Annex F

Report of the Sub-Committee on Bowhead, Right and Gray Whales

Members: Walløe (Chair), Allison, An, Baba, Berggren, Best, Bickham, Bjørge, Borodin, Brandao, Brandon, Breiwick, Brownell, Butterworth, Carlson, Clapham, Clark, Cooke, Daníelsdóttir, Deimer-Schuette, DeMaster, Donovan, Dueck, Edwards, Fujise, Funahashi, Galletti, Gedamke, George, Givens, Goodman, Goto, Groch, Gronvik, Hatanaka, Heide-Jørgensen, Huebinger, Hyugaji, Illyashenko, Iñiguez, Ipatova, Ivashchenko, Kanda, Kasuya, Kato, Kitakado, Kock, Krahn, Lambertsen, Lawrence, Leaper (Rebecca), LeDuc, Martin, Mate, Matsuoka, Moore, Morishita, Murase, Nakamura, Nishiwaki, O'Hara, Ohsumi, Øien, Okamura, Palazzo, Palka, Pamplin, Pastene, Peel, Perrin, Pike, Punnett, Punt, Rambally, Reeves, Reijnders, Ripley, Robbins, Rogan, Rojas Brancho, Rosa, Rose, Rosenbaum, Rowles, Schweder, Simmonds, Skaug, Stachowitsch, Suydam, Tanaka, Taylor, Tominaga, Urbán, Vladimirov, Wade, Walloe, Waples, Weinrich, Winship, Witting, Yamakage, Yasokawa, Yoshida, Young, Zeh, Zelensky

1. OPENING REMARKS, ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEURS

Walløe welcomed the participants and was elected chair. Suydam, Skaug and George acted as rapporteurs.

2. ADOPTION OF AGENDA

The adopted agenda is given in Appendix 1.

3. REVIEW OF AVAILABLE DOCUMENTS

The documents available for discussion by the sub-committee included SC/58/BRG2-24, 27-30; SC/58/O7, 8, 14; SC/58/IA1, SC/58/Rep2, SC/58/ProgRep Australia and SC/58/ProgRep South Africa; Gaines *et al.* (2006) [SC/58/ForInfo 36].

4. BOWHEAD WHALES

4.1 Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales

4.1.1. Stock structure hypotheses (joint session with AWMP)

4.1.1.1 REPORT FROM SEATTLE WORKSHOPS

4.1.1.1.1 US STOCK STRUCTURE WORKSHOP

A five-part plan for studying stock structure of bowhead whales in the Bering, Chukchi and Beaufort (B-C-B) seas was developed by US researchers prior to and during the 2004 International Whaling Commission/Scientific Committee (IWC/SC) meeting (Table 1). Projects under the five research themes were reviewed, refined and endorsed at the first Workshop on B-C-B Bowhead Whale Stock Structure, in February 2005. As a continuation of these efforts, and to provide specific advice to the Aboriginal Whaling Management Procedure – Standing Working Group (AWMP-SWG) B-C-B Bowhead Whale AWMP Implementation Review, a second workshop focused on bowhead stock structure studies was convened in March 2006 in Seattle, Washington USA. A brief summary of that meeting was provided to the committee including, agenda, a list of participants and short reports of progress on projects under each research theme.

Table 1. Five BCB bowhead whale stock structure research themes.

Project
1. Research Planning and Hypothesis Testing
Planning and coordination
Modelling and hypothesis testing
2. Genetics Sampling and Analysis
Tissue collection: US harvest sampling
Tissue sampling: Russian & US biopsy
Genetics analysis methods & application
3. Animal Mixing and Abundance
Photographic survey: St. Lawrence Is.
Photographic analysis: AK Coast
If possible, photographic survey: Chukotka
4. Spatial Distribution and Abundance
Traditional knowledge
Historical catch data reanalysis
Collaboration with Russian Scientists

5. Migration patterns
Analysis/acquisition of LT acoustic data
Satellite tracking
Isotopic analysis of baleen

4.1.1.1.2 FIRST INTERSESSIONAL AWMP WORKSHOP OF THE 2007 BOWHEAD IMPLEMENTATION REVIEW

SC/58/Rep2 describes an AWMP intersessional workshop that was held in Seattle in April 2006. The aims of the workshop were to (1) specify the basic structure and types of simulation trials needed for the implementation review and (2) initiate discussion on the range of parameter values to be considered. The stock structure hypotheses discussed at the March 2006 Stock Structure workshop were important for specifying simulation trials in addition to furthering the understanding of bowhead biology.

Participants in the intersessional workshop reviewed and discussed the available data on stock structure. Particular attention focused on differences between the newest microsatellite loci (see SC/58/BRG11) and the old loci. The workshop discussed the advantages and disadvantages of using the old (n=11), new (n=22) or a combined set of the loci, but came to no firm conclusion. They agreed to seek outside expert advice. Questions were raised at the workshop about the feasibility of developing microsatellite loci with tri- and tetra-nucleotide repeat sequences within the Data Availability Agreement (DAA) time frame.

The sub-committee endorsed recommendations from the Workshop regarding priorities for genetic data generation. Of top priority was scoring the new loci for 17 whales described in the Workshop's report, for the purposes of a unified analysis investigating the 'Oslo bump' (Jorde *et al*., 2006). It is also critical to score all old and new loci for any whales from St. Lawrence Island (including rescoring to fill in missing data), and to increase the number of scored samples from spring Barrow whales. Other priorities include scoring all 33 loci for roughly 50 to 80 whales selected from a genetically homogeneous group of whales in the Canadian Arctic to provide a 'control' group where it is known that the animals are genetically distinct. Foxe Basin whales were recommended, or if these number too few, Hudson Bay whales or a combination of whales from these two sites. If the Canadian data cannot be obtained, then samples from the Sea of Okhotsk could be used. Finally, collection and analysis of biopsy samples from Chukotka, especially from the spring and summer, is also important, and the sub-committee urged Russia to expedite sharing of these samples with interested scientists.

Notwithstanding these priorities, the sub-committee hopes that the final genetic dataset for bowheads will include microsatellite scores for all available Bering-Chukchi-Beaufort Seas samples for both the new and old loci, to the extent this is possible by the deadline imposed by its Data Availability Agreement.

A discussion was held about other data that might be useful for addressing stock structure. These data included: photogrammetric, acoustic, telemetry, visual, stable isotopes, traditional knowledge, and historical catch.

The workshop considered a total of nine hypotheses, four single stock and five two stock scenarios. The hypotheses were:

(1) Baseline single stock,

(2) Single stock with social structuring,

(3) Single stock with 'Generational Gene Shift' (GGS),

(4) Single stock with feeding ground site fidelity.

(5) Two stocks - Chukchi Circuit - mixed,

(6) Two stocks - Chukchi Circuit - segregated,

(7) Two stocks with temporal segregation,

(8) Two stocks with spatial segregation but both stocks are present near SLI, and

(9) Two stocks with spatial segregation but only one stock present near SLI.

During discussion about the intersessional workshop, Donovan provided the responses from the six genetics experts about combining the old and new loci. The responses were mixed. One expert commented that combining the old loci with the new might be attempting to combine 'apples and oranges' because the sets were generated for different purposes. This expert suggested estimating the error rate of scoring the loci and using only those that pass some criteria. Another expert thought the more loci the better but the choice of loci would depend upon the specific question that is being addressed. Yet another expert suggested analysing the old and the new loci separately and then in combination and test for differences. Finally, an expert suggested submitting each locus to a set of criteria. Only those that passed the criteria should be used.

With regards to developing tri- or tetra-nucleotide repeats, Bickham responded that it would not be possible to develop such new loci in time to meet the September 2007 deadline of the Data Availability Agreement. Bickham noted that the only advantage to the use of such loci is that they may be easier to score. There is no inferential advantage to using such loci compared to the di-nucleotide repeats employed in SC/58/BRG11, unless they provide more accurate data. Because a great deal of care was taken in the development of the 24 new loci described in SC/58/BRG11, accuracy of scoring has not been a problem with these loci. Bickham also commented that during the planning of the research described in SC/58/BRG11 consideration was given to the use of tri- and tetrameric loci, and in consultation with several experts on microsatellite analysis it was determined that a panel of pure CA di-nucleotide repeat loci was preferable. This is because, at least in part, CA repeats are the most common microsatellite in mammalian genomes and they are the easiest to develop. In addition, there is a very large body of literature using CA repeats in mammalian population genetics and more is known of their evolutionary patterns than for any other form of microsatellite. For these reasons, Bickham concluded that discussions about the need to develop tri- or tetra-nucleotide loci for the bowhead whale genetics program should be put to rest.

4.1.1.2 GENETIC INFORMATION

SC/58/BRG9 provided information on sequences of the mitochondrial control region. These data were used to test for spatial, temporal and cohort structure in bowhead whales from the Bering-Chukchi-Beaufort seas. Results of χ^2 and F_{st} tests were not significant for any comparisons including spatial (North Slope vs. St. Lawrence Island, North Slope vs. Savoonga and North Slope vs. Gambell), temporal (fall vs. spring migrations for the North Slope and for Barrow only), and age groups (old vs. young).

The sub-committee agreed that the recent dataset on mtDNA should supercede the previous one.

