Annex E

Report of the Abundance Steering Group

1. INTRODUCTORY ITEMS

The Abundance Steering Group met virtually, 19-22 April 2022. Participants were: Allison, Bell, Biuw, Branch, Brandão, Butterworth, Cañadas, Choco, Citta, Doniol-Valcroze, Esteban, Ferguson, George, Givens, Hakamada, Ham, Herr, Hines, Jackson, Katara, Kelly, Lundquist, Matsuoka, Miller, Morishita, Nelson, New, Donovan, Øien, Porter, Punt, Robbins, Rogan, Ross-Gillespie, Schubert, Sigurdsson, Skaug, Solvang, Staniland, Suydam, Tandy, Vikingsson, Vermeulen, Walløe, Weinrich, Wilson, Witting, Zerbini.

1.1 Opening Remarks

The convenor, Givens, welcomed participants to the meeting, recalling that the Scientific Committee (SC) had agreed in 2016 to form the Standing Working Group for Abundance Estimates, Stock Status, and International Cruises (ASI) to ensure that abundance estimates used by the SC receive a consistent level of formal review. Since then, ASI has worked to develop a suitable review process and has undertaken many such reviews.

It had quickly become apparent that the workload for ASI was greater than could be accomplished during the annual SC meeting. Accordingly, in 2019 the SC agreed to form the Abundance Steering Group (ASG) to coordinate an intersessional review process. The ASG is comprised of the SC Chair and Vice Chair; the Secretariat's Head of Science, Conservation, and Management; the Secretariat's Head of Statistics; and the convenors of the following SC subcommittees and standing working groups: ASI, ASW, EM, IST, IA, NH, SM and SH. In addition to the members of ASG, numerous independent experts also participated in the ASG pre-meeting this year.

Givens thanked the participants for contributing their expertise to the pre-meeting, and he offered special thanks to the 25 independent reviewers (listed in Item 6) whose thoughtful reviews, voluntarily contributed intersessionally, would be relied upon during ASG deliberations at the pre-meeting.

1.2 Election of the Chair

Givens was elected Chair. New was elected Co-chair.

1.3 Appointment of Rapporteurs

Kelly and Doniol-Valcroze were appointed rapporteurs. Givens thanked them for their continuing commitment to helping ensure the success of ASG and ASI, and the outstanding work they contribute each year.

1.4 Adoption of Agenda

The agenda, as adopted, is given as Appendix 1.

1.5 Documents Available

The following documents were available to the ASG: Bedriñana-Romano *et al*. (2018), Bradford *et al*. (2021), Branch (2007), Brandão *et al*. (2021), Calambokidis and Barlow (2020), Cooke and Jackson (2017), Félix *et al*. (2021), Ferguson *et al*. (2022), Galletti Vernazzani *et al*. (2017), Hakamada *et al*. (2009), Hakamada *et al*. (2016), Jefferson and Moore (2020), Lawson and Gosselin (2018), Leonard and Øien (2020a), Leonard and Øien (2020b), Matsuoka and Hakamada (2014), Pace *et al*. (2017), Pace *et al*. (2021a), Pace *et al*. (2021b), Renault-Braga *et al*. (2021), Smith *et al*. (2021), Solvang *et al*. (2021), Stewart and Weller (2021), Wenzel *et al* (2020) and Williams *et al*. (2011). Reviews of these documents were also available to the ASG and have been archived by the Secretariat.

2. ASG PROCESS AND ICG RECOMMENDATIONS

As the ASG conducted the review process during the pre-meeting, several lessons about the process itself became apparent.

First, a concern raised during the ASG pre-meeting was that many analyses submitted for review use methods that are not described in detail in the submitted paper, requiring reviewers to access previous papers to make a full evaluation. This situation is quite common for papers submitted to the SC, given the long-term nature of many important cetacean research projects. This issue is compounded by the increasing need to recruit new reviewers who might not necessarily be fully aware of the long history of some of these studies and their consideration at the SC. While additional background papers could be provided to reviewers, this has the potential to add to their burden substantially. To reduce the burden, the senior author of each submission could be asked to provide one other document with detailed methods, if needed. However, not all papers submitted for review involve authors who choose to be engaged in the ASI review process. In general, it should be the responsibility of the convenor requesting ASG review of a paper to provide the paper and sufficient other background material to ASG to facilitate the review. The ASG **recommended** that ASI convey this request to convenors requesting ASI reviews.

