Report of the Scientific Committee

Bled, Slovenia, 24 April-6 May 2018

Annex Q

Report of the Standing Working Group on Abundance Estimates, Status of Stocks and International Cruises

**This report is presented as it was at SC/67b.
There may be further editorial changes (e.g. updated references, tables, figures) made before publication.**

International Whaling Commission

Bled, Slovenia, 2018

Annex Q

Report of the Standing Working Group on Abundance Estimates, Status of Stocks and International Cruises (ASI)

Members: Zerbini (Convenor), Givens (co-Convenor), Al Harthi, Allison, Andriolo, Aoki, Archer, Baba, Baker, Bell, Bickham, Brandon, Brierley, Brownell, Burkhardt, Buss, Butterworth, Canadas, Carroll, Charlton, Collins, Cooke, Coscarella, Cubaynes, Dalla Rosa, De Freitas, De la Mare, DeMaster, Di Tullio, Diallo, Domit, Doniol-Valcroze, Donovan, Double, Ferguson, Ferriss, Fortuna, Galletti, Genov, George, Goto, Gunnlaugsson, Gushcherov, Hielscher, Hughes, Iñíguez, Inoue, Jackson, Jaramillo-Legorreta, Jarman, Kato, Kim, Kitakado, Lang, Lundquist, Mallette, Marmontel, Matsuoka, McKinlay, Miller, Miyashita, Mizroch, Morishita, Morita, Moronuki, Murase, Mwabili, Øien, Olson, Palka, Panigada, Park, Pastene, Porter, Punt, Reeves, Robbins, An, Scheidat, Scordino, Scott, Slooten, Slugina, Strasser, Svoboda, Taguchi, Tamura, Taylor, Thomas, Trejos, Vikingsson, Wade, Walløe, Walters, Wambiji, Weinrich, Weller, Wilberg, Willson, Yasokawa, Yoshida and Zharikov.

1. INTRODUCTORY ITEMS

1.1 Opening remarks
The Standing Working Group on Abundance Estimates, Status and International Cruises (ASI) was established following discussions within the IWC Scientific Committee (IWC, 2017, p.94) to formally review and agree on the status of the abundance estimates submitted to the Scientific Committee across all of the Committee's sub-committees and working groups. The Working Group is also responsible for assisting the Committee and the Secretariat in developing a biennial document to inform the Commission on the abundance and status of whale stocks. Finally, this Group also considers survey design and data analysis related to abundance estimates of IWC-related projects. The Terms of Reference of the Working Group were listed in IWC (2018, p.389).

Following the current Committee's guidelines, reported abundance estimates that may be used by the Committee need to be reviewed and categorised with respect to their level of usage. These categories are:

- Category 1: acceptable for use in in-depth assessments or for providing management advice;
- Category 2: underestimate - suitable for 'conservative' management but not reflective of total abundance;
- Category 3: while not acceptable for use in (1) or (2), adequate to provide a general indication of abundance, and
- Category P: provisional estimates.

In reviewing abundance estimates, the Working Group was instructed to allocate the abundance estimates available to this meeting into one of the categories above for inclusion in the IWC Table of Accepted Abundance Estimates.

1.2 Election of the Chair
Zerbini and Givens were elected co-Chairs.

1.3 Appointment of rapporteurs
McKinlay was appointed rapporteur with assistance from Weller.

1.4 Adoption of the agenda
The adopted agenda is provided in Appendix 1.

1.5 Documents available
The following documents were available to the Working Group: SC/67b/ASI/01-03, 05-17; SC/67b/AWMP/01-rev1, 12, 16; SC/67b/NH/04; SC/67b/SM/07, 09; SC/67b/SH/05, 08/rev-1; Doniol-Valcroze *et al.* (2015); Frasier *et al*. (2015); da Silva *et al*. (in press); IWC (2018); and Hansen *et al*. (in press).

2. REVIEW INTERSESSIONAL WORK

2.1 Process to review abundance estimates

The Working Group notes that its Terms of Reference include the review of estimates of abundance, trends in abundance and status (e.g. current abundance relative to pre-exploitation abundance) presented to the Scientific Committee (SC). These estimates are often needed for other sub-committees or working groups within the SC to complete their agendas, both at the annual meeting and intersessionally (e.g. workshops). In addition, many estimates are expected be included in the IWC 'Table of Accepted Abundance Estimates', which is presented to the Commission on a biennial basis and made available to the general public (e.g. via the IWC website).

Abundance estimates can be produced by applying statistical methods to survey data (e.g. line-transect surveys, mark-recapture techniques) or they can be obtained, for example, from population dynamics models. Often, such estimates are computed using standard methods, but it is not uncommon for the SC to receive estimates calculated using novel methodologies, especially considering the high technical standards evident in many IWC SC analyses and discussions. In addition, for the proper computation of trends in abundance, the review of multiple estimates, which are in some cases produced using different methods, or methods that have evolved over time, is needed. Therefore, providing adequate reviews of such estimates can be complex and time-consuming. For this reason, development of a process to facilitate the review of abundance estimates (and other relevant information) would optimise the work of ASI and allow other sub-committees or working groups to finalise their agendas more efficiently.

A structured process to review estimates of abundance (and other relevant information) is outlined in Tables 1 and 2. This process ranks the information available to the ASI working group in an order consistent with how the information shall be used by the SC. In summary, estimates will be identified and ranked in order of priority. Reviews will be conducted during the SC annual meeting or intersessionally. If the work is done intersessionally, a report with an evaluation of the estimates by the ASI working group will be provided at the following SC annual meeting (similarly to the review of the abundance estimates of humpback whales in Iceland reported in SC/67b/ASI/02).

Table 1. Proposed steps to review abundance estimates by the ASI working group.

Step	Description
1	Estimates of abundance requiring review are identified (by the responsible party specified in Table 2).
2	Estimates are prioritized according to four levels defined in Table 2. Prioritization of the estimates would be conducted by the SC Chair and Vice-Chair, the Head of Science and the Convenors of the relevant working groups/sub-committees and the review conducted under the auspices of the ASI working group.
3	One or more documents (e.g. SC papers, reports, publications) containing a description of the methods used to compute the abundance estimates (or estimates of trends or status) are provided to the ASI email group according to the timeline specified in Table 2
4	Reviews will occur according to the timeline proposed in Table 2

Table 2. Proposed levels of prioritisation and timelines for provision of the estimates to the ASI working group and completion of reviews by this group.

Priority Level for Review	Purpose	Party Responsible for Identification and Communication of the Estimates	Timeline for Provision of Estimates to the ASI Group	Timeline for Provision of the Reviews by the ASI Group
1	Estimates of abundance required by the sub-committees to complete their work during the annual meeting (within this highest priority will be given to estimates required to provide management advice)	Convenors of sub-committees/working groups, SC members	By the beginning of the annual meeting.	At the annual SC meeting.
2	Estimates of abundance needed for SC meetings or workshops to complete their agendas within the intersessional period	Convenors of sub-committees/working groups, SC members.	At the annual SC meeting.	At the annual SC meeting (if sufficient time is available) or intersessionally prior to the beginning of the intersessional meeting or the workshop

3	Estimates of abundance needed for future SC annual meetings and meetings/workshops thereafter.	Convenors of sub-committees/working groups, SC members.	At the annual SC meeting or during the intersessional period.	Reviews would be completed intersessionally by a small group appointed by the SC Chair, Head of Science, and the ASI convenors and provided to the SC at the next annual meeting.
4	Estimates of abundance already included in the IWC Table of Abundance Estimates or those to be included but are not immediately required by any sub-committee or working group to complete their agenda.	IWC Secretariat (C. Allison).	At the annual SC meeting or during the intersessional period.	Reviews would be completed intersessionally by a small group appointed by the SC Chair, Head of Science, and the ASI convenors and provided to the SC at the next annual meeting.

The Working Group **agreed** that the process to review abundance estimates by the ASI working group, as described in Tables 1 and 2, should be adopted by the Scientific Committee.

Attention: SC

The Working Group ***agreed*** *to adopt a process to optimize the review of abundance estimates received by all Sub-Committees and Working Groups of the Committee described in Tables 1 and 2 above.*

2.2 Minimum requirements for presentation and review of abundance estimates.

The Working Group considered the minimum requirements for presentation and review of abundance estimates proposed in SC/67b/ASI14 and reproduced in Table 3. To allow proper review of abundance estimates an adequate description of the data collection and of the analytical methods is required. This description must include details on the survey design, survey platform, data collection procedures, data processing and analysis, statistical methods used compute the parameters of interest, and assumptions considered. Table 3 summarises proposed minimum requirements for presentation and review of abundance estimates by the Working Group and for inclusion in the IWC Table of Accepted Abundance Estimates.

Table 3. Description of minimum requirements for presentation and review of abundance estimates for inclusion in the IWC consolidated table.

Topic	Description
Survey Region	Describe the geographical region to which the estimate applies and identify whether this region fully or partially covers the range of the stock(s) under consideration, at the time the study was conducted.
Time Period	Describe the time period (e.g. year, season) to which the estimate (or set of estimates) applies/apply.
Sampling Period	Specify the time period during which sampling was conducted. If sampling occurs in multiple years, specify whether temporal and geographical consistency was achieved across years, and list other factors that potentially reduce comparability of data collected across the sampling period.
Survey Design	If applicable, include figures/maps showing the proposed and realized survey design for the whole study area and, if applicable, for different strata. If realized coverage is inconsistent with that proposed, include a description of the factor(s) that precluded the survey to be completed as planned.
Method	Identify the method used to compute the estimates. Examples include: design-based distance sampling, spatial models applied to line transect data, mark-recapture methods, shore-based counts, population models, and combinations of these.
Survey Platform and Data Collection	Provide an adequate description of the survey platform and details of the data collection procedures and data processing. For line-transect surveys: • A description of the survey platform (e.g., size of vessels, including the height of the survey platform(s) or type of aircraft and whether they are equipped with bubble or belly windows). • “Searching” modes (e.g., naked-eye, binoculars, towed arrays), searching strategy (e.g., passing or closing model, presence of independent observers/platforms) and methods for estimating perpendicular distance (e.g., reticles, angle boards, clinometers, acoustics). • Indicate whether observers/acousticians were experienced or whether training had been provided.