SC/58/BRG11 presented results of the development of new microsatellite loci for bowhead whales. Previous studies of bowheads were conducted with microsatellites that were a collection of various repeat types and from a variety of species. The initial focus of the current study was to develop a panel of 25 loci specifically derived from bowheads. CA repeats were the type of repeat chosen for development because of their relative abundance in the genome, they have been the most commonly studied repeat motif, and the best understood with regards to evolutionary patterns. A total of 34 loci demonstrated polymorphism on agarose and were run on the ABI3100 automated sequencer. Loci were then selected based upon their quality of amplification and their ease of analysis. A total of 24 loci were initially selected. Upon running additional individuals, it was discovered that one of the 24 loci (Bmy47) was X-linked and an additional locus (Bmy44) demonstrated the potential for null alleles. Currently 170 individuals have been run for the remaining 22 loci. The remaining individuals will be genotyped by 1 September 2006.

The sub-committee commended the authors for the development of the new loci.

A brief discussion was held about the suitability of using CA repeats instead of tri- or tetrameric repeats. As mentioned above, the use of CA repeats was suitable for microsatellite analysis because pure CA repeats are the most abundant microsatellites and easiest to interpret. The only potential advantage of tri- and tetrameric repeats is ease of scoring. If the development of dimer repeats is conducted carefully there should be few problems with scoring.

There was considerable discussion whether there was value in the old loci. Rooney either developed the old markers or used existing ones from other species. These 11 loci were not chosen because of optimal characteristics, only because they were available. There have also been problems scoring the old loci both for B-C-B and eastern Canadian Arctic bowheads. Because some were derived from other species, the primer sites might not precisely match the bowhead sequence, resulting in problems with amplification. One member noted that since Rooney developed the old markers about eight years ago, there have been large improvements in lab technology. Labs are much better now in screening and scoring loci. Markers that were considered acceptable eight years ago may now be discarded. Even though there may be problems with the old loci, they do provide some information. The sub-committee agreed the old loci should be scored for all new bowheads that are sampled.

SC/58/BRG19 reported the results from analyses investigating population structure within Bering-Chukchi-Beaufort Seas stock of bowhead whales using twenty-two new polymorphic microsatellite genetic markers. Samples consisted of 148 Barrow whales, 9 whales from Gambell, and 16 from Savoonga. This represents the largest sample from St. Lawrence Island ever analyzed, and more than twice the previous number of loci. The samples exhibit significant heterozygote deficiency, which is not easily isolated to any simple spatio-temporal group or age cohort. A thorough comparative investigation of allele frequencies revealed no significant differences among groups stratified by geography, season, or estimated age. Attempts to detect population substructure using the 'Structure' model (Pritchard *et al.,* 2000) found no evidence of more than one stock. A test to detect a historical population bottleneck found significant results. Taken together, these results do not provide evidence of any stock structure that should be a concern to management. However, the results should be considered preliminary, since more data should become available later this year. Further, these 22 new polymorphic markers are not yet generally available to other interested scientists.

Regarding the authors finding that several pair-wise locus comparisons suggested linkage disequilibria, Waples commented there might be a biological explanation. The test assumes an infinite population. The samples come from a finite population. Thus, the proportion of significant tests is expected to be higher than the nominal alpha level.

There was some discussion about the weaknesses of using the program Structure. Waples and Gaggiotti (2006) [SC/58/ForInfo32] compares standard methods for detecting population structure, including Structure. Structure has low power when separating populations that are weakly differentiated.

Some committee members noted that a considerable amount of the microsatellite data was missing for some individuals. For example, one whale could not be scored for 75% of the loci. Huebinger commented that there were some initial laboratory problems when creating the preliminary dataset. Overall, the percentage of missing data in the new dataset is lower than the old dataset. Many of the missing data will be completed for the final dataset that will be used for the 2007 assessment.

The sub-committee agreed there was need for establishing criteria that would be used for assessing which loci and which individual animals would be used for the analysis. Successfully scoring 30 of 33 loci might be a criterion for including an individual animal in the analysis. All researchers analyzing the microsatellite data should exchange files about which loci and animals pass criteria so that all researchers are using the same datasets.

SC/58/BRG18 described an application of the analysis methodology described in SC/58/SD3 to B-C-B Seas bowhead whales. The temporal lag correlation feature found for bowheads migrating past Barrow in the autumn using 11 microsatellite markers and referred to colloquially as the 'Oslo bump' (Jorde *et al*., 2004) was not found in this analysis, which used an improved dataset of 22 new, reliable markers and a larger number of sampled whales. These results suggest that the original 'Oslo bump' finding may have been an artifact of the small sample size and the particular whales and loci studied, but since the new dataset will be supplemented with additional samples in the coming months these results should not yet be considered conclusive evidence against the 'Oslo bump'.

There was considerable discussion about these results. Analysis of the old markers produced the Oslo bump but preliminary assessment of the new loci and samples did not. Some members asked whether there could be some specific information in old loci that is not captured by new loci. Givens responded that the interesting pattern observed with the old dataset might have been an artifact of the limited number of loci and animals used. If the 'Oslo bump' is real it should be manifested in the larger dataset. Analysis of the final dataset later this year should provide a more conclusive answer.

The sub-committee further discussed the expert responses about the use of the old loci (see Item 4.1.1.1.2, above). Waples commented that there was no a priori reason to throw out old loci. However, several members had identified empirical reasons to be concerned about some of the old loci, including scoring irregularities observed for both Canadian and B-C-B samples. The sub-committee agreed that it was important to have loci that provided consistent scores. Standardized quality control criteria were needed to evaluate each locus and whale. The sub-committee recommended that criteria be established for choosing the best loci.

SC/58/BRG13 investigated whether a single stock out of genetic equilibrium could result in genetic heterogeneity as has been found in recent bowhead whale data. The idea that non-equilibrium dynamics could cause differences in genetic frequencies between age cohorts was called the Generational Gene Shift (GGS) hypothesis. Aspects of bowhead whale biology making them prone to this effect are: long generation time, being out of demographic equilibrium due to population bottleneck and recovery, and variable testes size suggesting unequal reproductive success among males. The hypothesis predicts the effect will be strongest between specific age cohorts. The simulations focused on young whales born in the last 30 years, middle-aged whales born during the 30 years after the end of commercial whaling, and old whales born before commercial whaling began.

Simulations were conducted using R-Metasim (Strand, 2002) an individual-based model that tracks genotypes of individuals and bases the fate of individuals on rates specified in projection matrices. The simplified version of bowhead population history burns the population into a dynamic equilibrial state for 500 years, compressed whaling into a single catastrophic year followed by exponential growth to the 2003 abundance (a period of 93 years). Uncertainty was captured in sensitivity trials for initial population size, lowest abundance following commercial whaling (N_{low}), and the presence, number, and reproductive variance of 'supermales'.

Simulations were initialized with 10 microsatellite loci based on allele frequencies of North Pacific minke whales and a haplotype frequency distribution consistent with observed data. Projection matrix parameters were estimated, using the fixed-stage duration method, for matrices for the stable population period, and for exponential growth from two levels of N_{low}. Due to a coding error, growing populations had an unreasonably high proportion of supermales so the results presented here are an overestimate of the likelihood of GGS. Specific combinations of parameters are termed scenarios and each was replicated by simulation from the same initial conditions 500 times. Analysis of mtDNA results showed evidence of GGS in Young vs. Middle comparisons. Unexpectedly high significant results were found in comparisons involving the Oldest cohort. Old males with unique haplotypes drove the results. Significance of these comparisons virtually disappeared when old males were excluded from analysis. However, this also resulted in comparisons involving Oldest showing more relatedness than expected by chance, manifested as large numbers of P-values >0.9.

Little evidence for GGS was found in nuclear markers, especially keeping in mind that these results are an overestimate of effect size. The only factor that affected significance of results was presence of supermales, and they needed to have high reproductive dominance to see the effect. The unexpected level of high P-values was also observed in nuclear marker results, but only in scenarios with equal reproductive success. It was also seen at year 500, when the population was large, so this may be an effect of comparing age cohorts in general, rather than a result of population bottleneck. Although the results were regarded as preliminary until unexpected results are explained, the effect of GGS was relatively low in magnitude for mtDNA and very low for microsatellites. Preliminary investigation of levels of relatedness within and between cohorts showed some potential for explaining unexpected results. Until these patterns are explained, caution should be used in interpreting results of strata comparisons from populations that are out of equilibrium.

In discussion, it was noted that the simulation results were based on the genotypes of the entire population and not a sample. The sub-committee discussed the curious result of the overabundance of p-values near one. Several members suggested that the inclusion of parent/offspring pairs in the simulations might be influencing the results. One aspect of future simulations is to determine the effect of sampling. The initial results suggest that GGS does not explain the Oslo bump, but unexpectedly, GGS might influence results of mtDNA analysis. The authors acknowledged the unexpected results and the need to understand them. The subcommittee agreed the results warrant further investigation.

