduced many of the features seen in the empirical data, that is: pulsing of genetically related animals, genetic differences in age cohorts, but not spatial differences. Thus, they conclude that the empirical genetic data sampled from BCB bowhead whales are consistent with a single, randomly-mating population (that was severely hit by commercial whaling). The genetic difference between Barrow and St. Lawrence Island exhibited a significant difference between the simulated and empirical datasets. This means that the detected difference in the empirical data cannot be explained in the current version of the simulation model. In recent workshops, the groupings resulting from program STRUCTURE (on the empirical dataset) have had a large influence in generating stock structure hypotheses. The SWFSC results show that the empirical STRUCTURE analyses are entirely consistent with a single population that is out of genetic equilibrium probably due to the effects of commercial whaling.

In papers SC/59/BRG15 and BRG17), researchers from SWFSC provide evidence that microsatellite (mSAT) errors have significant implications to inferences about stock structure. The estimated error rate in the BCB mSAT analysis (1%/genotype) falls within normal ranges in the literature. However, even these levels of mSAT scoring errors are highly influential on estimates of Hardy-Weinberg equilibrium. These analyses are particularly sensitive to homozygosity in rare alleles for single individuals. Thus, normal laboratory error rates can result in the potential to infer stock structure incorrectly. To avoid such bias, they recommend routine identification of influential individuals followed by multiple replication of those samples.

Skaug and Givens (SC/59/BRG20) have examined relatedness between pairs of individuals, as estimated from the microsatellite data. They find an unusually large number of related pairs involving one individual from Barrow and a second from Savoonga or Chukotka. These findings are not consistent with some two-stock hypotheses requiring spatial segregation.

3. Animal Mixing and Abundance

3.a Photo-identification surveys

Paper SC/59/BRG6 summarizes aerial photographic surveys conducted near Point Barrow, Alaska, from 12 April to 6 June in 2003, from 18 April to 7 June in 2004, from 6 to 9 September 2005, and 1 to 6 September 2006, and in the Bering Sea, Alaska, from 9 April to 2 May 2005. The 2003 survey was the most complete

photographic coverage of the spring migration past Barrow of any survey to date, and the 2004 survey was also thorough except that poor weather resulted in poor coverage of the mother/calf migration late in the season. Approximately 4,835 whale images were obtained in the respective seasons. The number of different marked whales with acceptable quality photographs to recognize between-year matches was 179 in 2003, 275 in 2004 and 71 in spring 2005. Within-year and between-year matching has been completed for the 2003–2005 spring photographs, and the databases are nearing completion. Eleven whales were matched between the 2003 and 2004 spring migrations, three whales were matched between 2003 and spring 2005, one was matched between spring 2004 and September 2005, and no matches were found between spring 2003 and September 2005. Photo recaptures from these studies will allow a new estimate of abundance for BCB bowhead, a methodological comparison with the estimate from ice-based counts in 2001 and better precision in the calculation of bowhead whale life-history parameters. Stock structure analysis is still underway, however, power analyses conducted earlier (SC/57/BRG16) reported "*we will not be able to reliably detect the existence of a second stock that makes up less than 30% of the Bering Sea photographs unless photograph quality is better than in past years.*"

3.b Photographic analysis

Bowhead whales were photographed during the later part of the 2005 spring migration in the Bering Sea. The later part of the migration contains a higher proportion of medium- and large-sized whales that are well marked. These photographs will be compared to 1981–2003 photographs to determine whether the recapture rate for Bering Sea bowheads differs from the rate at Barrow in 2004. Sizes of recaptured whales and their timing in those two areas will also be examined. As noted earlier, power analysis indicates that we will not be able to reliably detect evidence of stock structure unless a putative stock comprises at least 30% of the Bering Sea photographs.

A small set of photographs was obtained near Barrow in early September 2005 during the NSF Study of North Alaska Coastal Systems (SNACS) study (http://www.arcus.org/arcss/snacs/whales/). The timing of this sampling is before the main autumn migration from the Beaufort Sea reaches Barrow. Currently the September photographs are being compared with the 2003 and 2004 datasets, and a few recaptures have been found to date (SC/59/BRG6; Rugh, pers. comm.).

3.c Photographic surveys: Chukotka

In the initial BCB stock structure program proposal seeking funding from the US Government, aerial photographic survey of bowhead whales along the Chukotsk Peninsula during late summer were proposed. It was proposed that aircraft would be based out of Nome, AK or on St. Lawrence Island, and would fly the waters adjacent to the Chukotka coastline, conduct a photographic survey and could return without landing. However, this was deemed to be logistically quite difficult due to security and permitting issues. Thus, the Chukotka aerial photographic studies were never conducted.