	• Describe how visibility and environmental conditions during the survey (e.g. weather, Beaufort sea state) were assessed and recorded. • If applicable, provide a description of experiments conducted to estimate visibility (perception/availability) bias on the trackline. • Describe how data were stored (e.g., paper sheets, data-logging software). For mark-recapture methods: • Describe data types (e.g., photo-identification of natural markings, genotyping from biopsy samples) • Describe sampling methods (e.g., digital cameras, video, crossbow, rifle) • Specify ancillary information collected for each animal, such as sex, adult/juvenile/calf and criteria used; • Specify what ancillary data were collected, such as date, time, and position, and effort (e.g., hours/km surveyed) in each sampling occasion. For other methods: • Describe survey methods, data types, and auxiliary information to an extent that allows adequate evaluation of the sampling procedures.
Correction Factors	If applicable, specify whether correction factors were applied to the estimates to account for a missing proportion of the population. These include: correction for visibility bias on the trackline (availability and/or perception) in ship-based or aerial line transect surveys, proportion of animals in the population not presenting natural marks (e.g. "proportion of unmarked animals") or not susceptible to marking in the case of mark-recapture models. In addition, if bias from other sources (e.g. responsive movement in ship surveys, heterogeneity in capture probability in mark-recapture) is expected, provide a quantitative/qualitative description of the bias correction methods. If correction was imperfect, provide a qualitative assessment of the direction of uncorrected bias.
Data Processing	If applicable, describe criteria or exploratory analyses performed to select the data included in the analysis. Examples include: choices for truncation distances, how sightings of species identified with low confidence were treated, how potential issues with identifiability and quality of photographs were dealt with, and criteria used to censor data.
Modeling Approach	Models and model parameters should be clearly defined and statistical methods to estimate these parameters and the uncertainty associated with these estimates should be described in detail, especially if novel methods are used. Any assumptions associated with the estimation method, the data (e.g. population-level assumptions), or the sampling should be clearly stated. Sensitivity analyses should be considered for exploring the impact of key assumptions. If the estimation method is standard, references to the original work should be provided to facilitate the review. Application of novel methods would benefit from a brief discussion contrasting them with more established techniques (e.g. why this new method is expected to offer an improvement over established approaches). Model diagnostics appropriate to the methods used should be considered and discussed. If multiple models are used, provide a description of all models, specify model selection technique (e.g. AIC, BIC) and whether inference is based on a single model, multiple models or model averaging. Clearly specify covariates that are used to model certain effects (e.g. detection probability in distance sampling surveys or capture probability in mark-recapture studies).
Parameter Estimates	Provide values or estimates for all quantities required to compute the abundance estimates. For example, in line transect sampling these would include effort, number of sightings, detection probability, expected group size and correction factors for visibility bias. For mark-recapture models, examples of parameters of interest are capture probabilities, survival, and recruitment. If abundance is computed for different strata, provide stratum-specific parameter estimates whenever applicable. Estimates should be presented in a clear fashion (e.g. in a Table) and should always be accompanied by a measure of uncertainty (e.g. CVs, confidence intervals, posterior credibility intervals). If applicable, indicate estimates of model parameters for which uncertainty was not computed and explain why.
Recommended Estimates	In many cases, multiple abundance estimates from a single survey are presented (e.g. corrected and uncorrected for visibility bias, including and excluding lower quality data). If applicable specify in the text which estimate is recommended to be accepted as the best estimate for a given species/population/stock in a particular time period and state the reasons why that estimate is preferred.
Caveats	List known caveats related to the estimate(s) of abundance, each with appropriate explanation.

The Working Group **agreed** that the minimum requirements set out in Table 3 for the presentation of abundance estimates to be assessed by the Working Group should be adopted.

Attention: SC

The provision of proper review of abundance estimates by the Committee requires adequate description of the data collection protocols, data processing and analytical methods. The Working Group ***agreed*** *on minimum requirements developed for the presentation and review of abundance estimates described in Table 3 above.*

2.3 Process to validate non-standard software/methods

The Working Group noted that comprehensive validation of an abundance estimate is a process that would include many aspects of the associated analysis under consideration: for example, the data used (to ensure that these were correct and correctly entered), the options selected (e.g. as a software package might offer) for the analysis, the model and estimation approach underlying the analysis, the software and code used, and the results (as to whether their interpretation was correct). Note that even use of a widely accepted software package does not guarantee correct results; some options included in such packages may not have been subject to thorough testing of some form.

Both time limitations and costs preclude this full process from being conducted for every abundance estimate to be reviewed. The only obligatory requirement in every instance should be that the options selected for the analysis are fully detailed, *inter alia* to allow a check that they were appropriate for the circumstances. Table 3 of SC/67b/ASI/14 reviews the important components of an abundance estimation analysis to be considered by the Scientific Committee.

Priorities would always need to be identified on the basis of several factors, including:

- The importance (of the result) with respect to Commission priorities. For example, an abundance estimate used for providing management advice is usually more important than one pertaining to a small portion of a large stock in a limited region.
- The cost, in time and money, to complete the validation.
- The degree to which the estimate and/or software or code has been corroborated by other means. One may have more confidence in the internal calculations of a software package if it has been widely used. When several completely independent methods produce similar estimates, the priority for validating one of them may also be lower.
- The degree to which the methods are clearly and completely elucidated in the accompanying document(s).
- According greater priority to methods and/or software likely to have multiple applications than to those intended for a single application only.

Prioritisation of abundance estimates according to the factors outlined above will be carried out by the group appointed to review abundance estimates following the process described in Item 2.1.

The Working Group also **agreed** that it may be useful to develop a set of simulated datasets which can be used to test new methods. Such a framework was successfully used for the TOSSM project used by the SD/DNA Sub-committee for genetic analyses. The feasibility of this approach will be considered further in a pre-meeting to be held immediately before the 2019 SC meeting.

A funding proposal to document and ensure the longevity of existing C++ code previously developed for simulating line transect survey data was presented. Although the software was originally developed in the context of abundance estimation for Antarctic minke whales, the code is generic and would be useful for many different types of species and surveys. This code is already well developed but is at risk of becoming unusable unless it is properly archived and documented. The software is flexible, allowing, *inter alia*, simulation of environments (Beaufort conditions, gradients), how animals act (school size, diving behaviour, distribution patterns, behaviour in relation to vessels), and how surveys operate (number of sightings teams, speed of ship, passing or closing mode). The Working Group noted that the proposal was made in direct response to the Working Group agreement to consider developing simulated datasets to test new abundance estimation methods (above). This software would likely fulfil the line-transect portion of that project.

In considering the proposal, the Working Group felt that it (i) was well defined with specific goals, (ii) provided the opportunity to maintain and modernise a major project previously completed with SC support, (iii) might provide a stimulus for further external funding to support additional software improvements and extensions, and

(iv) would be beneficial to the current and future work of the Working Group, particularly in relation to assessing and developing methods for abundance estimation (see Work Plan, Item 7 in Table 7).

The Working Group considered this project to be imperative and **recommended** that the Committee endorsed this as a high priority budget item.

The Working Group **agreed** that a pre-meeting be organised immediately prior to the 2019 Scientific Committee meeting to consider the requirements and possible processes for the validation of non-standard software/methods used in abundance estimation. An intersessional email group under Butterworth was established to organise the pre-meeting.

Attention: SC

Considering the high technical standards of the work of the Committee, the Working Group often receives estimates of abundance computed using novel methodologies and customized software and code. The Working Group ***agreed*** *that a pre-meeting be organised prior to SC68A to develop a process to validate non-standard software and non-standard methods for estimation of abundance.*

2.4 Process to consider estimates computed from population models

Due to time constraints in the current meeting, the Working Group **agreed** that this item be considered at the pre-meeting to be organised prior to the 2019 SC as referred to in Item 2.3.

Attention: SC

The Working Group noted that a process to consider estimates of abundance computed from population models was needed. The Working Group ***agreed*** *that the development of this process would be discussed during a pre-meeting organised prior to SC68A*

2.5 Process to evaluate abundance estimates already included in the IWC consolidated table, but not yet reviewed by the SC

The Working Group **agreed** that estimates already included in the IWC Table of Accepted Abundance Estimates but not yet reviewed by the SC would be reviewed according to the process described in Item 2.1.

Attention: SC

Abundance estimates already incorporated in the IWC Table of Accepted Abundance Estimates may require review by the Committee in the future. The Working Group ***agreed*** *that these estimates would be reviewed following the process developed in Item 2.1.*

2.6 Amendments to the RMP Guidelines

The 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme', hereafter referred to as the 'RMP Guidelines' (IWC, 2012) constitutes a document prepared by the Scientific Committee to state the requirements and to guide the collection and analysis of survey data to compute abundance estimates for use in the Revised Management Procedure (RMP).

The Working Group noted that there was a requirement for the 'RMP Guidelines' to be modified in order to incorporate spatial modelling approaches to estimate abundance. It was noted that this work would have budgetary implications. The proposed modification to the RMP guidelines was not intended to capture any changes that might be required in relation to use of mark-recapture estimates, in that only model-based estimates would be considered at this time. The Working Group **agreed** that a suitable candidate would be found to amend the RMP Guidelines and that this would be undertaken by an intersessional email group led by Fortuna, which will include as members the Chair and Vice-Chair of the Scientific Committee, the Head of Science and the co-Convenors of the Working Group.

Attention: SC

The 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme' need to be modified to consider estimates of abundance using model-based methods. The Working Group ***agreed*** *that an intersessional email group will develop instructions and select a candidate to amend these Guidelines.*

2.7 Review national cruise reports with IWC oversight

The Working Group considered the proposals set out in SC/67b/ASI/14 in relation to assessing and reporting National Cruises. National cruises are an integral part of the work conducted by the Scientific Committee and the results of these cruises are often relevant for many of the SC sub-committees and working groups. They frequently yield information on multiple species (e.g. large whales and small cetaceans) or stocks, which are treated differently by the various groups within the Committee.

It was proposed that cruise reports are reviewed by the ASI working group if they:

(a) Provide new abundance estimates,

(b) Describe new research methods relevant for computing abundance estimates,

(c) Require advice from the SC with respect to methodological approaches related to estimation of abundance.

Other information provided in the cruise report (e.g. data on distribution, population structure) would be reviewed in the context of the ongoing work in other sub-committees (e.g. Northern Hemisphere Whale Stocks [NH], Southern Hemisphere Whale Stocks [SH]), whenever that is relevant to their agendas. In order to optimise the work of the Scientific Committee, it was suggested that reports of multi-year cruises are submitted to the ASI Working Group only once per biennium, preferably in years between Commission meetings (i.e., SC "A" years). Cruise planning reports would continue to be reviewed by the ASI Working Group with an emphasis on the methodology proposed for estimation of abundance.

In discussing these issues, the Working Group considered the extent to which summaries of national cruise reports should be included as a table or appendix to the ASI working group report. It was suggested that only limited summaries would be required, except in cases where something unusual happened on the cruise that would warrant consideration by ASI. In the latter case, the Convenor of ASI, in consultation with the Head of Science, would assess on a case-by-case basis those national cruises that might potentially require more detailed attention.

It was noted that some national cruises are important for the operation of the RMP (e.g. Iceland surveys by standard methods every 5 years), are conducted under IWC oversight, and the Scientific Committee has an obligation to review, accept or change those cruise plans.

In considering the reporting and assessment requirements for national cruise reports, the Working Group **recommended** that governments submit national cruise reports biennially in years between Commission meetings (i.e. SC "A" years), with the exception of those cruises with particular issues identified by IWC oversight, in which case the cruise report may be required to be assessed by the ASI Working Group. The Working Group also **agreed** that cruise reports will be summarised in the Working Group's report a simple table giving the name of the name of cruise, where/when it happened, and a reference. It was also **agreed** that the Convenors of the Working Group, in consultation with the Head of Science, may in some circumstances identify cruise reports that require more detailed assessment and reporting, including those that provide abundance estimates, describe new research methods for abundance estimation, or require advice on new methods for estimating abundance. Finally, the Working Group **agreed** that the RMP Guidelines should be modified to accommodate these procedural changes to the frequency and extent of the Working Group's assessment of national cruises conducted under IWC oversight.