4.1.1.3 OTHER INFORMATION

SC/58/BRG15 presented results of shore-based counts of migrating bowhead whales past the Cape Dezhnev area of Chukotka, Russia, during May and June of 1999 to 2001. It is unknown if the same whales migrate along the Chukotka coast each spring, nor is it known if they form a sub-population. The 1999 count was a feasibility study, and the counts from Cape Pe'ek in 2000 and 2001 were designed to permit estimation of the number of whales migrating past Cape Dezhnev. These surveys were similar to those of bowhead whales near Barrow, AK and of gray whales near Monterey, CA except that no experiments designed for estimating detection probabilities P were conducted. The number of migrating bowheads was estimated using three alternatives for P: (1) P =1 (all whales passing during watch with acceptable visibility conditions were seen); (2) P = Pb, bowhead detection probabilities estimated for the surveys near Barrow (except that >10 km range from Cape Pe'ek was assumed equivalent to >2km offshore near Barrow) and (3) Pg as analogous as possible to detection probabilities estimated for the gray whale surveys near Monterey. Whales/sighting were estimated as (number recorded)/ P. Methods of estimated the number of migrating whales from the Cape Pe'ek data and the assumptions on which they were based were as similar as possible to those of the surveys near Barrow. The migration period at Cape Pe'ek was assumed to extend from the first day a bowhead was seen through the last day a bowhead was seen in each year. Whales were assumed to migrate continuously throughout this period, regardless of weather, time of day and whether or not observers were counting them. Days were assumed to be 'watched' if observers counted for more than 2h with fair to excellent visibility and 'unwatched' otherwise during this period. The day estimate for a watched day is (N + C/2) * 1440/(watched minutes). N and C are the total whales/sighting summed over sightings scored as not previously seen (N) and uncertain whether previously seen (C), respectively. The season total estimate for each year is the sum of the day estimates over all the days in the migration period, with a weighted mean estimate used for the unwatched days. The weighted mean estimate, based on the watched days, was computed on a square root scale to give day estimates appropriate weight, considering the minutes of watch and the rate and variability of whale passage each day. A jackknife on watched days provided the SE for the season total estimate. The 2000 migration period was 14 May - 13 June with 18 (58%) watched days; 155 N whales and no C whales were seen. The 2001 migration period was 23 May – 15 June with 14 (58%) watched days; 148 N and 26 C whales were seen. Weighted geometric means of the 2000 and 2001 estimates of the number of migrating bowhead for the three alternatives for P with their 95% confidence intervals are: (1) 426 (301, 603); (2)

841 (601, 1176); and (3) 774 (558, 1073). Given observed migration speeds of bowheads in 2001, it is unlikely that any of the 94 N and 18 C whales seen from Cape Pe'ek in June of 2001 were counted by the survey near Barrow that year.

The sub-committee discussed the need to obtain another estimate of the number of bowheads passing by Chukotka in late May and June. It was suggested that if another count is conducted, it should include an 'independent observer' experiment to permit estimation of detection probabilities and acoustic monitoring to determine whether whales migrate beyond viewing range of observers or when watches cannot be conducted. Another member suggested that it might be useful to conduct a count at Big or Little Diomede Islands, in the middle of the Bering Strait, concurrent with a count at Cape Pe'ek to document the number of whales farther from the coast of Chukotka. The sub-committee commended Melnikov for successfully conducting the shore-based surveys under very difficult conditions. Dog teams provided the logistical support for the surveys.

In addition to conducting another survey, it would be valuable to biopsy and satellite tag whales in Chukotka during the summer. Because of permitting issues, it may be difficult to obtain permission to tag whales or conduct acoustic monitoring in Chukotka.

The sub-committee recommended that additional studies be conducted in Chukotka. These studies should include another shore-based count at Cape Pe'ek, the collection of biopsy samples and satellite tagging of bowheads, as described above.

SC/58/BRG20 reported on aerial photographic surveys that were conducted near Point Barrow, Alaska from 12 April to 6 June in 2003, 18 April to 7 June in 2004, and from 6-9 September 2005 and in the Bering Sea from 9 April to 2 May 2005. Approximately 1157, 1443, 105, and 454 photographs containing 1606, 1974, 114, and 965 images, respectively, were obtained. The 2003 survey had the temporally most complete photographic coverage of whales passing Barrow during spring of any survey to date, and the 2004 survey covered the main migration well although poor weather resulted in poor coverage of the mother/calf migration late in the season. The photographs from these studies will permit calculation of a population estimate for comparison with the estimate from ice based counts and better precision in the calculation of bowhead whale life-history parameters. The 2005 survey photographed bowheads during the later part of the bowhead migration, which includes 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. A power analysis indicates that 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. A small set of photographs was obtained near Barrow early in September 2005, which is before the main migration from the Beaufort Sea reaches Barrow. These will also be examined for evidence of a second stock.

SC/58/BRG22 analyzed baleen for stable carbon isotopes from nine whales landed at SLI. The purpose of the study was to determine whether animals harvested at SLI migrated between the Bering and Beaufort seas. Carbon isotope ratios are different between the two areas and isotope signatures are recorded in the baleen because whales are feeding in both locations. The expectation was that there would be no oscillation in isotope signatures in baleen if animals were not migratory. Results indicated that the whales harvested at SLI did migrate between the two locations; their baleen showed oscillations similar to whales landed at Barrow.

In discussion, an issue was raised of whether the oscillations might reflect periods of feeding and fasting instead of migratory patterns. George responded that there is direct evidence for feeding in both the Bering and Beaufort seas, but this issue will be explored further before the 2007 meeting.

SC/58/BRG24 provided an overview of progress made on stock structure studies during 2005. Details of most of the individual projects were reported on during sub-committee meeting, thus, few additional details were provided. One additional new result was from satellite tagging in Barrow in May 2006. Two whales were tagged. One tag is providing good locations. This animal was migrating farther north than expected and was recently near Cape Bathurst in the eastern Beaufort Sea.

SC/58/BRG27 described two BCB bowhead whale stock archetypes required for testing by the AWMP-SWG. Four scenarios based on two archetypes (Single Stock and 2 Stocks) were developed to address the nine hypotheses identified by the AWMP–SWG at their April 2006 workshop (SC/58/Rep 2). Each scenario was described by a map depicting seasonal distribution and movements and a table of indices showing the potential exposure of each putative stock to hunting (i.e., mixing matrices), summarized monthly by areas identical to those used to describe the commercial harvest. In addition, some general characteristics of the aboriginal hunt were provided, including tables summarizing bowhead harvests by month and village. These data demonstrate that over 90% of the harvest occurs in April, May, September and October, with over half the whales taken at Barrow. Collectively these data, satellite tracking and genetic analysis best fit the Single Stock archetype, as given in Rugh *et al*. (2003).

During discussion, a question was raised about why locations and timing of historical catch data were not included in the paper. Moore responded that a summary of historical catch data was available in SC/58/AWMP8. There have been some difficulties in obtaining the original data, but that the results in Bockstoce and Botkin (1983) were helpful in developing hypotheses. Schweder was concerned about the values in the mixing matrices. For example, he believed the proportion of putative stock 2 whales in area C for the Chukchi Circuit hypothesis might be too low. Moore responded that the value was based on the Chukchi Circuit hypothesis, which suggested animals would move north and west towards the Chukchi Borderland in summer, with few whales expected to pass Barrow on their south and westward migration in autumn.

To investigate the Chukchi Circuit hypothesis, Moore conducted an acoustic and visual survey from Barrow to the Chukchi Borderland, 26 June-23 July 2005 (Figure 1). The retreating sea ice edge and the Borderland has been suggested as a feeding location for bowhead whales because there may be adequate prey there. Acoustic sampling was conducted from the sea ice at 16 stations (stars: total = 30.5 hours) along the cruise track, but no bowhead whale calls were detected. Nor were any bowheads seen during visual surveys from the ship (64 hours) and from helicopter (boxes: 6 flights, 8.3 hours). The only bowheads seen were 3-5 whales near Barrow on 25 June, just prior to the start of the cruise. The timing of this survey was such that some whales should have been detected if they were present.

SC/58/BRG10 examined the types of calls made by bowheads over the course of spring migration at Barrow. There was no stock related information in the calls.

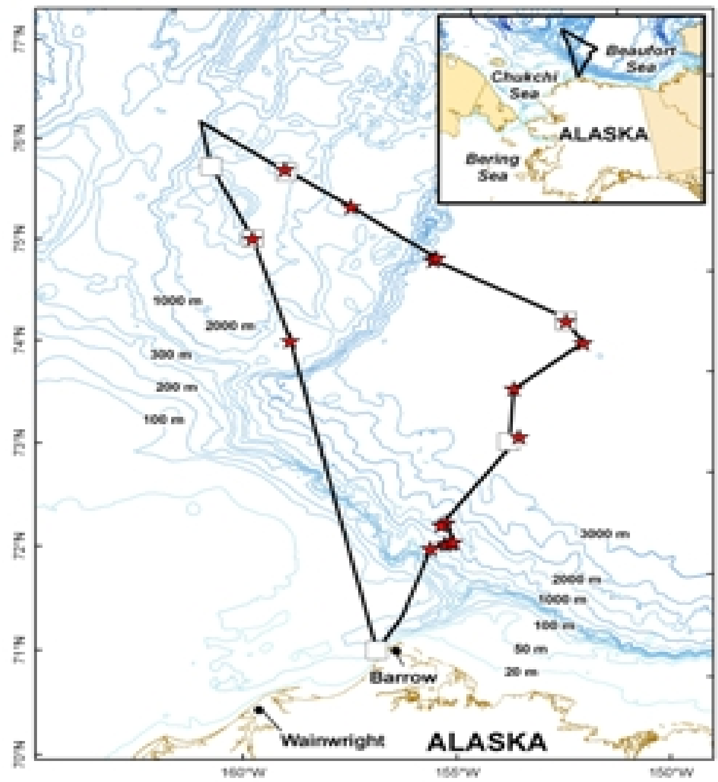

Figure 1. Cruise track of the 2005 NOAA Ocean Exploration Cruise, denoting passive acoustic sampling stations (stars) and opportunistic helicopter surveys (boxes) in search of bowhead whales, 26 June–23 July 2005.