4. Spatial Distribution and Abundance

4.a Traditional Knowledge

A "traditional knowledge" study was conducted at St Lawrence Island (SLI). Surveys of senior whale hunters in the SLI area indicated that: (1) the number of adult and sub-adult bowheads seen near the island has increased over their lifetime, (2) bowheads use two migration paths near the Island, and (3) in the last decade more whales are wintering near (and north) St Lawrence Island. A manuscript describing this information has been published in the Journal *Arctic* (Noongwook et al. 2007).

4.b Historical analysis

Bockstoce et al. (*In Prep.*) presented a re-analysis of the Yankee commercial bowhead catch data from 1848 to 1914 in the western Arctic. These data were summarized in Bockstoce and Botkin (1983) but were not mapped as GIS software was essentially unavailable at that time. Kills are plotted in 2-week periods and 5-year increments and their distributions evaluated. A manuscript detailing these results is *In Preparation* at the NOAA journal Marine Fisheries Review. New insights from this manuscript include a detailed spatial presentation of the reduction of the BCB bowhead whales. At the inception of the fishery whales were distributed as far south as 55°N and mainly in the western Bering Sea. Whales that summered in the Bering Sea may have been extirpated within the first 10 years of the fishery, however Bockstoce et al

(In Prep.) also noted that bowheads changed their behavior as a result of hunting and speculate that this may have led to a shift in their distribution.

4.c Collaboration with Russian Scientists
Biopsy samples were collected by hunters in Chukotka under the direction of the auspices of the Association of Traditional Marine Mammal Hunters of Chukotka (ATMMHC) and Dennis Litovka (TNIRO). Chukotka samples were transmitted to VINRO. As agreed, samples were then divided and analyzed in both Russia (mtDNA) and the US (see SC/59/BRG9). Genomified DNA from Alaskan BCB bowheads (collected in recent years) were transmitted to the VINRO for comparative studies.

Zeh and Melnikov (SC/58/BRG15) have completed estimates of numbers of bowhead whales migrating past Cape Dezhnev, Chukotka, Russia from shore-based surveys conducted in May and June of 2000 and 2001. Survey methods were similar to those for bowhead whales near Point Barrow and gray whales off Monterey, CA except that there were no data for estimating detection probabilities. Under the assumption that all whales passing during watch with acceptable visibility conditions were seen, the estimated number of migrating bowheads was 430 (CV 22%) in 2000 and 558 (CV 31%) in 2001. The weighted geometric mean of these estimates is 470 with 95% confidence interval 332 to 665. If the detection probability was assumed to be similar to detection probabilities estimated from the Barrow bowhead count or the Granite Canyon gray whale count, the weighted geometric mean estimate was approximately twice as large. It was estimated that very few of the whales counted off Cape Pe'ek in June would have been counted during the ice-based survey at Barrow in that same season and year. However, the degree to which the ice-based abundance estimate is biased downwards from missing these whales is probably low.

5. Migration Patterns

5.a Analysis/acquisition of acoustic data
Two types of passive acoustic surveys were conducted in support of a comprehensive effort to investigate stock structure in the BCB population of bowhead whales: (1) an over-winter survey northeast of Barrow, Alaska using autonomous recorders (SC/58/BRG8); and (2) a dipping-hydrophone survey along a cruise track northwest of Barrow, to investigate bowhead occurrence near the Chukchi Borderland in summer (SC/58: Annex F). In neither survey were bowhead calls detected in areas or at times supportive of any of the multiple stock hypotheses. Although provisional reports from both surveys were provided to the IWC Scientific Committee (SC) in 2005 and 2006, a final summary of results from both surveys was submitted as SC/59/BRG/18.

5.b Satellite Tracking
The Alaska Department of Fish and Game (ADF&G) has begun a project (along with the AEWC, the NSB and the MMS) to study bowhead whale movements and behavior using satellite telemetry. Two satellite transmitters designed by M.P. Heide-Jorgensen have provided information in 2006. A 45 ft male bowhead (#60010) was tagged on 12 May near Barrow and behaved in a manner consistent with our conventional understanding of bowhead migratory behavior based on aerial and ship-based surveys and monitoring the harvest (Moore and Reeves, 1993). The whale traveled directly across the Beaufort Sea and arrived in Amundsen Gulf (east of 127° W Longitude) in early June and stayed there until early August when he traveled directly to the northwest end of Banks Island and back. Although the northeasterly extent of his movement was unexpected, he did not travel outside the known range of the BCBS. This whale began his westward migration in early October when he moved rapidly across the US Beaufort Sea to arrive at Barrow on 14 October. Another whale (#60009), tagged near Barrow on 21 September gave fewer locations but showed that both whales occurred together along the northern Chukotka coast in November.