Attention: SC, CG-R

The Committee ***recognises*** *the value of information provided by national cruises with IWC oversight. The Committee noted that a process to optimise the review of national cruise reports is needed and*

(1) ***recommends*** *contracting governments to submit reports of multi-year cruises with IWC oversight biennially, in years between Commission meetings (e.g. SC "A" years);*

(2) agrees *that cruise reports will be summarised in a table;*

(3) ***notes*** *that that in certain circumstances, cruise reports may require additional evaluation; and*

(4) ***agrees*** *that the 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme' should be modified at next year's meeting to accommodate procedural changes with respect to the submission and review of national cruise reports.*

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3. EVALUATIONS OF ABUNDANCE ESTIMATES AND UPDATES OF THE IWC CONSOLIDATED TABLE

3.1 Evaluation of new abundance estimates

3.1.1 Large whales

3.1.1.1 BERING-CHUKCHI-BEAUFORT SEAS BOWHEAD WHALE

SC/67B/AWMP/01Rev1 reported on the analysis of photo-identification data collected from a 2011 aerial survey of Bering-Chukchi-Beaufort Seas bowhead whales. The 2011 data were scored and matched to existing images from 1985, 1986, 2003, 2004 and 2005. Other inter year comparisons between this set of years were also conducted to generate a complete matching matrix for the 6 years. These data were used to estimate bowhead adult survival rate and population abundance using Huggins models embedded in a Robust Design capture-recapture analysis. The estimated adult survival rate was 0.996 with approximate lower confidence bound 0.976, which is consistent with previous estimates and with research showing that bowhead lifetimes can be very long. Estimated 2011 abundance was 27,133 (CV=0.217, 95% CI 17,809 to 41,337) adding to the evidence (e.g. Givens *et al*., 2016) that the stock is abundant, increasing from previous years, and unlikely to be harmed by limited subsistence hunting.

The Working Group noted that this abundance estimate updated a previous one discussed at last year's meeting (IWC, 2018a) using a revised correction factor to account for the proportion of unmarked animals in the population (p*). In discussion, a questions regarding the reason p* from 2011 differed from other years was raised. In response, it was noted that the decreasing trend in p* over the period of the surveys may be the result of strong population growth with increasing numbers of young whales that are less likely to be prominently marked compared with older whales. Another possible explanation was that, in 2011, most marked animals arrived later in the season, while survey coverage was greatest earlier in the season. This latter possibility was thought unlikely to be an important factor in determining p* because the estimation procedure corrected for survey coverage. Another question pertained to why the 2011 estimate of p* was preferred over an inverse variance weighted average of values for all primary periods. In response, it was noted the model produced a separate marked whale abundance estimate for 2011, and the most appropriate correction factor for that estimate would be the p* specific to that year, since p* in 2011 differs from values seen in previous decades. Nevertheless, an alternative estimate using the inverse variance weighted average was provided, but this estimated was not accepted.

The Working Group concluded that the SC/67b/AWMP/01Rev1 estimate was suitable for providing management advice and using with the *Bowhead SLA*. It also noted that there is a second abundance estimate, also for 2011, using entirely independent data from an ice-based survey (Givens *et al.*, 2016), and this estimate is already endorsed by the Committee and used in the *Bowhead SLA*. The Working Group **recommended** that the photo-id estimate be referred to the Standing Working Group on the AWMP for consideration of whether it should be incorporated in *SLA* calculations, and if so, how it would be used in conjunction with the ice-based estimate.

SC/67b/AWMP12 provided an update on plans to conduct a population survey for Bering-Chukchi-Beaufort seas bowhead whales. The last successful survey was conducted in 2011. Because the Committee wants population estimates every 10 years, the next survey and estimate need to be completed by 2021. Two different types of surveys will be attempted in 2019. The first is an ice-based count to be carried out during April and May. This method has been used most frequently in the past but changes in sea ice have increased concerns about safety and suitability of the ice. A visual count is planned but the acoustic component will not be attempted in 2019 to reduce risk and expense. Instead, the visual count will be corrected for whales outside visual range using previously collected acoustic data.

In response to a question on the reliability of using past acoustic data to correct future ice-based counts, it was explained that even though the distribution of shorefast-ice is changing, the whales always approach the survey area from the southwest and pass close to the ice edge near Utqiaġvik. This means their passage near to observation stations is restricted and that previous acoustic data should be suitable for correcting the visual counts. It was further noted that several of the past BCB bowhead ice-based survey estimates have also relied on existing acoustic data and the methodology was well-established within the Scientific Committee.

The second planned 2019 survey for BCB bowheads is a line-transect survey across the US and Canada Beaufort Sea and Amundsen Gulf during August. NOAA and the North Slope Borough Department of Wildlife Management convened an expert workshop in March 2018, to begin planning for this survey. The workshop report is provided in SC/67b/AWMP/16. Workshop objectives were to: 1) identify known gaps in information needed for a successful survey, 2) identify research that could be conducted to address those information gaps, 3) recommend survey design and protocols, 4) discuss analytical methods that could be used to produce the most precise, unbiased abundance estimate possible from these data, and 5) estimate the survey cost and identify project partners. SC/67b/AWMP/16 also summarizes progress made on all these topics.

The Working Group established a small group to formulate general advice and help draft survey protocols appropriate for the likely types of bowhead sightings, particularly with respect to the presence of infrequent high-density feeding aggregations. The use of updated data collection and recording equipment was recommended. The importance of simulation testing of planned protocols (to assess the impact on the abundance estimate) was emphasised. The Working Group **agreed** with the recommendations of this group, which are detailed in Appendix 2.

3.1.1.2 EAST CANADA-WEST GREENLAND BOWHEAD WHALE

SC/67B/INFO32 provides an estimate of the 2013 population size of the EC-WG stock of bowhead whales based on an aerial survey conducted by the Department of Fisheries and Oceans (DFO) in the eastern Canadian Arctic. The survey involved three aircraft for the full month of August also targeted Baffin Bay narwhal stocks. This was the first attempt to cover the full extent of the summer distribution of the EC-WG bowhead whale stock. The study area was stratified based on geographic boundaries as well as presumed densities of narwhals and bowhead whales (systematic parallel transects for high density strata and equally spaced zigzags for low density areas). Distance sampling methods were used to estimate detection probability away from the trackline. Perception bias was calculated with a mark-recapture model based on duplicate sightings from the double platform experiment and g(0) for the combined observers was estimated at 0.97. Abundance in Isabella Bay was estimated using density spatial modelling to account for its complex shape and uneven coverage. The majority (79%) of bowhead whales sighted were single. Estimates were corrected for availability bias using a new analysis of 22 satellite-linked time-depth recorders transmitting information on the diving behaviour of bowhead whales in the study area in August 2012 and 2013. Those data allowed for specific correction factors to be developed for each stratum. However, this instantaneous correction did not take into account the time-in-view of sightings because the available dive data did not include direct measures of surface and dive times. The fully corrected estimate for the EC-WG population was 6,446 bowhead whales (CV 26.4%). The precision of this estimate was improved by the large number of sightings (242 vs. 34 in the 2002 survey). Due to weather, the coverage remained incomplete (Fury and Hecla Strait and Northern Foxe Basin could not be surveyed) and therefore the abundance might have been underestimated. However, information from concurrent satellite tracking of 11 individuals suggests that only a small proportion of the population was outside the survey area during August 2013.

The Working Group thanked Canadian scientists for attending the meeting to present their work, appreciating the scope of the study and its importance for assessing the species. It was noted that the estimates presented were relatively precise for those typically observed for aerial surveys, to which the authors responded that the high precision arose due to a combination of factors, including that most sightings occurred in areas with good survey coverage and in clear weather, and that effort was stratified effectively. Results indicated that most of the variation arose from encounter rates along tracklines.

Consequently, the Working Group **endorsed** the abundance estimate of 6,446 bowhead whales (CV 26.4%) for the EC-WG bowhead stock as Category 1. The Working Group **agreed** that the results of SC/67b/INFO/32 should be referred to the Standing Working Group on the AWMP for consideration for use with the *West Greenland Bowhead SLA.*

Frasier *et al*. (2015) describes analyses of genetic capture-mark-recapture data to estimate the abundance of the EC-WG stock of bowhead whales, as an alternative to aerial surveys, which have had difficulties in covering the entire summer distribution of this population. Over the period 1995–2013, 1,177 biopsy samples were collected at Canadian and Greenland sites representative of the range of movements observed in EC-WG bowhead whales. These samples resulted in the identification of 992 individuals, but only 49 recaptures were made between years and across different areas. The low number of recaptures, by itself, suggests a large population size. Bayesian methods were used to estimate abundance using either the full dataset or a recent 5-year-period, but given that the population has been increasing, the assumption of a closed population over the full study period was not met. An analysis taking into account the spatial distribution of samples provided estimates of abundance for each location but had difficulties estimating movement rates and abundance in unsampled locations due to the low number of recaptures. Future plans include to continue to increase sample size and expand to new sampling locations.

The Working Group welcomed the presentation of this work. In response to a question on the extent to which missing location information and the potential for asymmetric migration of animals might affect the precision of estimates, it was noted that satellite tagging had helped to identify movement patterns and supported the model assumption that migration was symmetric, but that uncertainties associated with location-specific estimates meant that a location-independent estimate derived from all the data was preferred. It was further noted that the estimates presented in Frasier *et al.* (2015) were not used for management purposes by Department of Fisheries and Oceans Canada (DFO), a decision that may have been influenced by the fact that another estimate derived from more traditional methodologies existed.

The Working Group noted that two datasets were used to compute abundance estimates in Frasier *et al.* (2015): one spanning 19 years ('full') and another spanning 5 years ('5-year'). It was noted that using a closed mark-recapture population model over 19 years is a substantial violation of the closed population assumption (no births, deaths, immigration or emigration). Barlow *et al.* (2011) used simulation to estimate biases in closed population estimators for a 3-year study of humpback whales in the North Pacific and estimated a +5.4% bias due to using a closed model for an open population. If this scales linearly with time, positive bias of roughly 34% could occur in a 19-year period. It was suggested that only the 5-year analyses be considered. It was also noted that the location independent analyses was computed with a Bayesian implementation of model M_0 from Otis *et al.* (1978). However, model M_{th}, with time varying capture probability and individual heterogeneity in capture probability (Chao *et al.* 1992) has been shown through simulation studies to provide less biased estimates when there is a reasonable amount of heterogeneity in the population (Schwarz and Seber 1999). In considering these factors, the Working Group **recognised** the value of the methodological approach and **encouraged** authors to further develop their models and submit their results in the future.

3.1.1.3 NORTH ATLANTIC HUMPBACK WHALE

The Working Group noted that the intersessional workshop on the development of Strike Limit Algorithms for Greenland hunts (SC/67b/Rep06) had thoroughly reviewed an estimate of abundance for western Greenland (WG) humpback whales in 2015 presented in Hansen et al. (in press) (Table 4). The Working Group **endorsed** the conclusions of the workshop that this estimate is suitable for use in management, including all aspects of the SLA development and application and **agreed** to accept the estimate as Category 1.

Table 4. Summary of new agreed fully-corrected line-transect abundance estimates (see text) for common minke, fin and humpback whales in West (WG) and East (EG) Greenland.