4.1.1.4 REVISION OF HYPOTHESES

The sub-committee agreed there was no new evidence for additional stock structure hypotheses at this time. This does not preclude the possibility that new hypotheses may be generated as additional data become available.

4.1.2 Other new scientific information

SC/58/BRG8 augmented the provisional report provided last year (Stafford and Moore, 2005) on detection of bowhead whale calls using an autonomous recorder deployed in the western Beaufort Sea. Bowhead calls and ambient noise measurements were analyzed from data recorded over a 7.5 month period, October 2003 to mid-May 2004. Bowhead calls were recorded in October, then not again until March. Call rates increased during April, with calls recorded every day 1-12 May, when the batteries in the instrument failed. Ambient noise records varied by over 20 dB in the 500 Hz frequency band over a 4-day period in January. Overall, these data support the migration timing for B-C-B bowhead whales, as described for the single stock archetype, and suggest that bowheads reside in a dynamic acoustic environment.

SC/58/BRG10 presented results from the analysis of hydrophone array data collected (1044h) during the spring 2001 Bowhead census off Point Barrow, Alaska from 16 April through 31 May. This resulted in the detection of 95,419 bowhead sounds (song notes and calls) and 38,095 reliable locations. The reliably located sounds were further analyzed to evaluate the hypothesis that sound variability changes throughout the 45-day period of the migration. Acoustic variability was quantified using a suite of 26 acoustic measures subjected to principle components analysis (PCA). The resultant PCA factors were used as indices of each sound's relative similarity within a multi-dimensional sound space. PCA factor values were then used as inputs to generalized additive models (GAM) to test and control for the significance of seasonal and distance-offshore effects. Results indicate that during the migration there is structure in the acoustic characteristics of bowhead sounds. Song elements are different than calls, but within calls, there are not discrete types of sounds but rather a continuum of forms. GAM analyses of PCA values for all sounds and for only song notes indicate a significant effect of both distance-offshore and season variables, and that the seasonal significance remains when the distance-offshore effect is removed. The GAM significance as a function of season does not imply that call features change dramatically or incrementally, rather that there are gradual and subtle changes in call features throughout the season. These results demonstrate that bowhead calls are highly variable, and do not reveal indications of systematic change over the course of the migration period or as a function of distance-offshore. Furthermore, there were indications of acoustic changes during the last several weeks that might be associated with the occurrence of mothers and calves.

SC/58/BRG14 presented results for estimating the ages of bowhead whales by pooling data from several methods including aspartic acid racemization in the eye lens, examination of ovarian corpora in adult females, and methods using the growth patterns of baleen plates. Each of these methods is reliable only over a limited range of whale sizes (and ages). In this paper, data were pooled for age estimates from these various techniques and tested with several growth models on the entire range of age estimates, from fetal whales to those potentially over 100 years of age. Gompertz and von Bertalanffy growth models and a growth model with a growth spurt were fit to data on body length (188 whales) and baleen length (150 whales). The authors found that a model with a growth spurt best characterized body length as a function of age, with the growth spurt beginning at age of four to five years. Male bowheads reach sexual maturity in their mid-teens to early twenties, and females most likely in their early to mid-twenties.

A brief discussion was held about how this synthesis of age estimation techniques was very useful. The representation of a pause in growth shortly after weaning was highlighted. After weaning, body growth of bowheads slows considerably as the baleen lengthens to allow for efficient feeding on small copepods before resuming body growth. A question was asked about why length or baleen measurements were missing from some whales. George responded that sometimes whales, especially the very large ones, are very difficult to pull onto the ice. Obtaining all measurements from all whales is not always possible.

The subcommittee encouraged continuation of the work related to modelling growth curves but suggested expanding the analysis to include other measurements, such as flipper lengths and widths. Zeh welcomed the recommendation and stated that additional modelling would continue, with results presented in 2007.

At SC/57, the Commission requested the SC to provide guidance on the sizes of bowhead calves. This request came about because a very small whale was landed in 2004. This whale had milk in its stomach. Even so, there was some uncertainty about whether this whale was a calf. SC/58/BRG23 presented information on lengths of bowhead whale calves. Calves are typically born in May at a length of about 4 to 5m and grow quickly in the first summer. As mentioned in SC/58/BRG14, there is a pause in growth of body length shortly after weaning. Therefore, lengths of calves in autumn can overlap with whales that are in their second or even third summers. Baleen length, however, does not appear to overlap. Thus, body length and especially baleen length should be used in combination to assess whether a landed whale is a calf. A landed whale should be considered a calf when its length is 7.5m or shorter and its baleen is less than 60cm. Calves may inadvertently be landed in the future because of length overlap of calves and older animals, calves may stray from mothers for long period of time in the autumn and hunters have difficulty in determining precise body length and baleen length of whales while they are still in the water.

4.1.3 Catch information

SC/58/BRG21 reported catch information for the 2005 Alaskan subsistence harvest. A total of 68 bowhead whales was struck resulting in 55 animals landed. The efficiency (the ratio of the number landed to the number struck) of the hunt was 81%, which is about the same as the average efficiency over the past 10 years (79%). Of the 55 whales, 25 were males, 28 were females and the sex was not determined for two whales. Of the 28 females, 8 were presumably mature (>13.4m in length). Four were pregnant although length and sex of the foetus could only be determined for three. Three female foetuses were 273, 277 and 450 cm in length. A fifth female may also have been pregnant (based on the presence of a corpus luteum on one ovary). A sixth whale was not pregnant and the other two were not examined closely. SC/58/BRG21 also provided an addendum to the 2004 harvest report. One whale was inadvertently not included in the 2004 report. This 8.8 m, female whale was landed on 31 December 2004 at Gambell, Alaska.

Two bowheads were landed in 2005 in the Providentsky region of Chukotka, Russia,. One animal was a male and the other a female. The male was 15.5m and weighed ~59.5 tons. The female was 14 m and weighed ~34.3 tons.

4.1.4 Management advice

The subcommittee agreed that the same advice given in 2005 was appropriate. The Bowhead SLA remains the most appropriate tool for providing management advice for this harvest (IWC, 2003, p. 22), at least in the short term, and consequently the results from the Bowhead SLA indicate that no change is needed for the current block quota for 2003-07. Further, an Implementation Review, focusing on stock structure, is being conducted with the goal of completing it at the 2007 annual meeting so that management advice at that meeting is based on the best science available then. The Bowhead SLA was developed and tested under a single-stock hypothesis. The review will examine the robustness of the Bowhead SLA with respect to plausible hypotheses via simulation trials.

4.2 Davis Strait/Baffin Bay and Hudson Bay/Foxe Basin bowhead whales

4.2.1 Stock structure

SC/58/BRG4 presented information on the genetic relationships among bowhead whales. Genetic relationships were examined and tested for population sub-structuring based on samples collected in the waters of the Eastern Canadian Arctic and Western Greenland. An analysis of 15 nuclear DNA microsatellite loci was completed for 286 individual bowheads sampled at Pelly Bay, Igloolik, Repulse Bay and Pangnirtung in Nunavut, Canada and from Disko Bay in Western Greenland. An additional sample of whales from the Beaufort Sea representing the putative Bering-Chukchi-Beaufort (B-C-B) Seas stock/population was also included in the analysis. A Bayesian clustering (assignment) procedure ('Structure') was used to interpret the genetic profiles obtained from the samples in order to identify the inferred population structure detected from the observed genotypes. The analysis consistently revealed a lack of identifiable structure for these samples and the clustering analysis supports the results obtained from satellite tracking and aerial survey studies that indicate a single population of bowheads in the Eastern Canadian Arctic and Western Greenland. The small sample of whales from the Beaufort Sea was not clearly distinguished from the other samples in the analysis. Additional collaborative work is currently ongoing to increase the number of samples from the B-C-B population for comparison to the Eastern Canadian samples and to increase the number of loci examined in order to increase the power of the analysis.

The sub-committee commended the Canadian and Greenland researchers for the recent efforts to collect and analyze the new samples. There were considerable discussions about whether the two stocks should be combined or remain separated. The new genetics data will be important in assessing stock structure. The results from the Bayesian clustering procedure (STRUCTURE [Pritchard *et al.,* 2000]) provided no evidence for more than one stock. However, several members again commented on the low statistical power of Structure, especially for populations that are weakly differentiated. Therefore, the Structure results were consistent with one population but the presence of multiple stocks cannot be ruled out at this time. The sub-committee acknowledged the need for additional genetics data, but also recognized that other data were important for evaluating stock structure.