These movements are consistent with published literature regarding migratory behavior (Moore et al. 1995, Mate et al. 2000; Moore and Reeves, 1993). However, important new information on swimming speeds, probable feeding areas, precise migratory routes and migration timing are provided by these data (Quakenbush, ADF&G, unpublished data).

5.c Isotopic analysis of baleen
A total of 11 baleen plates were collected from previously harvested bowheads at Gambell and Savoonga, on Saint Lawrence Island in the Bering Sea. One additional plate was collected from a Savoonga whale

taken in winter. The plates of known origin (9) were analyzed at the University of Alaska Fairbanks where for stable carbon and nitrogen isotopes. The $\delta^{13}C$ and $\delta^{15}N$ levels were measured via elemental analysis-isotope ratio mass spectrometry (EA-IRMS) as in past studies. Preliminary results presented during SC/58 of the baleen analysis suggest that St. Lawrence Island animals were migrating into the Beaufort Sea in a manner consistent with whales similarly sampled at Barrow (SC/58/BRG22). However, SC members questioned whether the carbon oscillations were merely reflecting annual bouts of feeding and fasting and not migration. SC/59/BRG13 addresses this question and presents a more refined analysis and statistical testing of the data. They examined both $\delta^{13}C$ and $\delta^{15}N$ isotope data in combination and found the patterns incompatible with feeding and fasting (i.e., both isotope patterns moved in unison which would not occur during fasting where N becomes differentially enriched). Thus they conclude that the $\delta^{13}C$ and $\delta^{15}N$ fluctuations in sampled SLI animals provide good evidence that they annually migrated from the Bering to the Eastern Beaufort Sea.

Summary

The BCB population of bowhead whales has received intensive research during the last 35 years (e.g., Braham et al., 1980; Rugh et al., 2003; Marquette et al., Burns, 1993; George *et al.*,2004) resulting in over 300 papers presented to the IWC alone (see http://www.iwcoffice.org SCAMDocs1969plus.pdf). Intensive bowhead research took place in the 1970s, which was summarized in the 1980 Marine Fisheries Review's captured issue on bowhead whale research and whaling (Braham et al., 1980). The early program was [at least] comparable to the current US research efforts in terms of survey effort spatial distribution and number of researchers involved. At that time the critical issues included estimating population size, subsistence harvest and lost rates, reproductive parameters, etc. While stock structure was not explicitly stated as a research objective, in essence it was part of the program. That is, the researchers recognized the critical need to define the migratory routes and home-range of western arctic bowhead whales; and determine if there were significant summering populations in areas other than the Eastern Canadian Beaufort Sea that presumably would *not* be counted. Considerable ship-based and aircraft surveys, combined with local knowledge concluded then that most bowhead whales did in fact migrate into the Beaufort Sea (Braham et al., 1980).

The next large review culminated in the publication of *The Bowhead Whale* (Burns *et al*., 1993) in which extant data on bowhead whale biology, distribution, and life history were summarized. That work considered the question of stock structure and evidence of multiple populations outside the five recognized stocks, but was inconclusive. Burns (1993) stated:

> *"We cannot unequivocally state that: (1) a separate population of bowheads that summered in the Bering and central Chukchi seas formerly existed, (2) that such a stock was extirpated, or (3) that greater occupancy of that range is not occurring as the population increases."*

Burns (1993) postulated that the more southerly distribution of bowhead whales at the onset of commercial whaling reflected the heavier sea ice conditions of the "Little Ice Age" and not (necessarily) the distribution of a separate stock of whales. (Burns, 1993: 754) wrote:

> *"Commercial whaling for bowheads in the Bering Sea began in 1848, during the last years of a prolonged period of cold climate that has been referred to as The Little Ice Age. The effect of subsequent climatic amelioration on [the] distribution of bowheads in the Bering Sea, coupled with intensive exploitation of an initially large population, with more animals on the periphery of the "core' summer range, has not been adequately examined".*

Similarly, on the east coast of North America at about the same period, bowhead whales were distributed far south of their current distribution (nearly to New England). Ross (1993: 524) states:

> *[The Grand Bay fishery] took place at a the lowest latitude of any of the bowhead fisheries in the North Atlantic sector (51N-52N), apparently at the southern limit of the Davis strait stock in that climatic period."*

For several decades, Native and other observers have reported that some bowheads summer along the Chukotka Peninsula (e.g., Bogoslovskaya 2003; Zelensky et al., 1995). However the abundance of summering populations has not been estimated, nor is the degree of summer site fidelity known. With

regard to animals summering near Chukotka, Burns (1993) surmised *"there is considerable variability [in summering areas] depending on ice conditions and, presumably on the availability of prey."*

While sample size is limited, satellite telemetry has offered independent information on whale movements. Paper SC/59/BRG12 briefly summarizes the telemetry data for two bowhead whales recently tagged. Their tracks were quite consistent with past aerial and ship-based surveys as summarized in Moore and Reeves (1993) and with other bowhead satellite telemetry tracks (Mate et al., 2000).