Species/Sub-area	Year	Estimate	CV	Approx. 95% CI
Fin				
WG	2005	9,800	0.62	3,228-29,751
WG	2007	15,957	0.72	4,531-56,202
WG	2015	2,215	0.41	1,017-4,823
EG	2015	6,440	0.26	3,901-10,632
Common minke				
EG	2015	2,762	0.47	1,160-6,574
WG	2007	9,066	0.39	4,333-18,973
WG	2015	5,095	0.46	2,171-11,961
Humpback				
WG	2015	993	0.46	434-2,272

SC/67b/ASI/09 presents abundance estimates of humpback whales from the shipboard Iceland – Faroese survey area of the sixth North Atlantic Sightings Survey (NASS) conducted in June/August 2015. Tracks were designed using Distance for the two dedicated vessels. A third vessel simultaneously conducting fisheries surveys, followed tracks designed for these and covered the area west of Iceland during the first and last part of the survey, and around Iceland during the middle part. Two independent platforms with a minimum of two observers each operated independently on all vessels. Most humpback whale sightings were made during the latter part of July north of Iceland and in the Faroese survey area. A few sightings were made in June and August west of Iceland with no indication of a change in density there. No sightings were made in the Southwest area. There is therefore little chance that a shift in distribution during the survey could have biased the results. For sightings with multiple estimates of perpendicular distance, the one providing the most accurate measurement of distance, group size estimate and highest confidence in species identification was selected for analysis. This occurred in 8 cases where the first sighting was not selected, but exploratory analysis indicated that the choice of the record would have a small effect on the abundance estimation. Using conventional line transect methodology and excluding tracks from the fishery survey vessel that were compromised, a combined estimate for all vessels and the two independent platforms corrected for perception bias using mark-recapture methods was 10,031 (CV 0.36; 95% CI 4,962-20,278). As requested by an intersessional correspondence group (see below) the estimate for the 2007 survey using all levels of species ID confidence (which was not available when an estimate of humpback abundance for 2007 was first presented in Pike *et al*., 2010) is also given in this paper. This estimate was 18,105 (CV 0.43; 95% CI 7,226-45,360). Availability bias was considered small for this species in these surveys.

SC/67b/ASI/03 reported the findings of an intersessional correspondence group (ICG) tasked with reviewing abundance estimates for humpback whale around Iceland, including those presented in SC/67b/ASI/09. The purpose of the review was to determine the best estimates for assessing trends in the population over time. Several papers were reviewed, including Pike *et al*. (2002a, 2005, 2009, 2010, 2018), and Paxton *et al*. (2009). The review concentrated on an estimate using 2007 data that was presented to SC67a last year (Pike *et al*., 2010) but not formally assessed, and an estimate using 2015 data in Pike *et al*. (in review). A number of issues were considered, including survey design, analysis decisions, analysis methods, model goodness-of-fit, the potential for reactive movements of animals in response to the survey, and corrections to counts for perception and availability bias.

In summary, the ICG was satisfied in relation to all the issues considered and recommend that estimates for 2007 and 2015 for the area covered by the surveys be classified as Category 1.After considering the advice from the ICG and reviewing the new analyses presented in SC/67b/ASI/09, including an updated version of Pike *et al*. (in review), the Working Group **endorsed** the perception bias corrected 2007 abundance estimate of 18,105 (CV=0.43; 95% CI 7,226-45,360) and the perception bias corrected 2015 abundance estimate of 10,031 (95% CI 4,962–20,278), both applicable to the Icelandic/Faroese study area. Because these estimates were computed with data from shipboard surveys it is assumed that availability bias has a negligible effect in these estimates.

3.1.1.4 NORTH ATLANTIC MINKE WHALE
The Working Group noted that abundance estimates of North Atlantic minke whales from areas CG and WG in Greenland presented in Hansen *et al*. (in press, SC/67b/INFO40) (Table 4) were also extensively reviewed by intersessional workshop on the development of Strike Limit Algorithms for Greenland hunts (SC/67b/Rep06). The workshop concluded these estimates were suitable for providing management advice. The Working Group **endorsed** this conclusion and **agreed** these estimates should be accepted under Category 1.

3.1.1.5 NORTH ATLANTIC FIN WHALE
SC/67b/Rep06 also thoroughly discussed updated aerial survey estimates for West and East Greenland fin whales provided in Hansen *et al*. (in press, SC/67b/INFO40). The main change to the estimates considered by the Working Group last year (IWC, 2018a) is the correction of fin whale abundance for availability and perception bias to give a fully corrected abundance estimate in 2015 of 2,215 (95% CI: 1,017- 4,823). It was agreed that the availability bias correction factor was also appropriate to correct for previous fin whale estimates computed from aerial surveys. The workshop on the development of Strike Limit Algorithms for Greenland hunts (SC/67b/Rep6) recommended the fin estimates in Table 4 for use in conditioning, trials and actual application of SLAs. The Working Group **endorsed** the conclusions of the Workshop and **agreed** the fin whale abundance estimates listed in Table 1 should be accepted as Category 1.

3.1.1.6 NORTH PACIFIC BRYDE'S WHALE
SC/67b/ASI/15 provided updated g(0) estimates for North Pacific Bryde's whales. The new g(0) estimates were used to update previous abundance estimates that assumed g(0)=1. The g(0) estimates were obtained by applying mark-recapture distance sampling methods (MRDS) to sighting data from Independent Observer (IO) mode conducted during the IWC-POWER surveys in 2015 and 2016. Results of the sensitivity test for the g(0) estimate for the best model were 0.863 for TOP barrel and IO platforms, and 0.672 for TOP barrel. Following suggestions from the Intersessional Workshop on the North Pacific Bryde's whale Implementation Review, a weighted harmonic mean of the g(0) estimates under 'good' and 'bad' Beaufort sea states were obtained for areas 1E, 1W and 2. The workshop agreed that similarity between dedicated sighting surveys by NRIFSF (National Research Institute of Far Seas Fisheries) and those under JARPNII was sufficient to allow application of the IWC-POWER survey estimates of g(0) for the Top Barrel only (IWC, 2018b). Previous abundance estimates assuming g(0)=1 were updated using g(0)-corrected for Beaufort sea state conditions. The updated abundance estimates are given in Table 5.

In response to questions on several aspects of the work presented in SC/67b/ASI/15 it was noted that a dedicated researcher operated from the upper bridge to identify duplicate animals, and that abundance estimates had been corrected for Beaufort state on a per-year basis to accommodate differences between northern and southern survey areas. Two sets of abundance estimates were provided, one corrected by the per-year estimates of g(0) and another with g(0) constant across all years. It was noted that although the intersessional workshop on North Pacific Bryde's whale Implementation Review had recommended the latter (IWC, 2018b), the workshop had also requested that year-specific Beaufort correction be performed, and that has now been performed.

In discussion the Working Group was advised that the RMP Sub-Committee planned interpolations to extend some of these estimates beyond the area covered by the surveys in question, to progress its work on the current Implementation Review for this population. The results from these interpolations would be reported to next year's meeting for their review by the Working Group.

In considering the estimates, and taking into account the recommendations of the recent Implementation Review, the Working Group **agreed** the abundance estimates computed with year-specific Beaufort-corrected g(0) estimates (Table 5) should be accepted as Category 1.

Table 5. Accepted line transect abundance estimates for North Pacific Bryde's whales.

Year	Area	Estimate	CV	95% CI
1995	1W	12,149	0.41	5,579-26,454
1995	1E	15,695	0.42	7,079-34,801
1995	2	4,340	0.45	1,876-10,039
2000	1W	6,894	0.47	2,872-16,549
2000	1E	19,200	0.56	6,929-53,204
2000	2	6,083	0.61	2,030-18,229
2011	1W	25,158	0.38	12,202-51,872
2011	1E	9,315	0.33	4,957-17,505
2014	2	6,491	0.36	3,254-12,950

3.1.1.7 NORTH PACIFIC HUMPBACK WHALE

SC/67b/NH/04 provided a preliminary report on the abundance of humpback whales in a summer feeding ground in the North Pacific. Abundance estimates were derived using sighting data from 2010-2012 and 2017 surveys of the International Whaling Commission Pacific Ocean Whale and Ecosystem Research (IWC-POWER). A design-based line transect method was primarily used for the estimation of density and abundance. In addition, a spatial modelling approach was tested as a model-based method using generalized additive models (GAMs) with potential covariates of longitude, latitude, SST and distance from the coast. The different methods produced somewhat different estimates, and further research is warranted to improve the spatial modelling. The authors of the paper will work to examine and update estimates so that they might be used for future in-depth assessment of this species in the North Pacific Ocean.

The Working Group noted that the model-base abundance estimates were appreciably higher than the design-based estimates. The author acknowledged that the model-based estimates included some novel covariates and should be considered preliminary and subject to further refinement. Exploring alternate underlying distributions for grid abundance estimates and/or school counts (e.g. count processes) could improve model fit. The Working Group **encourages** further development and exploration of model-based approaches, their comparison with traditional design-based approaches, and would welcome the presentation of new estimates in the future.

3.1.1.8 WESTERN GRAY WHALE

SC/67b/ASI/02 presented abundance estimates for western North Pacific gray whales that correspond to the various stock structure hypotheses developed at the series of range-wide workshops. An individual-based population model was fitted to individual data from photo-identification programmes operating off NE Sakhalin and (in some years) SE Kamchatka, supplemented by sex determinations from biopsy, tracking of individuals to wintering grounds, and photo-id matches between Sakhalin/Kamchatka and Baja California, Mexico. Abundance estimates are presented for the Western Feeding Group and for the Western Breeding Stock in 1995 and 2015. Abundance estimates for the Western Feeding Group in 2015 range from about 130 to about 300 whales (aged 1 yr and over) depending on stock structure hypothesis, while abundance estimates for the putative Western Breeding Stock are all less than 100.

As requested by the Working Group last year, a full specification of the model used was provided in an Appendix of SC/67b/ASI/02. The formal model is generic: case-specific applications such as to gray whales are specified in the form of model inputs.

In response to a question about the effect of sex not being known for all animals, the author explained that the sex ratio at birth was assumed to be 50:50 but the probability that any given animal of unknown sex is, say, female will depend on the sighting history according to the formulae in the Appendix of SC/67B/ASI/2.

In response to a question about the likelihood formulation, the author explained that a two-step process was used. First, an approximate likelihood was obtained by treating each individual's biography as independent of the others. This approximate likelihood was then used to guide the sampling from the posterior distribution. The maximum-likelihood estimates use the approximate likelihood, which was essentially the same formulation as that used in previous iterations of the model for gray and right whales. The posterior distributions of the population trajectory use the full likelihood, but the approximate likelihood is used to enhance the efficiency of sampling of the full likelihood and thereby reduce runtime.

The Working Group expressed their appreciation to Cooke for following up on last year's recommendation to provide a consolidated explanation of the estimation method, including full details of the likelihood function and how posterior samples are generated. The Working Group noted that for abundance estimation using population models of this kind of population, formal validation of the method and the software would be a major task with budgetary implications. This matter was discussed further under agenda item 2.3 where alternative, possibly easier, validation approaches, such as the use of test data sets, was considered.

The Working Group noted that because nearly all the animals in the Sakhalin population had been individually identified, the surveys approximated a census of the entire population, and hence the estimates were not much greater than simple counts. It was also noted that a previous version of the model had been positively reviewed by researchers from St. Andrews University under an IUCN contract. In considering how the estimates might be used, the Working Group recalled that estimates were explicitly tied to the stock structure hypotheses postulated by the IWC Scientific Committee's Range-wide Review of the Population Structure and Status of North Pacific gray whales (IWC, 2018c).

The Working Group **endorsed** the Western Feeding Group population estimates (Year = 1995, N = 74, CV = 0.05 and Year = 2015, N = 200, CV = 0.03) computed for the base-case stock-structure hypothesis (3a) provided in SC/67b/ASI/02 for use in the Committee's rangewide modelling exercises for North Pacific gray whales. The Working Group **agreed** that the analysis method and abundance estimates would be further reviewed a pre-meeting workshop scheduled to occur before next year's meeting to determine how best to use the results for providing management advice.