Several members inquired as to why no spatially stratified comparisons of allele frequencies and no F_{st} estimates were included in SC/58/BRG4 as requested at SC/57. Dueck responded that recent satellite tagging information (SC/58/BRG5) provided no clear guidance on how to pool the data.

Despite this, the sub-committee recommended that a pair-wise comparison, not including first-order relatives, be made of adult females sampled during the summer in Foxe Basin and Disko Bay, presumed locations for each stock. Sample sizes were sufficient from both of these areas.

Some of the loci used in the analysis were the same as the 'old loci' used for B-C-B stock structure analysis. A question was raised about whether these loci were satisfactory. Huebinger responded that the authors of SC/58/BRG4 indicated to him that some of the old loci were satisfactory but others were excluded for some of the same reasons they were excluded during the B-C-B analysis. The newly developed bowhead loci will also be scored for the whales sampled in Canada and Greenland.

SC/58/BRG5 presented results from a satellite tracking project that occurred between 2002 and 2005. A total of 28 bowhead whales was tagged in northern Foxe Basin (n=16) and Cumberland Sound (n=12). Of these, 17 tags transmitted for periods from a couple of weeks to about seven months. Of 13 tags deployed in northern Foxe Basin that provided data for ≥18 days, eight moved through Fury and Hecla Strait and ranged throughout Gulf of Boothia and Prince Regent Inlet. The remaining five whales made mostly local movements. Of 4 whales tagged in Cumberland Sound that provided data for ≥26 days, all moved out of Cumberland Sound. Three of these whales travelled to Prince Regent Inlet, one of which made a nearly complete circumnavigation of Baffin Island. The latter took up winter residency in Hudson Strait. Six females accompanied by calves were among those whales tagged in Foxe Basin, and two moved into Prince Regent Inlet. Both an adult male and two juveniles were among those tagged in Cumberland Sound and that moved to Prince Regent Inlet. Combined with tracking results of Greenland whales, the findings indicate that bowhead whales are wide ranging, exhibit varying travel routes, and clearly have the capacity for making quick shifts of residence areas over long distances. The tracks also clearly demonstrate that bowhead whales move well beyond the stock boundaries formerly presumed for the two putative stocks. Whales from both Foxe Basin and Baffin Bay regions share common ranges in summer as well as winter. Common use of wintering ranges suggests that there is potential for significant genetic exchange between the various components of the eastern Arctic population.

Discussions focused on the usefulness of the tagging data for assessing stock structure. One question was raised about whether there are several mother/calf aggregations in the study area, which might indicate two stocks. Dueck explained that Foxe Basin and Prince Regent Inlet contained many mothers with young but there are few other known locations. The satellite tagging data show that some females with young move from Foxe Basin to Prince Regent Inlet contrary to previous speculation that animals in Prince Regent Inlet were those from Davis Strait/Baffin Bay stock. Dueck also mentioned that whales tagged from both stocks occurred in Hudson Strait in winter. Heide-Jørgensen commented that in addition to the satellite tracking, two other lines of evidence support the one stock hypothesis. One is the considerable age and sex segregation between Hudson Bay-Foxe Basin and Davis Strait–Baffin Bay. The other is the history of exploitation that shows that the Hudson Bay-Foxe Basin and Davis Strait–Baffin Bay populations were depleted simultaneously, indicating a link between the two areas.

The sub-committee agreed that several lines of evidence were pointing toward one stock but genetic data could still be interpreted to indicate two stocks. A synthesis of data and analyses would be welcomed for the 2007 meeting in order to provide a more reliable determination of the relative plausibility of one and two stock hypotheses.

4.2.2 Other new information

SC/58/BRG6 analyzed dive data from satellite tagged bowheads. Satellite-linked dive-recording instruments were deployed on four eastern Arctic bowhead whales. Two of the tagged animals were sexually mature females accompanied by calves. The other two animals were inferred to be an adult male and a juvenile female. Dive measurement data were received between July 5 and August 11, 2003. Tags reported data for 17-34 days for a total of 96 tag-days. Approximately 17,500 dives ≥8m in depth were recorded, providing data on dive characteristics for individuals, including max and mean dive depth, frequency of dive depth class and time-at-depth class, dive rate, and proportion of time at surface. All four whales dove to depths ≥100m. The maximum recorded dive depth was 400m. Most dives (59%) were to depths ≤12 m; only 4.2% were to depths >50m. Mean dive duration ranged from 2.6 min to 8.1 min (mean = 5.0 min., S.E. = 1.1 min, n = 4). Whales spent most of their dive time (63-78% of time-at-depth) at dive depths ≤12 m (mean = 71%, S.E. = 3%, n = 4). Overall proportion of time at surface (≤ 4 m depth) for individuals ranged from 19% to 35% (mean = 28%, S.E. = 4%, n = 4). Females accompanied by calves had the lowest mean dive duration and spent more time at the surface than the other whales. No differences in surface time or dive characteristics were observed for time-of-day. Overall sightability estimates, based on pooled surface time (above 4m depth) and partitioned by week, were 40% prior to breakup of landfast ice and ranged from 21% to 29% for subsequent weeks in which at least three tags were active.

Some concerns were raised about this analysis of dive data. Results could be biased because two of the four whales were females with calves. Mothers with young likely spent more time at the surface than other whales. Some members were concerned that surface time included time whales spent in the top 4m of the water column. This concern was raised because the dive data are used to correct aerial survey data (SC/58/BRG7). Both of these potential biases were positive with regards to surface time and would negatively bias the abundance estimate.

SC/58/BRG7 presented results of aerial surveys in the eastern Canadian Arctic conducted to estimate numbers in both the putative Davis Strait-Baffin Bay (DS-BB) and Hudson Bay-Foxe Basin (HB-FB) stocks and to develop a better understanding of the summering distribution of these whales. In 2002, bowheads thought to belong to the DS-BB stock, were surveyed in Eclipse Sound, Prince Regent Inlet and Gulf of Boothia. In 2003, surveys were flown in southern Gulf of Boothia, Foxe Basin and northwestern Hudson Bay to estimate numbers in the putative HB-FB stock. A second 2003 survey estimated numbers of DS-BB whales summering along the east coast of Baffin Island. In 2004, Eclipse Sound and Admiralty Inlet were re-surveyed and parts of Barrow Strait were surveyed. Surface counts of bowheads were analyzed in DISTANCE (Thomas *et al.*, 2001) and adjusted for whales not seen because they were diving. Adjustment factors for diving animals were derived using data collected from whales monitored with satellite-linked tags. An estimated 7309 (95% CI = 3161-16900) bowheads occupied Eclipse Sound, Prince Regent Inlet and Gulf of Boothia in 2002. In 2003, 1828 (95% CI = 940-3554) bowheads were estimated in Admiralty Inlet and along the east coast of Baffin Island and an estimated 981 (95% CI = 319-3018) whales occupied the southern Gulf of Boothia, Foxe Basin and northwestern Hudson Bay. Few whales were seen in the areas covered during the 2004 survey; not enough to produce an estimate. Due to the wide-ranging movements of bowhead whales demonstrated by tagging studies, survey estimates between years cannot be reliably combined. The best partial estimate from the combined bowhead population is 7,309 (95% CI = 3,161-16,900). This is considered a partial estimate because it covered the Prince Regent Inlet-Gulf of Boothia-Eclipse Sound (PRI-GoB-ES) survey area, which is only part of the known summer range.

The sub-committee again commended the Canadian and Greenland researchers for collecting much needed information on bowheads. Even though the committee was pleased to receive new data, many members expressed concern about some aspects of the abundance estimates.

There was a discussion about the estimation of surface time. SC/58/BRG6 shows substantial variation in the individual percent of time spent at the surface. It appears the correction factor was based on a large number of surfacings from a small number of whales. Therefore, the uncertainty in the estimate of surface time is greater than estimated by the authors. Heide-Jørgensen mentioned that dive data are available for another 14 whales. These data will be useful in calculating a more appropriate confidence interval. Givens also requested clarification in how the uncertainty in the surface time estimate was incorporated into the final abundance estimate.

Concerns were raised about the effective strip width. The widths differ substantially between 2002 and 2003. The 2002 width was quite small, thus the correction factor and abundance estimate was considerably higher than the estimate for 2003. There also seemed to be a peculiarly uniform width for the 2003 transects. The authors were encouraged to address these issues before finalizing the estimates.

The use of the instantaneous ratio of whales near the surface to correct for the proportion of whales that would be underwater and not visible to the survey crew was also questioned. It was noted that bowhead whales might be visible for a considerable time before the survey plane passed over them, thus making the use of an instantaneous rate inappropriate. Dueck responded that the time which bowheads were available to be seen was only a few seconds, making this potential bias very small.

Other issues were also raised about the abundance estimates. Several members were concerned that a relatively large estimate was derived in 2002 from the sighting of only 17 whales. Pike pointed out that the survey design used in the fiords of East Baffin Island and Eclipse Sound resulted in uneven coverage probability, which may result in bias in the abundance estimates.

4.2.3 Catch information

One male bowhead whale, 16.4m in length, was harvested at Repulse Bay, Canada on 18 August 2005.

4.3 Other stocks of bowhead whales

Heide-Jørgensen provided information about recent observations of bowheads near Svalbard in late April 2006 at 80ºN and 0ºW. There were 20 sightings of bowheads and seven biopsies were collected from these animals.