Second, it was apparent that convenors are sometimes uncertain about which papers to refer to ASI for review. Givens noted that ASI had tried to clarify this in 2021 by providing the following description of the intended role of ASI (IWC, 2022; item 11):

> The ASI was established to provide consistent, rigorous reviews of abundance estimates submitted to the Committee. It was also instructed to provide a broad overview on the abundance and status of whale stocks for the Commission and the public. Finally, the ASI offers advice on survey design, new technologies, data collection and analysis for abundance surveys coordinated by the IWC (e.g. POWER and SORP) and national research programmes. The ASI provides an advisory service for other sub-groups of the Committee upon request by individual convenors. Not all abundance estimates require review by ASI. Primarily, the ASI will review estimates that need to be endorsed for a specific purpose such as: (i) inclusion in the IWC Table of Accepted Abundance Estimates, including those on the IWC website; (ii) use in an assessment, other mission-critical modelling, or with RMP/AWMP calculations; (iii) informing the Commission on the status of stocks/species; or (iv) use as the basis for providing management advice and SC recommendations. However, there are also circumstances where information on abundance can be used by the Committee's subgroups to progress their work without review by ASI.

Although this was helpful, further discussion among convenors would also be beneficial. Staniland suggested that a decision tree might serve as a helpful reference. Givens agreed to raise the topic with convenors.

Third, the ASG noted that much cetacean research involves projects spanning many years. ASG drew attention to the importance of the long time series of data generated by such work, including whale (or calf) counts, abundance estimates, and photo-id databases. Regardless of how ASI categorizes abundance estimates arising from individual years or brief periods in such time series, the complete data record has inherent value for scientific insight, assessment and management. Furthermore, for some such long projects, regular abundance estimates are routinely provided (e.g., annually) as more data are collected, using the same survey and analysis methods as in prior years. In such cases, it is not necessary for ASI to review each new estimate when it becomes available. Instead, ASG **recommended** that ASI consider a process where such estimates could accumulate for several (perhaps 3) years before receiving review by ASI. After review, the set of recent prior estimates would all be added to the IWC Table of Agreed Abundance Estimates, if they are endorsed.

In addition to these general observations, the ASG discussed the following topics related to the review process.

2.1 Edits to Category Descriptions

In 2021, the SC agreed to revise the categories used by ASI when endorsing abundance estimates, making some changes to clarify wording and adding Category 1B for very small stocks (see item 11.1.1 of IWC (2022)). The Committee also agreed that a small intersessional correspondence group would discuss how best to draw a distinction between categories 2 and 3, and would develop supplementary wording to be presented to the

Committee in 2022 that explains how estimates in categories 1A, 1B, 2 and 3 might be used. The small group would also provide examples of the reasoning for choosing one category over another in various circumstances. Givens convened the small group intersessionally, and expanded its remit to include consideration of suggestions for minor wording changes to clarify all the categories.

Although some progress was made, the small group did not provide a final document in time for consideration at this pre-meeting. Therefore, the ASG agreed to defer consideration of this item until ASI sessions during the upcoming SC meeting, with the expectation that a document would be provided before then.

During ASG consideration of several abundance estimates at the pre-meeting (item 3, below) it was apparent that the category definitions would be improved by further clarifying matters related to stock definition and areas. Some surveys, and corresponding abundance estimates, are never intended to cover an entire stock, but rather to produce results for a specific area—often one relevant for management. The existing category descriptions are somewhat ambiguous about which category ASG/ASI should use when endorsing an estimate derived from a survey that did not cover an entire stock. The small group agreed to consider this issue as it prepared its recommendations for ASI.

2.2 Supplemental wording and examples to explain category selection
See item 2.1 above.

2.3 Process for reviewing author revisions
Sometimes ASI recommends revisions to the analysis of an abundance estimate it has considered. Such guidance may be intended to help the authors improve their estimate so that it can be endorsed by ASI with a higher categorization (e.g. 1A or 2, instead of 3 or P).

For example, this situation occurred with several estimates of franciscana abundance, from various authors, which were first considered at the 2021 Workshop on the Status of the Franciscana (IWC, 2021a). Estimates were reviewed there, suggestions for improvements were offered, and all of this was subsequently reviewed and endorsed by ASI (see item 11.1.2 of IWC (2022)). In a follow-up franciscana workshop planned for June, 2022, some revised and improved estimates that take account of those suggestions will be considered. Those estimates will subsequently be forwarded to ASG for consideration intersessionally. The question is how ASG should address the review of such estimates. To be clear, the franciscana estimates are only an example; this situation arises regularly in ASG's work, and each case is somewhat different.

Options for ASG's review of revised estimates include: (i) solicitation of new, independent reviews, (ii) solicitation of reviews from the previous reviewers, or (iii) direct consideration of the revised estimate at the next ASG meeting without additional review, provided that the authors provide a detailed explanation of how the methodological suggestions were addressed. The complexity of the revisions will differ from case to case, so option (iii) may not always be practical, and the matter might best be handled on a case-by-case basis. However, any guidance provided to the ASG convenors would be helpful.