3.1.1.9 SOUTHERN HEMISPHERE BLUE WHALE

SC/67b/SH/05 reported a capture-recapture abundance estimate of New Zealand (NZ) blue whales using photo-id data collected in the South Taranaki Bight (STB) region during January and February in three different years. A total of 90 blue whales were photo-identified across these years (2014: n=22; 2016: n=26; 2017: n=42). The program Multimark in R developed by McClintock (2015) was used to generate a Bayesian closed population abundance estimate. Multimark allows for the integration of multiple "mark types", including both left and right side photos to compute a single abundance estimate with an increased sample sizes. The model included covariates of sampling period to account for heterogeneity in capture probability, and survey effort to account for variation in capture effort. A closed population estimate was generated due to a lack of information on immigration and emigration rates, and because (1) no matches have been made between individual blue whales identified in New Zealand and those identified in Australia or Antarctica, (2) the NZ population has significant genetic differentiation from all other known Southern Hemisphere blue whale populations, and (3) all inter-annual individual resights within the NZ's EEZ have at least one match to the STB region indicating population mixing in this area. The authors used a closed population model to provide a conservative abundance estimate of blue whales in NZ.

The Working Group noted that while simultaneously considering left- and right-side photographs had increased effective sample sizes for mark-recapture estimation of population size, the estimate was still only based on 9 recaptures, resulting in a large CV. The Working Group also noted that the estimate would not be immediately used and **agreed** it should be evaluated by an intersessional correspondence group for presentation at next year's meeting. This group will be appointed following the process described in item 2.1 above.

SC/67b/SH/08 used photo-identification data of Antarctic blue whales from 1990/91 to 2014/15 in a capture-recapture analysis to produce estimates of super-population abundance for the circumpolar Antarctic. Photographs were collected during IWC, IWC-SORP, Institute of Cetacean Research (ICR), and South African Antarctic Blue Whale Survey (SAABWS) cruises. An estimate for the IWC Management Area III 1992/93 to 2013/14 was also produced. Population estimates were computed separately based on the left and right side photos. As the true population structure(s) is currently undetermined, different assumptions were made about Antarctic blue whale spatial population boundaries and mixing. For the circumpolar model, all Antarctic blue whales were treated as a single population and assumed to mix uniformly throughout Antarctica. The blue whales in Area III were treated as a distinct population with a higher probability of being re-sighted in Area III than in other Antarctic management areas. The R package RMark version 2.1.12 was used as an interface to program MARK version 8.0 to apply the POPAN open-population model. The authors provided circumpolar estimates of Antarctic blue whales for the years 1990/91 to 2014/15, and estimates of abundance for Area III for 1992/93 to 2013/14. As more photo-ID data become available in the future, the reliability of the capture-recapture estimates should improve.

The Working Group queried several issues in relation to the estimates presented in SC/67b/SH/08 Rev2, including the population- and sampling-level assumptions associated with the estimation, the fact that confidence intervals extended below zero, and the time period over which the estimate applied (i.e. were the estimates instantaneous or aggregate?). In response, it was noted that data were sparse towards the beginning of the series, and these estimates should be considered only preliminary; as more data are collected, more sophisticated methods may be possible. The Working Group considered that the estimation software used was well established and sound, but that more detail needed to be provided about how it was used. They noted that a simple model is likely to be more beneficial because these sparse data would be unlikely to support more complicated approaches. It was further noted that an assumption of a circumpolar super-population is unlikely realistic for these data, and that a simple model assuming a single survival and recruitment rate may be appropriate.

The Working Group thanked the authors for the work and **encouraged** them to revise the estimates, taking into account the points raised in discussion, including considering a simplified model and fully specifying assumptions underpinning the estimates.

3.1.2 Small cetaceans

3.1.2.1 MAUI DOLPHIN

SC/67b/ASI/05 presented an analysis of the genetic capture-recapture data for Māui dolphins (*Cephalorhynchus hectori maui*). The data were analysed in two ways: (i) the minimal model of Baker *et al* (2013) involving a single recruitment and mortality rate; and (ii) an individual-based population model which incorporated an age at first calving of 7yr and a minimum inter-calf interval of 2yr. The detailed specifications of the generic individual-based model and the fitting method are given in the Appendix to SC/67b/ASI/02, while the options used for the Maui dolphin analysis are provided in given in SC/67b/ASI/05. The best-fitting model using the AIC criterion had constant, sex-specific mortality rates and no individual heterogeneity. It showed that the population had very likely been declining over the period 2001-16, reaching 57 (SE 6) for the aged 1+ population in 2016. However, a scenario in which the population was assumed to stabilise by 2016 could not be excluded. Because the available data were insufficient to discriminate between different values for the intrinsic rate of increase (r_0) and carrying capacity (K), projections were made using plausible ranges of values for these parameters (r_0 = 0.02, 0.04, 0.06; K = 200, 500, 1,000). Regardless of the choice or r_0 and K values, the results showed that a reduction in anthropogenic mortality of 80% relative to the average level for 2001-16 was needed to ensure that the population decline is arrested or reversed with 95% probability.

The Working Group welcomed and noted the importance of this research in light of the species' critically low population size. The Working Group noted that validation of the abundance estimates obtained from the full individual-based population model would likely involve a considerable amount of work (see item 2.4). However, it was noted that the population estimate of 57 (SE 6) for 2016 is similar between the more sophisticated model used in SC/67b/ASI/5 and simpler open mark-recapture models (Baker et al., 2013). That estimate is also very similar to the closed population model estimate of 63 individuals (Baker et al. 2016) endorsed by the Working Group last year. The latter, however, does not include a correction for mortality and hence would be expected to be slightly higher than the open model estimates. The Working Group concluded that for the purpose of estimating abundance, the choice of model was, in this case, of lesser importance than the management implications, and that the main reasons for using the full individual-based model was to enable projections to be made under different mortality scenarios. The Working Group **agreed** that this supports previous Scientific Committee recommendations that there is an urgent need to minimise human induced mortality for the Maui dolphin (IWC, 2016). In considering these population estimates, and taking into account the clear need for immediate and on-going conservation actions to halt the population decline, the Working Group **endorsed** the abundance estimates of the Maui dolphin (85 individuals [95%CI: 54, 133] in 2001 and 57 individuals [95% CI : 44, 75] in 2016) and **agreed** they should be accepted as Category 1.

3.1.2.2 FINLESS PORPOISE

Document SC/67b/SM7 reported on the results of a range-wide survey to estimate population size of the critically endangered Yangtze Finless Porpoise (*Neophocena asiaorientalis*). Results provide evidence that the rapid decline experienced by this population between 2006 and 2012 has now slowed and that the population may be increasing. The Working Group could not review estimates of abundance and trends because the methods used to compute them were not described in the paper. The Working Group **encouraged** the authors to provide a document with a description of the methods for evaluation in the future. Further discussion of this document is presented in Annex M, item 7.2.

3.1.2.3 AMAZON RIVER DOLPHINS

Da Silva *et al*. (in press) reported on the decline of Amazon river dolphins (the boto, *Inia geoffrensis*, and the tucuxi, *Sotalia fluviatilis*) in the Mamirauá reserve, central Amazon, Brazil. Declines were estimated based on counts of dolphins in a stretch of approximately 30km in the Mamirauá Channel. This study was developed to assess relative rates of decline, not abundance, and they occurred in a small proportion of the total range of the two species. Further discussion of this paper is given in Annex M, item 2.2.

3.2 Update of the IWC abundance table

Abundance estimates recommended for inclusion in the IWC Table of Accepted Abundance Estimates during the last biennium (2017 and 2018) are presented in Appendix 3. The Working Group **agreed** that the table continues to be updated intersessionally.

Attention: SC, S, C-A

*New abundance estimates **endorsed** by the Working Group for inclusion in the IWC Table of Accepted Abundance Estimates are presented in Appendix 3. The Committee **agreed** that these estimates are incorporated into that table and uploaded to the IWC website. The Committee also **agreed** that the table should continue to be updated intersessionally.*

4. RESEARCH PROGRAMS

4.1 POWER Cruises

SC/67b/ASI12 reports the results from the 8th annual IWC-POWER cruise that was conducted between 03 July and 25 September 2017 in the eastern part of the Bering Sea. The survey was conducted aboard the Japanese R/V Yushin-Maru No.2. Researchers from Japan, the US and IWC participated in the survey. The acoustic survey was introduced to, for the first time, acoustically monitor for the presence of marine mammals, with particular importance for detecting and locating North Pacific right whales localizations. Survey trackline coverage was 71.9 % of the original trackline with a total of 1,571 n.miles. Sightings of fin (145 schools / 198 individuals), humpback (136/165), common minke (17/20), gray (15/22), North Pacific right (9 /18, including 2/3 duplicates), and sperm (25/33) whales were observed during the cruise. Fin and humpback whales were the most frequently sighted large whale species. Gray whales were sighted early in the survey, north of 64oN. There were no sightings of blue or sei whales during the cruise. The Estimated Angle and Distance Training Exercises and Experiments were completed. Photo-identification data were collected for 15 North Pacific right (12 unique individuals, 3 duplicates), 14 gray (all unique), 55 fin, 34 humpback (32 unique individuals), 1 minke and 56 killer whales. The majority of North Pacific right whales were sighted at the western edge of Bristol Bay and in the middle of the critical habitat. Five of the nine right whale sighting were detected and localised using acoustics. A total of 60 biopsy samples was collected from 28 fin, 18 humpback, 9 gray, 3 North Pacific right and 2 killer whales. A total of 240 sonobuoys were deployed, for a total of 841 monitoring hours. A total of 12 objects of marine debris were observed, considerably less than previous cruises. The 8th annual cruise of this programme was successfully completed and provided important information on cetacean distribution, in particular gray and North Pacific right whales, in an area which is poorly-known and logistically difficult to access, and where limited survey effort had been conducted in recent decades. These results will contribute to the aforementioned objectives of the IWC/SC.

The Working Group welcomed the important new information provided, especially with respect to North Pacific right whales, and highlighted the value of the acoustics component of the research program. The Working Group thanked the Government of Japan for generously providing the vessel and the crew for the survey. The Government of the USA was acknowledged for granting permission for the vessel to survey in their waters and for providing an acoustician and acoustic equipment. The Working Group recognised the value of the data contributed by this and the other IWC-POWER cruises, collected in accordance with survey methods agreed by the Committee and addressing an important information gap for several large whale species. The Working Group **encouraged** the future provision of abundance estimates arising from these data as discussed at the Planning Meeting described below.

Donovan introduced the report of the Planning Meeting for the IWC-POWER cruise for 2018 (SC/67b/Rep04), held in Tokyo from 4-6 October 2017. Donovan thanked Japan for hosting the meeting and the warm welcome. The Planning Meeting reviewed the available data (including preliminary results from the 2017 cruise) and status of analyses, including examination of the distance and angle experiments, and developed a workplan to take these issues forward, including obtaining consolidated abundance estimates. Parallel itineraries and plans were developed for surveying either the central or the western Bering Sea, contingent upon the outcome for a Russian permit application for 2018, which was expected to be received by 15 April 2018. Because the Russian permit was not received by this date, the 2018 IWC-POWER cruise will be held between 3 July and 25 September 2018 in the central Bering Sea. These dates include transit from and to Japan using the research vessel *Yushin-Maru No.* 2, kindly provided by Japan, which now has international clearance and can visit foreign ports (as it did during the 2017 cruise). This will be the ninth cruise under the successful international IWC-POWER programme. Together, the cruises conducted in 2017, 2018 and 2019 will cover the entire Bering Sea (Fig. 1). The 2018 cruise objectives are broadly the same as in previous years. The central Bering Sea cruise will continue to use the acoustic component successfully developed in 2017. The use of acoustics had been previously endorsed by the Scientific Committee and is conducted in cooperation with the US. The cruise will focus on the collection of line transect data to estimate abundance as well as collection of acoustic, biopsy and photo-identification data. This will make a valuable contribution to the work of the Scientific Committee on the management and conservation of populations of large whales in the North Pacific. A number of tasks to be completed prior to the cruise were identified. Koji Matsuoka of Japan has been appointed Cruise Leader. Appropriate deadlines and responsible persons were identified. It was noted that the budget for the survey in 2018 had already been approved.