A Russian-Canadian research team submitted an outline for a study to investigate the physical processes associated with bowhead whales feeding near the Shantar Archipelago in the Sea of Okhotsk. The proposal provided provisional data on bowhead whale distribution in relation to physical features and copepod prey associated with tidal currents and eddies. The sub-committee welcomed the new information on this stock and encouraged the authors to submit a full paper on the topic next year.

5. RIGHT WHALES

5.1. North Atlantic right whales

Rosenbaum summarized Gaines *et al.* (2006) [SC/58/ForInfo 36]. Gaines *et al.* (2006) analyzed mtDNA from bone samples from eastern North Atlantic right whales to better understand the effects from whaling. Novel haplotypes were discovered in the samples. Further, the diversity of haplotypes was greater in bone samples than the diversity in the entire western North Atlantic population. The analysis demonstrated that historical whaling markedly reduced the genetic variation in mtDNA.

Rosenbaum also summarized the report of the IFAW Second Workshop on Right Whale Acoustics: Practical Applications in Conservation, which was held in November 2005 (Leaper and Gillespie, 2006). A report of the first workshop was discussed by the Scientific Committee at the 2001 meeting in London. At that time the Committee endorsed all the recommendations of the workshop. Since 2001, a great deal of progress has been made both in development of software algorithms to automatically detect right whale sounds and also in hardware solutions for data collection and transport. Currently, technologies are available which can automatically collect and analyze right whale vocalizations and transmit them to shore.

5.2 North Pacific right whales

SC/58/O8 reported right whale sightings during the 2005 JARPN II survey in the sub-areas 7, 8 and 9 of the Western North Pacific. Two individuals were sighted in one group. Two biopsy-samples were collected and photo-identification was obtained for both individuals.

5.3 Southern right whales

Bannister drew attention to the Australian Progress Report, referring to aerial survey results off the southern coast of Australia in 2005. The programme had continued an annual series begun off southern Western Australia in 1976 and expanded along the coast into South Australia from 1993. The number recorded in 2005, 600 right whales including 176 cow/calf pairs, along some 2000 km of coastline from Cape Leeuwin, Western Australia (34°19'S, 115°10'E) to Ceduna, South Australia (32°07'S, 133°46'E) was the highest so far in the series. For cow/calf pairs over the period 1993-2005 the increase rate was 7.53% (95% CI 4.03, 11.04%).

Best reported on an aerial survey off South Africa in October 2005 where 684 right whales including 260 cow/calf pairs were recorded. This is the highest field count of calves in 27 years of surveys (SC/58/ProgRep South Africa).

SC/58/O7 reported southern right whale sightings during the 2005/6 JARPA II survey in Areas III, IV and V. A total of 82 individuals were sighted in 61 groups. Fifteen photo-identifications were obtained.

SC/58/IA1 reported two southern right whale sightings during the 2005/6 IWC-SOWER cruise in the western part of Area III. Three individuals were sighted in two groups. All three whales were photographed and the group of two was biopsied.

6. GRAY WHALES

6.1 Eastern North Pacific gray whales

6.1.1 New Scientific Information

SC/58/BRG16 presented information on 17 adult gray whales (16 mothers and a single adult) tagged in Laguna Ojo de Liebre, Mexico with Argos satellite-monitored radio tags in March 2005. Data were received from all tags and provided tracks of whales for a total of 86,059 km with the longest track 17,215 km (10,690 miles). Six whales were tracked >100 d and four tags provided data for >200 d. All six whales tracked >100 days spent most of their time in the Chukchi Sea. Apparent foraging in the Bering Sea was limited to one whale in the Chirikov Basin and another using the Russian coast from SW of the Gulf of Anadyr to the Bering Straits. Two whales in early to mid-June moved northeast in the primary ice lead (open water path in ice) of the Chukchi from Bering Straits to Point Barrow. By July, six tagged whales were simultaneously in the Chukchi and three of them were between Barrow and Icy Cape. One such whale traversed the Chukchi by travelling west along the 72ºN latitude to Wrangell Island, Russia, where it spent August NW of the island. The most favoured area during the feeding season was NNW of Bering Straits in the southern Chukchi, which was used extensively by four whales. The last three actively transmitting tags were on whales that spent August through mid-November in that general region, largely in Russian waters.

In mid-November the last three whales sending data simultaneously headed south through Bering Straits as near-shore ice in the Chukchi developed quickly. Increasing sea ice densities may have been the environmental cue stimulating the last of the south-bound migrants (last year's mothers) to depart the Chukchi. The relatively late initiation of their south-bound migration and arrival in southern waters suggests that mothers of the previous year may linger longer on the feeding grounds to restore lost energy reserves from calf creation and suckling.

The use of the Chukchi Sea by gray whales is not new. However, the proportion of tagged whales using that area and the extent of their use may indicate an increase in foraging there. These observations appear consistent with the predictions of Grebmeier *et al*. (2006) [SC/58/ForInfo23] related to reduced pelagic-benthic coupling of organic productivity due to a warming regime shift in the Bering Sea. Surprisingly, no whale stayed in just one area for the entire foraging season. Instead, whales had large home ranges during the feeding season. The four whales using the southern Chukchi for 3+ months over-lapped in mutual home range by only 3% of their collective range.

Seven tags operated for < 30 days with 6 tags stopping before they left the lagoon. One of those was the single whale (i.e., not accompanied by a calf), which was necropsied and determined to have died from non-tag related causes. Another whale lost its tag outside the lagoon 23 days after tagging while struggling free of entanglement in a gill net off central Baja. One whale was killed 202 days after tagging as part of the Russian harvest off the Chukotka Peninsula.

In discussion, Moore asked about the sea ice conditions the tagged animals were travelling through in June and July and whether the telemetry locations could be used to do a detailed analysis of ice types. In response, Mate noted that the whales moved north through generally open leads in mid-June. Some analysis had been conducted with low-resolution maps and suggests whales were moving through 30-40% ice cover at times. Also, ice data are available for the period in November when whales swam south as the sea ice advanced but require additional analysis.

6.1.2 Catch information

In 2005, 115 eastern North Pacific gray whales (45 males and 70 females) were harvested by native people of the Chukotka Autonomous region. Of this total, nine whales were lost which is a higher struck and lost rate than last year when only one whale was lost. The quota allocation for 2005 was 135 gray whales (from 146 submitted requests). Two of the gray whales harvested in 2005 had a strong chemical smell and products from these whales were inedible, even by sled dogs. Harvested whales ranged in mass from 6.0 to 30.4 tons, with an average of 10.27 tons. Due to difficult weather and sea conditions the hunt was unsuccessful in some areas and the quota was reallocated between villages.

Brownell noted that SC/58/O1 reported on the factory ship California that operated off California in the 1930s probably took about 680 gray whales. This catch was not previously reported and will be of interest to assessment modellers.

Mate suggested that the SC give attention to the additional use of the northeastern Chukchi Sea by eastern gray whales based on the telemetry results and those of Grebmeier *et al*. (2006) [SC/58/FI23] indicating whales were moving into new foraging areas and areas of oil and gas activity.

Pamplin reported that the Makah Indian Tribe was unable to harvest whales from this stock in 2005 because of domestic litigation. A court ruled in 2004 that the Makah Indian Tribe needs a waiver of the US Marine Mammal Protection Act (MMPA). The Tribe applied for the waiver in 2005.

6.1.3 Management advice

At this meeting, the sub-committee reaffirmed its advice from last year that the Gray Whale SLA remained the most appropriate tool for providing management advice for this harvest. The Secretariat has calculated strike limits for this stock given the agreed abundance estimate and catch history. The results show that no change is needed to the current block quota for 2003-2007. An Implementation Review is scheduled for 2009.

6.2 Western North Pacific stock for gray whales

6.2.1 New Scientific Information

SC/58/BRG2 presented information on a photo-identification catalogue containing images of 150 western gray whales collected between 1994 and 2005 off Sakhalin Island, Russia, by the joint Russia-U.S. research program. The overarching objectives of making this catalogue freely available are twofold: (1) to facilitate international cooperation and collaboration between current and future research groups collecting data on the western gray whale population; and (2) to provide an individual numbering scheme and standardized images of western gray whales that can be used for comparison by other research groups and organizations. This CD-based catalogue is available on request. The images and data included in the catalogue have been provided on the understanding that they will only be used with the permission of the authors. Copyright remains with the senior author (Weller) of the catalogue who retains ownership of all photographs and data therein.

SC/58/BRG3 provided the 2005 results of the on-going Russia-USA research programme on the western gray whale population summering off the northeastern coast of Sakhalin Island. A total of 92 whales (including 6 calves and four previously unidentified non-calves) were identified from photographs leading to a 1994-2005 catalogue of 150 photo-identified individuals. Genetic samples have now been collected from 124 individuals and the overall sex ratio is 60% males and 40% females. The total of known reproductively active females is still only 23 individuals. Fourteen (15.2%) of the 92 whales identified in 2005 were recorded as 'skinny'. This figure is much higher than the number of 'skinny' whales recorded in 2003 and 2004, 3 and 5 individuals respectively.