Variation in distribution may be related to behavioral patterns as demonstrated by North Atlantic right whale, which may serve as a good model for BCB bowheads. That is, individual bowheads may visit several summer feeding areas spread across extensive areas giving the appearance of separate feeding groups. Mate *et al.* (1997) wrote:

> "*Three of the tagged whales not only left the Bay of Fundy, but traveled more than 2,000 km each before returning to the general tagging area. One adult female with a calf went to New Jersey and back to the Bay of Fundy (3,761 km) in 42 days. Most locations were along bank edges, in basins or along the continental shelf. Eighty percent of locations were in water <182 m (100 fathoms deep…. Individuals moved rapidly among areas previously identified as right whale habitat."*

The current BCBS stock structure prepared for the 59th meeting of the SC is derived from over 80 recent papers regarding bowhead whale distribution, genetics, harvest, aerial and ship-based surveys, photo identification, traditional knowledge and other subjects. The contribution of advanced genetic analysis techniques constitutes a major advance in recent stock structure studies. The genetic studies have reveled complex genetic structure in BCB bowhead whales. Givens et al. (2007; SC/59/BRG14) succinctly summarized the findings regarding microsatellite analysis which generally apply to much of the analysis over the past 4 years:

> *"Although these [BCB] bowheads are clearly genetically distinct from bowheads in the Sea of Okhotsk, we find significant patterns of genetic inhomogeneity among the Bering-Chukchi-Beaufort Seas samples. These samples exhibit strong and widespread departure from Hardy-Weinberg equilibrium, including significant evidence of a birth year effect or a historical bottleneck consistent with gene drift after commercial exploitation or thousands of years earlier."*

Paper SC/59/BRG9 reports a parallel analysis of mtDNA sequences from 380 samples were used in mtDNA analysis. No significant differences were detected in spatial comparisons or in temporal comparisons along Alaska's North Slope. However, evidence of genetic differences mainly between young and old age cohorts was noted (e.g., animals born prior to ~1950 and those born after 1979). Differences were also seen between fall and spring whales from St. Lawrence Island. However, these seasonal differences could also be driven by spans in ages but data are insufficient to determine this. The age data are consistent with the idea that commercial whaling greatly affected the genetic equilibrium of the BCB stock.

Early in the bowhead stock structure program, it was determined that the bowhead SLA would be tested assuming a two-stock situation, should sub-structuring be found in subsequent research. Paper SC/58/AWMP8 explored results from early version of AWMP-lite, a simple multi-stock population dynamics model, for evaluation of the bowhead SLA in a 2-stock application. Various trials anticipated to be considered during the Implementation Review for the Bowhead SLA, failed to find any which were plausibly consistent with the best available information on bowhead abundance and distribution and which exposed any second stock to management risk. Although methods for model fitting and certain other features of AWMP-lite have changed since that conclusion was drawn, the fundamental result seems unchanged. After further expansion and refinements, participants at the January 2007 and March 2007 AWMP workshops, agreed that AWMP-Lite could be used to evaluate the implications of using the Bowhead SLA to evaluate strike limits under multi-stock scenarios. Early evaluation trials seem to give similar results – that plausible 2-stock scenarios do not suggest a conservation risk to either putative stock under current harvest levels and management approaches.

Assuming the positions of Yankee commercial whaling kills from about 1848 to 1860 were representative of BCB distribution at that time, bowhead whales once occupied the Bering and Chukchi seas during

summer. However, the negative results of the acoustic and visual survey undertaken in the 1970s (Braham *et al*., 1980a) by Moore in 2005 (SC/59/BRG18), and the lack of opportunistic sightings by scientists and crew on recent Arctic research surveys (e.g.,www.sbi.ut.edu), suggest a that few bowheads currently occupy the Chukchi Sea in summer. It is possible (if not likely) that bowheads will reoccupy the Chukchi and Bering Seas in summer as the population increases.

The "weight of evidence" of recent studies seems consistent with Rugh *et al*. (2003) and the conclusions of Burns (1993) that the BCB bowheads comprise a single labile population subject to the vagaries of ice and food. Rugh *et al.* (2003) noted (p. 275):

> "*The highly labile nature of the bowhead migration (affected by sea ice, food availability and potentially by anthropogenic perturbations) allows for whale occurrence in areas other than the expected migratory routes. Some whales might migrate east in the spring and return west well before the typical autumn migration; some whales might not migrate east of the Chukchi Sea in some years; and some whales might not migrate out of the Bering Sea."*

Based on this review, as is always the case in scientific inquiry, some questions remain about the genetic structure and distribution of BCB bowheads; hence, considerable research is ongoing. However, we find: (1) the extant evidence on BCB stock structure is most consistent with a single highly labile stock of whales that is out of genetic equilibrium. This disequilibrium is probably the result of a devastating reduction of bowheads from commercial whaling over a century ago, from which this stock is still recovering, and (2) there is no compelling evidence a conservation risk under current harvest levels and the AEWC/NOAA management regime, even if a putative "second stock" exists.