The Working Group **endorsed** the 2018-2019 IWC-POWER Cruise and thanked the government of Japan for the provision of the vessel and logistical support. The Working Group **strongly recommended** that Russia undertake all possible efforts to ensure that permits are issued to the 2019 IWC-POWER cruise to survey the western Bering Sea. The Working Group **looks forward** to receiving a report from this survey at the next Scientific Committee meeting.

SC/67b/ASI/13 proposed the line transect sighting survey cruise plans for the 2019 and 2020 IWC-POWER as a short term (up to 2019) and a middle term research programs (after 2020). The research vessel, *Yushin-Maru* No. 2 (YS2) will be available for each cruise. Cruises will occur from July to September. Photo-id and biopsy experiments will be components of both cruises in addition to distance sampling. The duration of the survey will be approximately 85 days involving international port refuelling and approximately 60 days in the research area. The 2019 cruise will be the last cruise for the Bering Sea and complete the initial phase of the agreed IWC-POWER programme. Details and objectives for the 2020 cruise will be discussed at the forthcoming Technical Advisory Group (TAG) meeting in 2018, in light of the results of the initial phase thus far and consideration by the TAG of the implementation of the agreed medium-term component of the programme. A planning meeting will also occur in autumn 2019. The data and report of these surveys would be submitted to the IWC/SC meetings after the cruises. Further details of the planning of 2020 will be discussed in the planning meeting.

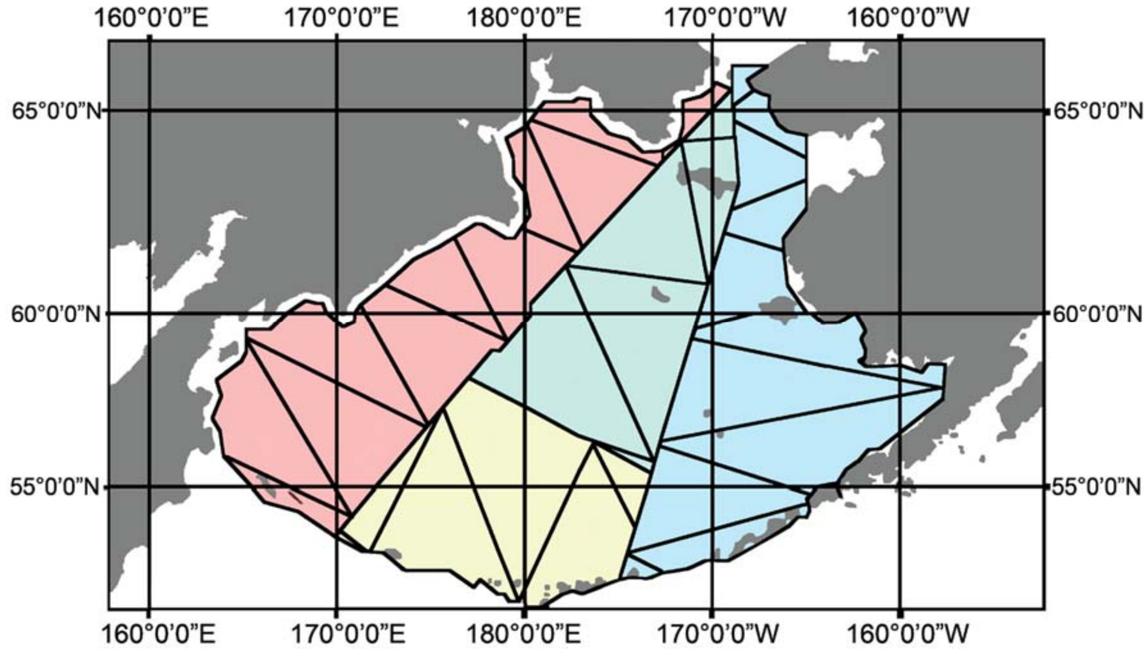

Fig. 1. Survey strata and proposed tracklines for POWER-cruises planned for the period 2017-19. The central block is divided into two strata for logistical reasons (trackline design). In 2018, either the central (green/yellow) or the western (red) block will be covered.

The Working Group welcomed news that the Government of Japan would provide support for the continuation of this important collaborative programme. It **endorsed** the proposed workplan for 2019 and 2020. Financial implications are discussed under Item 6.

Attention: SC, C-A, CG-R

The Committee ***reiterated*** *to the Commission the great value of the data contributed by the IWC-POWER cruises which cover many regions of the North Pacific Ocean not surveyed in recent years and so address an important information gap for several large whales. The Committee:*

(1) ***thanked*** *those governments, especially Japan who generously supplies the vessel and crew, for their continued support of this IWC programme;*

(2) ***agreed*** *that the 2017 cruise was duly conducted following the requirements and guideline of the Committee (IWC, 2012) and looks forward to receiving abundance estimates based on these data;*

(3) ***endorsed*** *the plans for the 2018, 2019 and 2020 POWER cruise and* ***recommends*** *a detailed planning meeting for these cruise;*

(4) ***strongly recommended*** *Russia facilitates the proposed research by providing permits for the IWC-POWER cruise to survey their national waters;*

(5) ***looked forward*** *to receiving a report from the 2018 survey at the next SC meeting.*

4.2 National Programs

SC/67b/ASI/06 presented the plans for dedicated sighting survey in the North Pacific in 2018 and 2019, under the NEWREP-NP program. The design and implementation of the survey will follow the 'Requirements and Guidelines for Conducting Surveys and Analyzing Data within the Revised Management Scheme (RMS)', as recommended by the NEWREP-NP review workshop. The original plan for 2018 was presented originally to the 2017 IWC SC meeting. The survey in 2018 will be based on two vessels, *Yushin-Maru No. 2* (*YS2*) and *Kaiyo-Maru No. 7* (*KY7*). The survey in 2019 will be conducted by the *YS2* and potentially *KY7*. SC/67b/ASI/06 specifies areas and timing of the surveys in the two years. The main objective of the surveys is to get systematic sighting data to study the distribution and abundance of common minke whales for management and conservation purposes. The report of the sighting survey in 2018 will be submitted to the 2019 IWC SC meeting.

In discussion, the sub-committee noted that the Implementation Review for western North Pacific minke whales was scheduled to begin in April 2018 and therefore any relevant data collected during the 2018 NEWREP-NP cruise would need to compiled and analyzed quickly if they are to be included as part of the review prior to its completion. In addition, it was suggested that gray whale photo-identification and biopsy sampling be added to the list of species mentioned in the "experiments" section of the document. The Working Group welcomed the survey plans, **endorsed** the proposal and **encouraged** future presentation of abundance estimates from this survey.

SC/67b/ASI/11 presented the research plan for a systematic vessel-based sighting survey in the Antarctic in the 2018/19 austral summer season, as a part of the NEWREP-A program. Same as in the case of the 2017/18 survey, the design and implementation of the survey will follow the 'Requirements and Guidelines for Conducting Surveys and Analyzing Data within the Revised Management Scheme (RMS)', as recommended by the NEWREP-A review workshop. The main objective of the survey is to get systematic sighting data for the study on distribution and abundance of large whales, which is important for management and conservation purposes. Krill and oceanographic surveys will be also conducted along the tracklines of the sighting survey. The survey will be conducted using two research vessels, *Yushin-Maru No. 2* (*YS2*) and *Kaiyo-Maru No.7* (*KY7*), in Area IV (70°E-130°E). Sighting surveys will be conducted under passing and IO modes. Routine biopsy sampling and photo-id of large whales will be also conducted. The report of the sighting survey will be submitted to the 2019 IWC SC meeting.

In discussion, it was asked if this cruise planned to incorporate outside experts to aid with biopsy sampling (as was suggested by an earlier NEWREP-A review workshop). In response, the authors stated that biopsy sampling would be done on an opportunistic basis. The research plan for the NEWREP-A dedicated sighting survey in the Antarctic in 2018/19 was welcomed and **endorsed** by the Working Group.

SC/67b/ASI/16 reported on a research plan for a cetacean sighting survey in the northwestern Sea of Okhotsk. The period of the survey will be from 3 August to 6 September 2018 (35 days), and the vessel will cover the research area north of the Sakhalin Island to 57ºN, west of 142ºE, including the Shantar Islands. The research area will consist of four blocks. During the transit to the research area, the vessel will conduct the sighting survey in passing mode. Primary objective will be minke whale distribution and abundance. Photo-identification of cetaceans such as northern right whales, gray whales and humpback whales will be also be attempted.

When considering this plan there were several questions regarding the design of the survey tracklines but it was ultimately **agreed** that, given the geography of survey area, in combination with some space use restrictions related to a nature reserve, the tracklines were suitable to achieve the stated research objectives. The working group **endorsed** the research plan and **encouraged** the researchers to report their findings to the Scientific Committee when available.

Attention: SC, C-A

The Working Group recognises the value of information provided by national cruises. The Working Group ***endorses*** *the proposed sighting survey plans and* ***encourages*** *submission of abundance estimates from these studies the future.*

Cruise reports received by the Working Group are listed in Table 6. The Working Group **encouraged** authors to produce abundance estimates with data from these surveys and to present these estimates for review in the future.

Table 6 – National cruise reports received during SC/67B.

Document Number	Title	Survey Region	Cruise Name	Authors
SC/67b/ASI/01	Report of the cetacean sighting survey in the Northwestern Africa coastal waters of COMHAFAT zone (Guinea, Sierra Leone and Liberia) (February/March 2018) cruise report.	Northwestern Africa	COMHAFAT	Diallo S.T. and I.L. Bamy
SC/67b/ASI/07	Results of the NEWREP-A dedicated sighting survey during the 2017/18 austral summer season.	Antarctic	NEWREP-A	Toshihiro Mogoe, Futoshi Yamaguchi, Shinya Kawabe, Taiki Katsumata, Hidenori Kasai, Yasuaki Sasaki, Takeharu Bando and Koji Matsuoka
SC/67b/ASI/08	Report of the Norwegian 2017 survey for minke whales within the Small Management Area EB - the Barents Sea.	Barents Sea	Minke Whale 2017 Norwegian Survey	Nils I Oien
SC/67b/ASI/10	Result of the Japanese dedicated cetacean sighting survey in the western North Pacific in 2017	Western North Pacific	NEWREP-NP	Koji Matsuoka, Takashi Hakamada, Yu Ueda, Takashi Kominami, Nobuo Abe, Chikamasa Ohkoshi and Tomio Miyashita
SC/67b/ASI/17	Cruise report of the cetacean sighting survey in the eastern part of the Sea of Okhotsk in 2017.	Sea of Okhotsk	Sea of Okhotsk Russian Survey	Pavel S. Gushcherov, Petr A. Tyupeleev, Maksim A. Shkarupa, Sergey V. Makrak, Vitaly I. Samonov and Tomio Miyashita

5. METHODOLOGICAL ISSUES

5.1 Consideration of Status of Stocks

The Working Group did not have sufficient time to discuss this item and **agreed** to consider it at the pre-meeting to be held prior to the 2019 SC meeting referred to in item 2.3.