SC/58/BRG12 contained the results from a preliminary analysis of anthropogenic scars scored from the Russia-USA photo-identification catalogue of 150 western gray whales (SC/58/BRG2). Thirty-two whales had anthropogenic scars. Thirty whales had encountered fishing gear at least once and three whales had survived at least one ship strike. The next step in this project is to consult with experts on these types of scars on whales from other locations to determine if they agree with what were classified as anthropogenic scars. The authors believe these estimates are conservative given the limitations of the dataset. Brownell also noted that efforts will be made in 2006 to collect more photos for this project.

In discussion, Donovan noted this was an interesting paper but noted that inferring mortality from scarring is problematic. He drew attention to the recommendation in the paper that more effort is needed to locate and photograph dead and injured animals to determine the cause of death.

SC/58/BRG17 was not presented, as none of the authors were present; the abstract follows.

SC/58/BRG17 presents the data of theodolite per hour scanning of gray whale number and behaviour observations at four standard stations at the Piltun spit conducted from late July to mid September 2005 and covered the period of offshore construction work at the Piltun-Astokh-B (PA-B) platform site. After the installation of the base of PA-B platform when there was still significant vessel activity in the construction area, fewer whales were observed in the vicinity of the platform than in the north of the feeding area. There was a statistically significant negative correlative between the number of vessels around PA-B and the number of whales present in the sector of observations. In the vicinity of the platform whales were feeding but exhibited neither resting nor social behaviour. These observations support the hypothesis of the disturbance impact of the construction activity on the behaviour and distribution of whales.

SC/58/BRG28 and SC/58/BRG29 presented the results of studies conducted in 2005 under the Russian program on the western gray whale research and monitoring off northeastern Sakhalin Island. Shore-based, aerial and vessel-based surveys indicated that the overall distribution of gray whales in the northeastern Sakhalin waters was similar to that in 2004. The overwhelming majority of the whales stayed in the traditional near-shore Piltun feeding area and their number there was also similar to 2004. Most of gray whales in this area (more than 70%) concentrated, as in previous years, in its northern part and within the 4-kilometer zone of the coastal shallows, with average depths < 15 m. The number of gray whales in the Offshore area somewhat increased in 2005 compared to 2004 but remained approximately twice as low as in 2002-2003. The whale redistribution in 2004-2005 is most likely due to the appearance of unusually high and easily accessible concentrations of preferred prey organisms in the Piltun area, including significant spawning congregations of sand lance. The total size of the gray whale aggregation present in the Piltun area in 2005 during the main part of the feeding season is estimated at approximately 120 animals. However, there are, likely, other groups of the Okhotsk-Korean gray whales present in the Sea of Okhotsk during the ice-free season that do not use the northeastern Sakhalin area as their main feeding ground and, hence, the number of the Western gray whale population may be somewhat larger than it is currently thought. Five mother-calf pairs were found in 2005 during shore-based surveys, and 113 individual gray whales were identified by the Russian photo-ID team in northeastern Sakhalin waters last year. Over 2002-2005, a total of 138 whales were identified and included in the Russian photo-ID catalogue. Evident signs of emaciation were found in 10 of the identified whales (8.85%) including 4 nursing females. It was determined that most of the undernourished whales improved their body condition over the course of the summer-fall season. Benthos studies showed that quantitative abundance of benthos at locations of gray whale feeding in 2005 did not differ significantly from 2003, confirming that the contemporary drop in the number of gray whales in the Offshore area is not related to the aggravation in benthos status there and probably primarily linked to higher prey availability in the Piltun feeding area. No visible changes in the number or distribution of gray whales which could be attributed to the 2005 offshore construction activities under the Sakhalin-I and Sakhalin-II oil-development projects were revealed during onshore and vessel-based surveys. Specific behavioural observations also found no notable impact of these construction activities on gray whales nor the presence of large vessels in the construction areas. All their movements, occurrence and surface-respiration-dive parameters recorded in 2005 were similar to those observed in previous years (according to Wursig and Gailey). Acoustic monitoring was conducted almost continuously from July 10 to September 27, and indicated that the sound levels recorded near the portion of the Piltun feeding area closest to construction sites (during the work period) did not exceed the forecasted sound levels, and did not affect gray whales.

As a summary, the results from 2005 surveys indicate that the groups of Western gray whales present off northeastern Sakhalin during the summer and fall has been stable in recent years and is potentially increasing. No visible indication of direct or indirect negative impacts were observed from oil-development activities on the gray whale aggregations.

In discussion, Ivashchenko noted that it would be helpful to include a table that clearly shows the available data on the whales and the statistical tests to support various statements regarding significant or non-significant effects. Furthermore, the anomalously high numbers of individuals reported in the Russian catalogue could be caused by using left and right side photographs of the same animal without matching them, or from inaccurate matching leading to false negatives. Vladimirov responded that the Russian catalogue has 138 good right side images, upon which the individual identifications are based, and that that the possibility of errors in the catalogue is minimal.

Ivashchenko noted that the maximum number of whales reported in a single day was as high as 160 animals, and with detection corrections presumably could number 180 animals. Because this number is considerably larger than the population estimated using the joint US-Russian Project catalogue (122 animals C.I. 113-131; SC/58/BRG30), it suggested serious errors of over-counting in the combined shore-based and vessel-based estimates (SC/58/BRG29, page 3, indicates a maximum count of 133-138 whales seen by the shore based team in October, and vessel based in the offshore area indicated 25, for a total of approximately 160 or more animals).

Vladimirov responded that dates when the maximum number of gray whales in the Piltun area (133-138 individuals according to shore-based surveys) and in the offshore area (25 according to vessel-based surveys) occurred on different days. Therefore, taking into account that the whales are not stationary (he agreed) it is incorrect to sum the results of these shore-based and vessel-based surveys. He repeated that the total number of gray whales in the feeding aggregations that consistently utilize the Piltun area is estimated at about 120 individuals according to the Russian survey data.

Clapham agreed that these high numbers suggested problems with observations and analysis, and said it would be misleading to have these data go into the report as they would suggest that the population was larger that it actually is. Zeh noted that the report of whales in other areas in SC/58/BRG28 suggested there may be more whales than currently estimated. However, the only means to resolve this was by comparing the Russian catalogue with the US/Russian catalogue.

Some members wished to forward last year's recommendation regarding 'the importance of the information exchange, particularly in light of the overlap of these research activities and the importance of maximizing information on this critically endangered population' (IWC, 2006b, p.119). Discussions surrounded means of combining the catalos.

Donovan pointed to the SCs comment last year that the Committee 'strongly recommends that researchers from the two programs work as quickly as possible to share and compare all their photographs' (IWC 2006b, p.121). He also noted that while we welcome new information from SC/58/BRG29, there was difficulty in making conclusions from several papers and it would be best to have more detail in separate papers.

Zeh pointed out that paper SC/58/BRG17 showed a negative correlation between the number of vessels and the number of whales, while paper SC/58/BRG28 states there was 'no direct impact or indirect negative impacts on whales from industry'. The two very different conclusions caused concern, and she questioned if there was a means to resolve it. Regarding the discrepancy between SC/58/BRG17 and SC/58/BRG28, the sub-committee noted all they could do was to ask for more details.

Best asked if there were plans to the make a comparison of the existing catalos. Brownell noted a meeting between the two groups was held but no additional work had been completed, and supported Zeh's recommendation to combine the catalos as the best way forward. Brownell recommended using the Russian-US Project catalogue as the base for matching whales from the Russian catalogue as agreed by the sub-committee last year (IWC, 2006a, p.30), which included using 3 or 4 experts to agree on new whales using established methods before adding photos to the base catalogue.

SC/58/BRG30 provided a population assessment of the western gray whale using the photo identification data collected off Sakhalin Island under the joint Russia-U.S. programme from 1994 to 2005. This is an update of last year's assessment (SC/57/BRG22) which had used data to 2003. New median estimates of key population parameters (with 90% Bayesian confidence intervals) are 0.986 (0.975 - 0.995) for the adult survival rate; 0.72 (0.60 - 0.83) for the survival rate from calf to yearling; 3.0% per annum (2.1% – 4.2%) for the average annual rate of population increase over 1994-2005; 0.43 (0.37 - 0.50) for the female sex ratio and 122 whales (113 - 131) for the 1+ (non-calf) population size in 2006. The updated assessment is more optimistic than last year, mainly due to reduced calving intervals observed in recent years, implying a higher reproductive rate. The modal calving interval has shortened from 3 years to 2 years in the most recent seasons, which is consistent with reduced disturbance from industrial activity during 2002-04. Forward projections of the population model to 2030, assuming no additional mortality or disturbance to reproduction, indicate a high probability (>99%) of population increase. However, if whales continue to be entangled in nets at the 2005 level (three females) then the population is predicted to decline with high probability, with a substantial risk of extirpation by 2030. The 2005 level of by-catch is therefore unsustainable, and it is important to avoid further human-caused deaths in this depleted population.

In discussion, Best questioned a figure showing 'projected' future calf production, which included levels that were lower than some early years, despite an increasing population. Cooke explained that it was indeed confusing and occurred because calf production fluctuates substantially from year to year, as reflected in the estimates for years up to 2005. In contrast, the medians of the future projected calf production levels increase smoothly with time, but the uncertainty for each individual future year is high because one cannot know in advance which will be the good and bad years.