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Appendix 1. Partial list of research papers resulting from stock structure and related bowhead whale studies conducted from 2004 to present.

PAPER ID	SUBJECT	PAPER TILE
SC/56		**SC/56/BRG & SELECTED AWMP PAPERS**
SC/56/BRG1	Population abundance	ZEH, J.E. and PUNT, A.E. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales.
SC/56/BRG2	Population structure	KOSKI, W.R., RUGH, D.J., PUNT, A.E. and ZEH, J. A new approach to estimating the length-frequency distribution of the Bering-Chukchi-Beaufort bowhead whale population using aerial photogrammetry and a summary of other life-history parameters estimated from photoidentification - photogrammetry data.
SC/56/BRG 3	Life history, growth	LUBETKIN, S.C., ZEH, J.E., ROSA, C. and GEORGE, J.C. Deriving von Bertalanffy age length relationships for bowhead whales (*Balaena mysticetus*) using a synthesis of age estimation techniques.
SC/56/BRG 4	Assessment (population)	PUNT, A.E. Updated assessments of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using length, age and abundance data.
SC/56/BRG 5	Satellite tracking, Canadian bowhead	HEIDE-JORGENSEN, M.P., LAIDRE, K.L., JENSEN, M.V., DUECK, L. and POSTMA, L.D. Dissolving stock discreteness with satellite tracking: Bowhead whales in Baffin Bay.
SC/56/BRG 6	Age estimation	ROSA, C., GEORGE, J.C., ZEH, J., BOTTA, O., ZAUSCHER, M., BADA, J. and O'HARA, T.M. Update on age estimation of bowhead whales (*Balaena mysticetus*) using aspartic acid racemization.
SC/56/BRG 8	Reproduction, age estimates	GEORGE, J.C., FOLLMANN, E. ZEH, J., SOUSA, M., TARPLEY, R. and SUYDAM, R. Inferences from bowhead whale ovarian and pregnancy data: age estimates, length at sexual maturity and ovulation rates.
SC/56/BRG 9	Population Length structure	GEORGE, J.C., KOSKI, W.R., SUYDAM, R. and RUGH, D. Body stretching of bowhead whales during hauling and butchering during the subsistence hunt.
SC/56/BRG 10	Reproduction	GEORGE, J.C., SUYDAM, R., ZEH, J. and KOSKI, W.R. Estimated pregnancy rates of bowhead whales from examinations of landed whales.
SC/56/BRG 11	Harvest, Management	SUYDAM, R.S., GEORGE, J.C., O'HARA, T., HANNS, C. and SHEFFIELD, G. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2003.
SC/56/BRG 12	Harvest analysis	SUYDAM, R.S. and GEORGE, J.C. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos, 1974 to 2003.
SC/56/BRG 13	Genetics mtDNA	LEDUC, R. and TAYLOR, B. A spatial analysis of bowheads in the North Pacific using mtDNA.
SC/56/BRG 14	Genetics mtDNA	LEDUC, R. and TAYLOR, B. A comparison of age/length classes of bowheads in the North Pacific using mtDNA.
SC/56/BRG 15	Genetics mtDNA, temporal analysis	LEDUC, R. and TAYLOR, B. A temporal analysis of migrating bowheads in the North Pacific using mtDNA.
SC/56/BRG 16	Genetics	MARTIEN, K.K., TAYLOR, B.L. and LEDUC, R. A temporal analysis of migrating BCBS bowhead whales using Boundary Rank.
SC/56/BRG 17	Genetics, mSAT, GGS, spatial anal.	GIVENS, G.H., BICKHAM, J.W., MATSON, C.W. and OZAKSOY, I. Examination of Bering-Chukchi-Beaufort Seas bowhead whale stock structure hypotheses using microsatellite data.
SC/56/BRG 18	Genetics, bottleneck	BICKHAM, J.W., HUNTER, D.D., MATSON, C.W., HUEBINGER, R.M., PATTON, J.C., GEORGE, J.C. and SUYDAM, R. Genetic variability of nuclear microsatellite loci in Bering-Chukchi-Beaufort Seas bowhead whales (*Balaena mysticetus*): A test of the genetic bottleneck hypothesis.
SC/56/BRG 20	Assessment	BRANDON, J. and WADE, P.R. Assessment of the Bering-Chukchi-Beaufort Sea stock of bowhead whales.
SC/56/BRG 21	Acoustics, Barrow spring	CLARK, C.W., CORTOPASSI, K.A., PONIRAKIS, D., FOWLER, M.C., FRISTRUP, K.M. and GEORGE, J.C. Seasonal variation in acoustic characteristics of Bowhead Whale (*Balaena mysticetus*) sounds during the spring 2001 migration off Pt. Barrow, Alaska.
SC/56/BRG 24	Migration timing, size structure	RUGH, D.J., KOSKI, W.R. and GEORGE, J.C. Interyear re-identifications of bowhead whales during their spring migration past Barrow, Alaska, 1984-1994.
SC/56/BRG 25	Harvest Kaktovik	KOSKI, W.R., GEORGE, J.C., SHEFFIELD, G. and GALGINAITIS, M.S. Subsistence harvests of bowhead whales at Kaktovik, Alaska.
SC/56/BRG 26	Length freq., size structure	KOSKI, W.R., GEORGE, J.C., SUYDAM, R., RUGH, D.J. and BRANDON, J. Aerial photography of bowhead whales at Barrow, Alaska, during the 2003 and 2004 spring migrations.
SC/56/BRG 27	Reproduction	KOSKI, W.R., MILLER, G.W., RICHARDSON, W.J. and WURSIG, B. Bowhead whale (*Balaena mysticetus*) mothers and calves during spring migration in the Alaskan Beaufort Sea: movements, behavior and life history data.
SC/56/BRG 28	Habitat use	KOSKI, W.R. and MILLER, G.W. Habitat use by different size classes of bowhead whales in the central Beaufort Sea during late summer and autumn.
SC/56/BRG 29	Genetics	GIVENS, G.H., GEORGE, J.C. SMITH, T.D., BICKHAM, J.W. and TAYLOR, B.L. Evaluation of the sequentially alternating stock hypothesis for Bering-Chukchi-Beaufort Seas bowhead whales based on microsatellite DNA evidence.
SC/56/BRG 31	Genetics	LEDUC, R. and TAYLOR, B. Using 'structure' to assess microsatellite loci quality and to address the implications of the suggested populations.