Attention: SC

The Working Group recognises the need to further consider how to report status of stocks and ***agreed*** *to address this topic at a pre-meeting to be held prior to next year's SC meeting (SC68A).*

5.2 Other

SC/67b/SM/09 describes new methodological approaches to improve estimation of abundance of river dolphins using unmanned aircraft vehicle. Drones (off-the-shelf quadcopters) flying 20 m high, 50 m from the side of the vessel, at 35º angle and constant 10 km/h are being tested in South America to refine estimates of group size in line transect surveys for both the boto and the tucuxi. Preliminary results show improved estimates for group size using drones when compared with visual observers. Future steps include testing thermal cameras, developing an automatic identification algorithm and developing statistical methods to use drones to compute correction factors for estimates obtained from cross-channel studies or as an alternate estimation method in narrow waterways

The Working Group welcomed this research and **encouraged** authors to present results of their planned research in the future.

6. WORK PLAN

The Work Plan for the biennium 2018/19-2019/20 is provided in Table 7. Items 5, 6 and 7 have budgetary implications.

Table 7. Work Plan of the Standing Working Group on Abundance Estimates, Status of Stocks and International Cruises for the biennium 2018/19 and 2019/20.

Item	Topic	Intersessional 2018-19	SC68a	Intersessional 2019-20	SC68b	Agenda Item
1	Review of Abundance Estimates	Review estimates identified at SC67B (New Zealand Blue Whales, Arabian Sea humpback whales)	Review intersessional progress and estimates available at SC68A	Review estimates identified at SC68A	Review intersessional progress and estimates available at SC68A	3
2	Upload the estimates accepted at the annual meeting to the IWC website and continue to update the IWC Abundance Table	Update the table with estimates accepted at SC67B		Update the table with estimates accepted at SC67B		2
3	Review and provide advice on plans for future surveys		Receive, review and provide feedback to research plans to conduct abundance estimates		Receive, review and provide feedback to research plans to conduct abundance estimates	4
4	Pre-meeting to consider: (a) validation of non-standard software and methods, (b) estimates of abundance computed from population models and (c) Status of populations	Meeting Preparation	Review of progress			2.3, 2.4, 5.1
5	IWC-POWER Cruise in the Bering Sea	Conduct 2018 survey and planning meeting for the 2019 Cruise	Review cruise report, report from the planning meeting and new abundance estimates from IWC-POWER cruises.	Conduct 2019 survey and planning meeting for the 2020 Cruise	Review cruise report, report from the planning meeting and new abundance estimates from IWC-POWER cruises.	4

6	Amend the RMP Guidelines to consider abundance estimates computed with model-based methods.	Identify a candidate to update the RMP Guidelines	Review an updated document of the Guidelines			2.6
7	Develop simulation software to evaluate methods for abundance estimates		Review Progress			2.3

Table 8. Intersessional Email Groups.

SC Agenda Item/ Sub-Committee	Type	Group (short name)	Terms of Reference	Members
Item 3 ASI	ICG	Review of Abundance Estimates	(1) Coordinate the intersessional review of abundance estimates by the ASI Working Group, (2) Appoint expert small group to conduct review of abundance estimates required for next year's meeting.	Zerbini (Convenor), Donovan, Fortuna, Givens, Herr, Suydam.
Items 2.3, 2.4, 5.1 ASI	ICG	ASI Pre-Meeting	Develop a process to (1) validate non-standard software and methods, (2) estimates computed from population models and (3) consider status of stocks	Butterworth (Convenor), Cooke, Donovan, Givens, Punt, Zerbini.
Item 2.6	ICG	Amendment of RMP Guidelines	(1) Develop a set of specific instructions for the amendment of the RMP guidelines to consider model-based abundance estimates, (2) Select a candidate to amend the RMP Guidelines according to these instructions.	Fortuna (Convenor), Butterworth, Donovan, Herr, Kitakado, Palka, Punt, Zerbini.
Item 4 ASI	ICG	IWC-POWER/SOWER	To provide advice on the 2018/2019 and 2019/2020 IWC-POWER cruises (including holding the Planning Meetings), on data analyses, storage and on requests for data/sample use of IWC-POWER/SOWER cruises	Matsuoka (Convenor), An, Bannister, Bravington, Brownell, Clapham, Donovan, Ensor, Kato, Kelly, Kitakado, Miyashita, Murase, Pastene, Wade, Zharikov, Zerbini.

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Appendix 1

Agenda

1. INTRODUCTORY ITEMS
    1.1. Opening remarks.
    1.2. Election of the Chair.
    1.3. Appointment of Rapporteurs.
    1.4. Adoption of the agenda.
    1.5. Documents available
2. REVIEW INTERSESSIONAL WORK
    2.1. Process to review abundance estimates by the ASI group.
    2.2. Minimum requirements for presentation and review of abundance estimates.
    2.3. Process to validate non-standard software/methods.
    2.4. Process to consider estimates computed from population models.
    2.5. Process to evaluate abundance estimates already included in the IWC consolidated table, but not yet reviewed by the SC.
    2.6. Amendments to the RMP Guidelines
    2.7. Review national cruise reports with IWC oversight
3. EVALUATIONS OF ABUNDANCE ESTIMATES AND UPDATES OF THE IWC CONSOLIDATED TABLE
    3.1. Evaluation of new abundance estimates
        3.1.1. Large whales
            3.1.1.1. Bering-Chukchi-Beaufort Seas bowhead whale
            3.1.1.2. East Canada-West Greenland bowhead whale
            3.1.1.3. North Atlantic humpback whale
            3.1.1.4. North Atlantic minke whale
            3.1.1.5. North Atlantic fin whale
            3.1.1.6. North Pacific Bryde's whale
            3.1.1.7. North Pacific humpback whale
            3.1.1.8. Western gray whale
            3.1.1.9. Southern Hemisphere blue whale
        3.1.2. Small Cetaceans
            3.1.2.1. Maui dolphin
            3.1.2.2. Finless porpoise
            3.1.2.3. Boto
    3.2. Update of the IWC abundance table
4. RESEARCH PROGRAMS
5. METHODOLOGICAL ISSUES
    5.1. Consideration of Status
    5.2. New Technologies
6. WORK PLAN

Appendix 2

Detailed Recommendations for the BCB Bowhead Whale 2018 Aerial Survey

In response to the management need for a new BCB bowhead whale abundance estimate by 2021, NOAA and the North Slope Borough Department of Wildlife Management convened an expert workshop to discuss the use of aerial line-transect surveys in the Beaufort Sea and Amundsen Gulf during 2019 to collect data for estimating the abundance of this population. SC/67b/AWMP16 is the workshop report. Workshop objectives were to: 1) identify known gaps in information needed to estimate abundance of the BCB bowhead whale population from aerial line-transect surveys; 2) identify research that could be conducted to address those information gaps; 3) recommend aerial survey design and protocols specific to BCB bowhead whales in the Beaufort Sea; 4) discuss analytical methods that could be used to produce the most precise, unbiased abundance estimate possible from these data; and 5) estimate the survey cost and identify project partners.

One relatively new phenomenon occurring in the western Beaufort Sea is the formation of ephemeral, high-density aggregations of feeding bowhead whales. These aggregations are encountered infrequently, but the number of whales observed in the aggregations may comprise a considerable proportion of the total number of whales detected during a survey year. For example, during five Aerial Surveys of Arctic Marine Mammals (ASAMM) flights conducted in the western Beaufort Sea from 24-27 August 2016, approximately 600 bowhead whales were observed, corresponding to 32% of the total number of bowhead whales observed during the full 4-month survey season (July-October) – hence, this is now a non-ignorable problem. The timing and location of these aggregations cannot be accurately predicted in advance. SC/67b/AWMP16 recommended that modified survey protocols be used to sample whales in these high density aggregations. The draft whale aggregation protocols in SC/67b/AWMP/16 were reviewed by the ASI working group, who identified several concerns and recommended that a small group of line-transect and aerial survey experts discuss ways to modify the aggregation protocols to address those concerns.

The primary goal of the small working group was to draft protocols to conduct aerial surveys of aggregations of whales in the ASAMM study area that would enable collection of data that could be used to produce an unbiased estimate of the total absolute abundance of the BCB bowhead whale population. To achieve this goal, four fundamental issues were addressed:

1. The need to circle to get an accurate estimate of the total number of whales and calves in a sighting. ASAMM data from 2012-2017 show that 76% of all bowhead whale calf sightings were detected only after the survey aircraft broke from the transect to circle sightings of adult whales (AWMP03).
2. The need to circle sightings to confirm species identification.
3. Whether the groups detected during aggregations should be (A) pooled into a single encounter, with a single perpendicular distance (e.g., the middle of the aggregation) and a single group size estimate; or (B) kept as individual events. The working group favored Option B, when feasible.
4. What tools should be used to collect data for Option B, and how those data should subsequently be analysed.

The small working group made the following recommendations:

A "group" is defined as the object detected from the transect, regardless of proximity of individual whales to each other. For example, a group could comprise a single whale, one cow-calf pair swimming closely together, several whales located within a few body lengths of each other, or a patch of tens of whales causing a broad disturbance on the surface of the water.

When a group is detected in an area of low sighting density, the aircraft should record the declination angle and an initial estimate of group size when the aircraft is on the transect and the group is abeam. The aircraft should circle detected groups, as weather and fuel allow, to confirm species identification, obtain a final estimate of group size, and determine whether calves are present. Circling should only occur over area that has already been surveyed on effort (i.e. passed abeam). This recommendation aligns with existing ASAMM survey protocols. The observer on the opposite side of the aircraft from the sighting should avoid scanning while circling.

Any whales detected for the first time while circling (i.e. after the aircraft has diverted from the transect) that are not in close proximity to the original groups that were detected from the transect should be considered "off-effort" sightings and should not incorporated into design-based abundance estimates.

The survey team should experiment with integrating a short lag (e.g. 10-30 sec) after recording a sighting that is abeam before circling on that sighting. During the lag, standard on-effort survey protocols should be used. The purpose of this lag is to provide a brief opportunity to determine whether the initial sighting is part of a dispersed aggregation. The merits of incorporating the time lag (e.g., minimizing the number of whales initially detected while circling) should be weighed against the drawbacks. Potential drawbacks include: inability to resight the initial sighting and subsequent loss of essential sighting information, such as species identification, accurate group size estimate, and determination of calf presence; and the additional time spent backtracking and circling, which reduces the available effort on transect.

When a high-density aggregation of whales is encountered, a distinct whale aggregation protocol survey mode should commence. The aggregation protocol should include the following steps:

Continue to fly directly on the transect without breaking track to circle (i.e., “passing mode”). During this step, it is important to record an accurate declination angle, initial group size estimate, and initial species identification for individual groups, until the point when group density overwhelms the data collection process. Maximizing the ability to record individual detections as separate sighting events will likely require adoption of time-saving data recording methods, such as voice recorders or the digital geometer. Once the group density precludes the ability to record separate detections as individual sighting events, observers should implement one of the following time-saving protocols: (A) pool groups into a single sighting event, recording the declination angle associated with the center of the pooled groups, the associated total number of individuals (or a categorical group size variable) and calves summed across all groups, and initial species identification; or (B) collect perpendicular distances in bins, recording the total number of individuals (or a categorical group size variable) and calves, and initial species identification for each distance bin.