Schweder noted that it would be more informative to show the whole distribution and not just the part up to the median. He also noted the large number of stages and parameters in the stage-based model in Figure 1. He asked if the authors had examined heterogeneity in photo-capture probabilities. Cooke responded that there was clearly substantial heterogeneity in within-season recapture probabilities, but only inter-season recaptures were used in the analysis. Differential capture probabilities between population components were allowed for in the model and estimated. Individual heterogeneity in photo-capture probability had not been estimated and this could lead to some negative bias in the population estimate. Because only a small proportion part of the population remained unidentified, the bias in the total estimate would be small, but he agreed with Schweder that examining individual heterogeneity would be useful. Some animals are not present in some years, but to date all animals photographed outside the study area were matched with animals in the catalogue and hence there was no evidence of animals additional to the studied population.

Kato asked about the number of years of data used to estimate the population size and what the estimate would be if calves were included. Cooke responded that he used all the photoid data from 1994 to 2005 to compute the estimate. The median population estimate for 2005 including calves is 126 animals.

SC/58/O14 reported on the status of conservation and research of western gray whales in Japan, following recommendations in IWC Resolutions in 2001-3, 2004-1 and 2005-3. No sighting of the western gray whale was found from both systematic and POP sightings from June 2005 to May 2006. However, a lactating cow (12.79m) with a calf (7.75m) was entangled by a large set net located off Enoshima Island (Onagawa Town, Miyagi prefecture; 38°23'19"N - 141°36'35"E) in the morning of July 15, 2005. The whales were not seen before the entanglement. Extensive biological data were collected from the animals. The Fisheries Agency of MAFF, Japan (FAJ) collaborated with local governments to initiate actions to eliminate anthropogenic mortality. The paper also reported that FAJ warned fisheries authorities of all prefectures situated along the migration route of western gray whale, after the incidental entanglements that occurred in the Tokyo Bay in May 2005. In its warning, FAJ advised the fisheries authorities of the possibility that some western gray whales may stray into set nets and become entangled. They instructed all set net owners within their jurisdiction to make the utmost effort to release entangled whales to the sea. In April 2006, during the northward migration of western gray whales, the FAJ made an announcement to all coastal prefectures to give similar instructions to all fishermen, fisheries cooperatives and concerned individuals within their jurisdiction.

Cooke asked about the size of the entangled calf and if it was of similar size to the animal entangled last year. Brownell said he looked at the photographs of the animal (in SC/58/O14) taken in May 2005 and noted that it had larger barnacles, and so was likely a calf from previous season (ie., a yearling), since calves observed at Sakhalin have smaller barnacles. So despite their similar sizes, these two whales appear to be of different ages.

Rosenbaum recommended that tissue samples be transferred to SWFSC for microsatellite analysis and comparison with the existing genetic data. Kato replied that the samples were preserved in a freezer and that he had asked the fisheries agency how to transfer the tissues to another institute. He was told that there had to be an agreement in place between the Japanese and US Commissioners in order to transfer the specimens. Brownell responded that an agreement between Commissioners was an unacceptable proposal since this was a science issue and not a political issue. Other members agreed with Brownell. It was pointed out that the genetic information is a critical part of the research on this population; furthermore, concerns about calibration of microsatellite markers were raised and the need to have the analysis conducted in one laboratory.

Members pointed out that an important lesson from this paper is that western grays are vulnerable from fishing gear. Two western grey whales were entrapped alive in July 2005, and when fishermen in Japan tried to release them they died. Brownell suggested a specific training workshop on techniques to release animals unharmed, as is underway in the US and Canada, should be conducted in Japan.

Mate presented a proposal to attach satellite tags on western gray whales to better evaluate their movements and anthropogenic risks. The proposal was to apply satellite tags to whales on the feeding grounds near Sakhalin. The sub-committee considered the proposal and agreed that such tags could yield useful information. However, they were uncomfortable with applying tags to reproductive females since they number so few, and recommended that only males be tagged.

7. WORK PLAN

The following work plan was proposed for the coming year:

(1) Review new information on the stock structure of the B-C-B Seas stock of bowhead whales;

(2) Perform the annual review of catch information and new scientific information for the B-C-B Seas stock of bowhead and ENP gray whales in order to advise the Commission as requested in Schedules 13(b)(1) and (2); and

(3) Review new information on the western North Pacific stock of gray whales, right whales and the small stocks of bowhead whales.

8. ADOPTION OF REPORT

The report was adopted on 1 June 2006 at 22:05. The sub-committee expressed its appreciation to Walløe for chairing the meeting. The Chair expressed thanks to the rapporteurs (Suydam, Skaug, and George) for their efforts.

REFERENCES

Bockstoce, J.R. and Botkin, D.B. 1983. The historical status and reduction of the western Arctic bowhead whale (Balaena mysticetus) population by the pelagic whaling industry, 1848-1914. *Rep. Int. Whal. Commn* (Special Issue) 5: 107-41.

Gaines, G., Aguilar, A., Clapham, P.J. and Rosenbaum, H.C. 2006. Right whales in the eastern North Atlantic Ocean on the brink of extinction: genetic diversity lost and consequences for the species. In review. [SC/58/For Info 36].

Grebmeier, J.M., Overland, J.E., Moore, S.E., Farley, E.V., Carmack, E.C., Cooper, L.W., Frey, K.E., Helle, J.H., McLaughlin, F.A. and McNutt, S.L. 2006. A major ecosystem shift in the Northern Bering Sea. *Science* 311:1461-1464. [SC/58/For Info 23]

International Whaling Commission. 2003. Report of the Scientific Committee. *J. Cet. Res. Manage.* (Suppl.) 5: 1-92.

International Whaling Commission. 2006a. Report of the Scientific Committee. *J. Cet. Res. Manage.* (Suppl.) 8: 1-65.

International Whaling Commission. 2006b. Report of the Scientific Committee. Annex F. Report of the sub-committee on bowhead, right and gray whales. *J. Cet. Res. Manage.* (Suppl.) 8: 111-123.

Jorde, P.E., Schweder, T., Bickham, J.W., Givens, G.H., Suydam, R. and Stenseth, N.C. 2006. Detecting genetic structure in migrating bowhead whales off the coast of Barrow, Alaska. *Molecular Ecology*: In prep.

Leaper, R. and Gillespie, D. 2006. Report of the second workshop on right whale acustics: Practical applications in conservation. International Fund for Animal Welfare, Yarmouth Port, MA 02675, USA.

Pritchard, J., Stephens, M. and Donnelly, P. 2000. Inference of population structure using multilocus genotype data. *Genetics* 155: 945-959.

Rugh, D., DeMaster, D., Rooney, A., Breiwick, J., Shelden, K. and Moore, S.E. 2003. Bowhead whale (*Balaena mysticetus*) stock identity. *J. Cetacean Res. Manage*. 5(3): 267-80.

Stafford, K.M. and Moore, S.E. 2005. Provisional analysis of bowhead and gray whale calls recorded on autonomous instruments in the Beaufort Sea, 2003-2004. Paper SC/57/BRG3 presented to the IWC Scientific Committee, June 2005, Ulsan, Korea. 9pp.

Strand, A. 2002. METASIM 1.0: an individual-based environment for simulating population genetics of complex population dynamics. *Mol. Ecol.* [Notes] 2: 373-376.

Thomas, L., Strindberg, S., Marques, F.F.C., Borchers, D.L., Buckland, S.T., Anderson, D.R., Burnham, K.P., Hedley, S.L. and Pollard, J.H. 2001. DISTANCE 4.0. Beta 4. Research Unit for Wildlife Population Assessment, University of St Andrews, UK. [Available at: http://www.ruwpa.st-and.ac.uk/distance].

Waples, R.S. and Gaggiotti, O. 2006. What is a population? An empirical evaluation of some genetic methods for identifying the number of gene pools and their degree of connectivity. 2006. *Mol. Ecol*. 15: 1419-1439. [SC/58/For Info 32].

Appendix 1

AGENDA

1. Opening remarks, election of Chair and appointment of rapporteurs
2. Adoption of agenda
3. Review of available documents

4. Bowhead whales
   - 4.1 Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales
     - 4.1.1 Stock structure hypotheses (joint session with AWMP)
       - 4.1.1.1 Report from the Seattle Workshop
       - 4.1.1.2 Genetic information
       - 4.1.1.3 Other information
       - 4.1.1.4 Revision of hypotheses
     - 4.1.2 Other new scientific information
     - 4.1.3 Catch information
     - 4.1.4 Management advice
   - 4.2 Davis Strait/Baffin Bay and Hudson Bay/Foxe basin bowhead whales
     - 4.2.1 Stock structure
     - 4.2.2 Other new scientific information
     - 4.2.3 Catch information
   - 4.3 Other stocks of bowhead whales

5. Right whales
   - 5.1 North Atlantic right whales
   - 5.2 North Pacific right whales
   - 5.3 Southern right whales

6. Gray whales
   - 6.1 Eastern North Pacific gray whales
     - 6.1.1 New scientific information
     - 6.1.2 Catch information
     - 6.1.3 Management advice
   - 6.2 Western North Pacific stock of gray whales
     - 6.2.1 New scientific information
     - 6.2.2 Catch and stranding information

7. Work plan
8. Adoption of report