SC/56/BRG 32	Genetics	PASTENE, L.A., GOTO, M. and KANDA, N. Genetic heterogeneity in the B-C-B stock of bowhead whale as revealed by mitochondrial DNA and microsatellite analyses.
SC/56/BRG 33	Genetics, biological analysis	BANDO, T., ZENITANI, R. and OHSUMI, S. Preliminary investigation of stock structure of B-C-B bowhead whales based on analyses of biological parameters.
SC/56/BRG 34	Genetics, mSAT error estimation	MORIN, P.A. and LE DUC, R.G. Analysis of bowhead DNA quantity and microsatellite characteristics: implications for potential biases in population structure analysis.
SC/56/BRG 35	E. Canadian bowheads	COSENS, S.E. Baffin Bay-Davis Strait and Hudson Bay-Foxe Basin bowheads: update on research 2003/2004.
SC/56/BRG 36	Genetics, temporal analysis, Oslo bump	JORDE, P.E., SCHWEDER, T. and STENSETH, N.C. The Bering-Chukchi-Beaufort stock of bowhead whales: one homogeneous population?
SC/56/BRG 37	Life history	TAYLOR, B.L. Comparing assessment of stocks for bowhead and minke whales in the North Pacific.
SC/56/BRG 44	Genetics	TAYLOR, B.L, LE DUC, R.G. and GEORGE, J.C. Interpreting genetic heterogeneity in the B-C-B stock of bowhead whales: a response to SC/56/BRG32.
SC/56/BRG 45	Genetics	GIVENS, G.H., SMITH, T.D. and BICKHAM, J.W. Comment on how Jorde et al. (2004) attribute table-wide bowhead whale heterozygote deficiency equally to all microsatellite loci.
SC/56/BRG 46	Ship surveys, Russia	MAMINOV, M.K. Distribution and abundance of marine mammals on the northeastern Sakhalin shelf, Russia July-September 2003: vessel based surveys.
SC/56/BRG 49	Russian Harvest data	BORODIN, R. Subsistence whale harvest of the Russian Federation in 2003.
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SC/57/BRG 3	Migration, Acoustics (5a)	STAFFORD, K.M. and MOORE, S.E. Provisional analysis of bowhead and gray whale calls recorded on autonomous instruments in the Beaufort Sea, 2003-2004.
SC/57/BRG 4	Genetics	GIVENS, G.H. Confounding of age and temporal separation in analysis of genetic correlation in Bering-Chukchi-Beaufort Seas bowhead whales.
SC/57/BRG 5	Assessment	BRANDON, J.R., BREIWICK, J.M., PUNT, A.E. and WADE, P.R. Alternative resampling schemes for life history parameters used in Bayesian stock assessments of bowhead whales.
SC/57/BRG 8	Genetics, paleohistory	BORGE, T., BACHMANN, L. and WIGG, Ø. Genetic variation in Holocene bowhead whales (*Balaena mysticetus*) in the Northeast Atlantic.
SC/57/BRG 10	Genetics, temporal pattens	SCHWEDER, T., JORDE, P.E., and STENSETH, N.C. Temporal genetic pattern in BCB bowhead whales in the fall migration at Barrow: a reflection of a structured population?
SC/57/BRG 11	Genetics	POSTMA, L.D., DUECK, L.P., HEIDE-JØRGENSEN, M.P., DE MARCH, B.G.E. and COSENS, S.E. Molecular genetic relationships among bowhead whales (*Balaena mysticetus*) in Eastern Canadian Arctic and Western Greenland waters.
SC/57/BRG 15	US Harvest	SUYDAM, R.S., GEORGE, J.C., HANNS, C. and SHEFFIELD, G. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2004.
SC/57/BRG 16	Photogrammetry, size structure	KOSKI, W.R., GEORGE, J.C., SUYDAM, R., RUGH, D.J., ZEH, J., DAVIS, A.R., MACTAVISH, B.D., BRANDON, J. and MOORE, S. An update of aerial photography of bowhead whales conducted during the 2003-2005 spring migrations.
SC/57/BRG 17	Morphometrics	GEORGE, J.C., SUYDAM, R., O'HARA, T., FOLLMANN, E.H. and ALBERT, T.F. Preliminary quantitative characterization of some aspects of the external morphology of the bowhead whale (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock.
SC/57/BRG 19	Genetics, tech. Development	BICKHAM, J.W., HUEBINGER, R.M., PATTON, J.C., GEORGE, J.C. and SUYDAM, R.S. Progress report on the development of new microsatellite markers for bowhead whales.
SC/57/BRG 20	Genetics, ancient DNA	WEBER, D.S., GAINES, C., BROWNELL, R.L., CLAPHAM, P.J., COOPER, L.N. and ROSENBAUM, H.C. The impact of Basque whaling on right (*Eubalaena glacialis*) and bowhead (*Balaena mysticetus*) whales in the western North Atlantic: a reevaluation of a perspective on genetic data.
SC/57/BRG 21	Summary of research	GEORGE, J.C., BICKHAM, J.W., GIVENS, G., LEDUC, R., MELNIKOV, V., MOORE, S., MORIN, P., RUGH, D., SUYDAM, R., TAYLOR, B.L., WADE, P. and ZEH, J. Update on stock structure research on the Bering-Chukchi-Beaufort Seas stock of bowhead whales.
SC/57/BRG 24	Russian Harvest data	BORODIN, R.G. Subsistence gray and bowhead whaling by native people of Chukotka in 2004.
		SC/58/BRG & AWMP
SC/58/AWMP8	Assessment	GIVENS, G.H., PUNT, A.E. AND ZEH, J. The scenario space for the Bowhead SLA Implementation Review: a search for plausible trials exhibiting