When the aircraft reaches the point where whale density has obviously diminished to background levels, it should break off the transect and circle back through the aggregation, recording detailed sighting information for distinct groups located within 3 km of the transect. If the groups were only detected within a much narrower strip (e.g,, from 0.5 to 1.0 km from the trackline), the protocols should consider attempting to search only within that band in order to exclude detailed sighting information from groups that were clearly not detected initially. The goal here is *not* to try to match groups initially detected from the transect with groups investigated while circling. Rather, this step provides data that can be used to sample the distribution of group sizes in the aggregation and better estimate average group size, uncertainty in group size estimates, number of calves, and species composition for the aggregation as a whole.

When the aggregation has been surveyed in depth (or as fuel and weather allow), the aircraft should return to the downstream point on the transect where it initially diverted to circle, and resume surveying in regular closing mode down unsurveyed transect as long as whale density remains at background levels.

The small working group recommended that these field methods be tested and modified, if necessary, during the 2018 ASAMM field season in order to provide trusted methods that could be used during the proposed 2019 BCB bowhead abundance estimation survey.

In addition, the small working group recommended that simulation trials be conducted to identify the sensitivity of the resulting abundance estimate to various components of the aggregation protocols. These simulation trials should be a priority, not an afterthought. Details that need to be addressed to make the simulations useful in evaluating the recommended aggregation protocol include: modeling the spatial distribution of whale clustering to reflect their likely distribution during the surveys; modeling the observers’ search, detection, and data recording process to reflect the inherent biases associated with the passing and closing modes of the aggregation protocols.

Appendix 3

Table of Accepted Abundance Estimates (2017-2018)

[Rows in gray represent the abundances accepted at last year's meeting]

Area	Cat.	Eval. Ext	RMP/AWMP Status	Date Stamp	Range of Years	Method	Corr	Est.	CV	Approx. 95% CI	Original Reference	Comments	Areal coverage	Programme
North Pacific Bryde's whales														
1W	1	1	C	1995	1988-96	LT	P	12,149	0.41	5,579-26,454	SC/67B/ASI/15_rev1	g(0) = 0.671, CV = 0.24. Require copy of time series		JARPN
1E	1	1	C	1995	1988-96	LT	P	15,695	0.42	7,079-34,801	SC/67B/ASI/15_rev1	g(0) = 0.689, CV = 0.23. Require copy of time series		JARPN
2	1	1	C	1995	1988-96	LT	P	4,340	0.45	1,876-10,039	SC/67B/ASI/15_rev1	g(0) = 0.659, CV = 0.28. Require copy of time series		JARPN
1W	1	1	I	2000	1998-2002	LT	P	6,894	0.47	2,872-16,549	SC/67B/ASI/15_rev1	g(0) = 0.719, CV = 0.20. Require copy of time series		
1E	1	1	I	2000	1998-2002	LT	P	19,200	0.56	6,929-53,204	SC/67B/ASI/15_rev1	g(0) = 0.584, CV = 0.33. Require copy of time series		
2	1	1	I	2000	1998-2002	LT	P	6,083	0.61	2,030-18,229	SC/67B/ASI/15_rev1	g(0) = 0.712, CV = 0.26. Require copy of time series		
1W	X1	1	I	2011	2008-15	LT	-	15,422	0.29	-	SC/67A/RMP4	g(0)=1, superseded by estimates in SC/67B/ASI 15	78.4	POWER/JARPN II
1E	X1	1	I	2011	2008-15	LT	-	6,716	0.22	-	SC/67A/RMP4	g(0)=1, superseded by estimates in SC/67B/ASI 15	92.4	POWER/JARPN II
2	X1	1	I	2014	2013-15	LT	-	4,161	0.26	-	SC/67A/RMP4	g(0)=1, superseded by estimates in SC/67B/ASI 15	78.9	POWER

W N Pacific					2008-2015	LT		26,299	0.185	18,000-38,000		Combined estimate ~26,000 (sum of the three rows above)		
1W	1	1	I	2011	2008-15	LT	P	25,158	0.38	12,202-51,872	SC/67B/ASI/15_rev1		78.4	POWER/JARPN II
1E	1	1	I	2011	2008-15	LT	P	9,315	0.33	4,957-17,505	SC/67B/ASI/15_rev1	g(0) = 0.721, CV = 0.20. Require copy of time series	92.4	POWER/JARPN II
2	1	1	I	2014	2013-15	LT	P	6,491	0.36	3,254-12,950	SC/67B/ASI/15_rev1	g(0) = 0.641, CV = 0.29. Require copy of time series	78.9	POWER
North Atlantic common minke whales														
East Greenland	1	1	S, E, I	2015	2015	LT	P+A	2,762	0.47	1,160-6,574	Hansen et al. in press, SC/67B/FI 40	P = 0.97, CV = 0.04, A = 0.19 (CV =0.27)		
East Greenland	X1	1	S	2015	2015	LT	P+A	2,681	0.45	1,153-6,235	SC/67a/Rep06	Superseded by Hansen et al. in press; SC/67b/FI40		
West Greenland	1	1	S, E, I	2007	2007	SC	P+A	9,066	0.39	4,333-18,973	Hansen et al. in press/SC/67b/FI 40	P = 0.97, CV = 0.04, A = 0.19 (CV =0.27)		
West Greenland	X1	1	S	2007	2007	SC	P+A	9,853	0.43	4,433-21,900	SC/67a/Rep06	Superseded by Hansen et al. in press; SC/67b/FI40		
West Greenland	1	1	S, E, I	2015	2015	SC	P+A	5,095	0.46	2,171-11,961	Hansen et al. in press/SC/67b/FI 40	P = 0.97, CV = 0.04, A = 0.19 (CV =0.27)		
West Greenland	X1	1	S	2015	2015	SC	P+A	5,241	0.49	2,114-12,992	SC/67a/Rep06	Superseded by SC/67b/FI40		
ES	P				2014-16			12,846			SC/67a/RMP03	Final estimate to be calculated on completion of full survey cycle		

EW	P				2014-16			16,537				Final estimate to be calculated on completion of full survey cycle
CM	P				2014-16			57,472				Final estimate to be calculated on completion of full survey cycle
North Atlantic fin whales												
East Greenland	1	1	S, E	2015	2015	LT	P+A	6,440	0.26	3,901-10,632	Hansen et al. in press/SC/67B/FI 40	P=0.99, CV=0.007, A = 0.30, CV = 0.10
West Greenland	1	1	S, E	2005	2005	LT	P+A	9,800	0.62	3,228-29,751	Hansen et al. in press/SC/67B/FI 40	P=0.51, CV=0.21, A = 0.33, CV = 0.43
West Greenland	1	1	S, E	2007	2007	LT	P+A	15957	0.72	4,531-56,202	Hansen et al. in press/SC/67B/FI 40	P=0.86, CV=0.09, A = 0.28, CV = 0.22
West Greenland	1	1	S, E	2015	2015	LT	P+A	2,215	0.41	1,017-4,823	Hansen et al. in press/SC/67B/FI 40	P=0.99, CV=0.007, A = 0.21, CV = 0.22
West Greenland	X1	1	S	2015	2015	LT	P	465	0.35	233-929	IWC/67a/Rep06	Superseded by Hansen et al. in press; SC/67b/FI40
North Atlantic humpback whales												
East Greenland	1	1	S, E	2015	2015	LT	P+A	4,223	0.44	1,845-9,666	Hansen et al. in press; SC/67B/FI40	P=0.98, CV=0.02, A = 0.43, CV = 0.27
East Greenland	X1	1	S	2015	2015	LT	P+A	4,288	0.38	2,097-8,770	IWC/67a/Rep06	Superseded by Hansen et al. in press; SC/67b/FI40
West Greenland	1	1	S, E	2015	2015	LT	P+A	993	0.44	434-2,272	Hansen et al. in press; SC/67B/FI40	P=0.98, CV=0.02, A = 0.43, CV = 0.27
West Greenland	X1	1	S	2015	2015	LT	P+A	1,008	0.38	493-2,062	IWC/67a/Rep06	Superseded by Hansen et al. in press; SC/67b/FI40

Iceland/Faroe Islands	1	1	S, E, I	2007	2007	LT	P	1,8105	0.43	7,226-45,360	SC/67B/ASI/9	P=0.78, CV=0.13.
Iceland/Faroe Islands	1	1	S, E, I	2015	2015	LT	P	10,031	0.36	4,962-20,278	SC/67B/ASI/3 and ASI/9	P=0.69, CV=0.21.
Bowhead whale												
Bering-Chukchi-Beaufort	1	1	S, E	2011	1985-2011	MR: PId	-	27,133	0.22	17,809-41,377	SC/67B/AWM P1-rev1	
East Canada-West Greenland	1	1	S, E	2013	2013	LT	P+A	6,446	0.26	3,722–11,200	Doniol-Valcroze et al. 2015, SC/67B/For Info 32	P=0.97, CV=0.02, A = sub-area specific corrections
Svalbard	3	1		2015	2015	LT	A	343	0.488	136-862	Vacquié-Garcia et al. (2017)	Partial coverage and high CV
Okhotsk Sea	3	1		2016	1995-2016	MR	P+A	218	0.22	142-348	SC/67a/NH10	(require copy of time series)
Gray Whales												
Western Feeding Group	1	4		1995	1995-2015	MR:PA	-	74	0.05	66-81	SC/67B/ASI/2	(require copy of the time series), base-case stock structure hypothesis (3a), age 1+
Western Feeding Group	1	4		2015	1995-2015	MR:PA	-	200	0.03	187-211	SC/67B/ASI/2	(require copy of the time series), base-case stock structure hypothesis (3a), age 1+
Sakhalin Island	3	4		1995	1995-2015	MR:PA	P+A	74	0.06	65-82	SC/67a/NH11	(require copy of time series)
Sakhalin Island	3	4		2015	1995-2015	MR:PA	P+A	191	0.04	175-208	SC/67a/NH11	(require copy of time series)

Sakhalin and Kamchatka	3	4	1995	1995-2015	MR:PA	P+A	129	0.08	107-149	SC/67a/NH11	(require copy of time series)
Sakhalin and Kamchatka	3	4	2015	1995-2015	MR:PA	P+A	282	0.05	255-312	SC/67a/NH11	(require copy of time series)
N. California / N. Vancouver Isl.	1	1	2015		PId		243	0.08		Calambokidis et al. (2017)	SD=18.9; N_{min}=228
California	2	1		2014/15			28,790		23,620-39,210	Durban et al. (2017)	Suitable for use in *SLA* and conditioning range-wide model. Some methodological issues.
California	2	1		2015/16			26,960		24,420-29,830	Durban et al. (2017)	Suitable for use in *SLA* and conditioning range-wide model. Some methodological issues.
Maui's Dolphin											
North Island, NZ	1	4	2016	2001-2016	GMR:PA	-	57		44-75	SC/67B/ASI5	Require copy of time series
North Island, NZ	1	1		2015-16	MR		63	0.11		Baker et al. (2012)	Based on assumption of closure
Hector's Dolphin											
Cloudy Bay, NZ	1	1		2011-12	MR		269	0.12		Hamner et al. (in press)	Based on assumption of closure

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