		management risk.
SC/58/BRG4	Genetics	POSTMA, L.D., DUECK, L.P., HEIDE-JORGENSEN, M.P. and COSENS, S.E. Molecular genetic support of a single population of bowhead whales (*Balaena mysticetus*) in Eastern Canadian Arctic and Western Greenland waters. 15pp.
SC/58/BRG5	Distribution, telemetry	DUECK, L.P., HIEDE-JORGENSEN, M.P., JENSEN, M.V. and POSTMA, L.D. Update on investigations of bowhead whale (*Balaena mysticetus*) movements in the eastern Arctic, 2003-2005, based on satellite-linked telemetry. 17pp.
SC/58/BRG6	Population estimation	DUECK, L.P., HIEDE-JORGENSEN, M.P., JENSEN, M.V. and POSTMA, L.D. Diving characteristics and sightability estimates of eastern Arctic bowhead whales, *Balaena mysticetus*, based on satellite-linked telemetry. 36pp.
SC/58/BRG7	Population estimation	COSENS, S.E., CLEATOR, H. and RICHARD, P. Numbers of bowhead whales (*Balaena mysticetus*) in the Eastern Canadian Arctic, based on aerial surveys in August 2002, 2003 and 2004. 19pp.
SC/58/BRG8	Distribution, acoustics	STAFFORD, K.M., MOORE, S.E. and MUNGER, L. Bowhead whale calls recorded on autonomous instrument in the Beaufort Sea, 2003-2004. 8pp.
SC/58/BRG9	Genetics mtDNA	LEDUC, R., MORIN, P., KOONOOKA, M., GEORGE, C., NOONGWOOK, G., HANCOCK, B., ROBERTSON, K. and TAYLOR, B. Mitochondrial sequence variation in the Bering/Chukchi/Beaufort Seas bowhead whales. 4pp.
SC/58/BRG10	Acoustics, spring 2001	CLARK, C.W., CORTOPASSI, K., PONIRAKIS, D., FOWLER, M., FRISTRUP, K.M. and GEORGE, J.C. Seasonal variation in acoustic characteristics of bowhead whale (*Balaena mysticetus*) sounds during the spring 2001 migration off Pt. Barrow, Alaska. 12pp.
SC/58/BRG11	Genetics mSAT	HUEBINGER, R.M., BICKHAM, J.W., PATTON, J.C., GEORGE, J.C. and SUYDAM, R.S. Progress report on the development of new microsatellite markers for bowhead whales. 2pp.
SC/58/BRG13	Genetics, simulations	RIPLEY, B.J., MARTIEN, K.K. and TAYLOR, B.L. A simulation approach to understanding non-equilibrial dynamics in a recovering long-lived species: the bowhead whale. 12pp.
SC/58/BRG14	Age, growth, life history	LUBETKIN, S.C. and ZEH, J.E. Deriving age-length relationships for bowhead whales (*Balaena mysticetus*) using a synthesis of age estimation techniques. 20pp.
SC/58/BRG15	Population abundance	MELNIKOV, V. and ZEH, J. Chukotka Peninsula counts and estimates of the number of migrating bowhead whales. 10pp.
SC/58/BRG18	Genetics mSAT	GIVENS, G.H. and OZAKSOY, I. Transience of a temporal lag correlation feature in bowhead microsatellites. 6pp.
SC/58/BRG19	Genetics, stock structure	GIVENS, G.H., HUEBINGER, R.M., BICKHAM, J.W., GEORGE, J.C. and SUYDAM, R. Reexamination of stock structure in bowhead whales from the western arctic: preliminary analyses based on new microsatellites. 9pp.
SC/58/BRG20	Photogrammetry, length structure	KOSKI, W.R., RUGH, D.J., ZEH, J., GEORGE, J.C., SUYDAM, R., DAVIS, A.R. and MOCKLIN, J. An update on analyses of bowhead whale aerial photographs obtained in 2003-2005. 5pp.
SC/58/BRG21	US Harvest data	SUYDAM, R.S., GEORGE, J.C., HANNS, C. and SHEFFIELD, G. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2005. 6pp.
SC/58/BRG22	Baleen analysis, stock structure	KNOCHE, M.J., SUYDAM, R.S. and GEORGE, J.C. Preliminary investigations of stock structure in Bering-Chukchi-Beaufort Seas bowhead whales (*Balaena mysticetus*) from stable carbon isotopes analysis of baleen. 8pp.
SC/58/BRG23	Calf length, life history	GEORGE, J.C. and SUYDAM, R.S. Length estimates of bowhead whale (*Balaena mysticetus*) calves. 4pp.
SC/58/BRG24	Summary	GEORGE, J.C., MOORE, S. and SUYDAM, R. Update on stock structure research on the Bering-Chukchi-Beaufort Seas stock of bowhead whales. 6pp.
SC/58/BRG25	Life history	LAMBERTSEN, R.H. Susceptibility of the great polar or bowhead whale to global warming. [Plus errata] 10pp.
SC/58/BRG27	Stock structure archetypes	GEORGE, J.C. and MOORE, S.E. Hypothetical stock structure archetypes for the Bering-Chukchi-Beaufort Seas bowhead whale population. 20pp.
		SC/59/BRG & AWMP
SC/58/Rep2	Intersessional Report	First Intersessional AWMP Workshop for the 2007 bowhead Implementation Review, 24-27 April 2006, Seattle, USA. Paper SC/58/Rep2 presented to the IWC Scientific Committee, June 2006, St Kitts and Nevis, WI. 28pp. [Paper available at the Office of this Journal].
SC/59/AWMP1	Age estimation	MORITA, J.G. AND GEORGE, J. C. 2007. Age classification of bowhead whales using recursive partitioning.
SC/59/BRG4	Harvest, management	SUYDAM, R, GEORGE, J.C., ROSA, C., PERSON, B., HANNS, C. T., SHEFFIELD, G. BACON, J. 2007. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2006.
SC/59/BRG5	Size structure	GEORGE, J.C., BOCKSTOCE, J.R., PUNT, A.E., AND BOTKIN, D.B. 2007. Preliminary estimates of bowhead whale body mass and length from Yankee commercial oil yield records.
SC/59/BRG6	Photographic studies	KOSKI, W.R., D.J. RUGH, J. ZEH, J.C. GEORGE, R. SUYDAM, A.R. DAVIS, J. MOCKLIN AND K. TRASK. Review of bowhead whale aerial photographic studies in 2003-06.

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