The ASG agreed that this question should be referred to ASI. Several of the papers under consideration at this pre-meeting included revisions in response to earlier ASI suggestions, and these were handled in a variety of ways during the intersessional period by the convenors of ASG. It was not necessary to consider the more general question now, since it pertains to what ASG should do next year.

3. REVIEW OF ABUNDANCE ESTIMATES
The classification system used to categorize abundance estimates endorsed by ASI and included in the IWC Table of Agreed Abundance Estimates is explained in item 11.1.1 of IWC (2022). The ASG noted that although the categories have numeric labels (and one is 'Not Suitable'), they are not intended to rank the scientific quality or importance of studies. These categories are used only to identify how estimates can be used most appropriately by the Committee and its subgroups, since many of the studies reviewed were not designed explicitly to inform the tasks undertaken by the SC.

For example, the estimate of North Atlantic minke whales (Solvang *et al*., 2021) considered in item 3.2 below is recommended for Category 1A; estimates in this category would be suitable for use in the Committee's

Revised Management Procedure for commercial whaling. The estimate for Rice's whale (Garrison *et al*. (2020); item 11.1.10 of IWC (2022)) endorsed last year by the SC as Category 1B was challenged by a low sighting rate and other issues, but is nevertheless very important to help guide management for this critically depleted species. An estimate for blue whales off Sri Lanka (Priyadarshana *et al*. (2016); item 11.1.3 of IWC (2022)) endorsed last year as Category 3 was derived from a survey covering perhaps only 1-2% of the total geographic area occupied by the stock (thereby rendering the estimate without value for estimating total population abundance, and also being heavily susceptible to process error), but this estimate would potentially be very helpful for local management, including mitigating impacts from fishing and whale watching. All of these estimates will prove very useful in the appropriate contexts and represent important scientific advancements, irrespective of their numerical category labels.

ASI **recommended** that all papers considered below should be assigned the highest level of Evaluation Extent (1, estimate was considered in detail by the sub-committee) in the IWC Table of Agreed Abundance Estimates, with the exception of Cooke and Jackson (2017), which should be given an Evaluation Extent of 4 (estimate was partially considered by the sub-committee and a new method was used). The Evaluation Extent metric is discussed further by IWC (2014a).

3.1 Indo-Pacific finless porpoise near Hong Kong

Jefferson and Moore (2020) present a study of density and abundance of Indo-Pacific finless porpoises in waters to the south and east of Hong Kong, the first abundance estimate since the early 2000s (Jefferson *et al*. 2002). Single-platform line-transect surveys in closing mode using medium-size vessels were conducted for small cetaceans in most of the waters around Hong Kong since 1996. Density and abundance of finless porpoises in the Hong Kong area were estimated using a Bayesian hierarchical framework, consisting of a Markov process model used to describe population dynamics and a distance-sampling observation model that links the line-transect data to the latent biological process. Time series analyses for both dry- and wet-season data from 1996 to 2019 showed annual fluctuations in abundance indices, but no evidence of a significant long-term trend in finless porpoise abundance in Hong Kong. In 2019, there were approximately 176 finless porpoises (corrected estimate) in Hong Kong's waters in the dry season (winter/spring), the season of highest use (where the abundance was adjusted using a correction factor to account for unsurveyed regions in certain years/seasons). Highest densities (0.535 porpoises/km^2) were recorded in South Lantau (south-west of Hong Kong) in the dry season.

The independent reviewers found the survey to be well designed, analysis methods to be excellent and well implemented, and the length of the survey data series to be valuable; the study itself was well documented. However, the reviewers noted it was difficult to understand what population component is being estimated, due to questions of stock definition, range, and seasonal movements; variable and excluded survey coverage; and the fact that the model treats seasons (wet and dry) separately. One reviewer also questioned the estimation of *g*(0) using data from a towed POD (for acoustic detections), which is considered unreliable in other regions. Reviewers also noted the nature of the model also raised difficult questions about which estimates to treat as the "final answer" for the IWC Table of Agreed Abundance Estimates. The correction factor (which aims to correct for unsurveyed regions in some years/seasons by assuming that proportions in different areas remain the same as what was observed in the early 2000s) is also not well supported, and leads to corrected total abundance estimates lacking CVs.

In discussion, the ASG noted it was difficult to judge how much of the population was covered by surveys. Porter commented by email that, in her view, Category 2 was appropriate, as the porpoises in the survey area comprise only a fraction of the larger population in the South China Sea.

The ASG agreed with the reviewers that the correction factor was not well supported. It was further noted that the ASI has never endorsed an abundance estimate that was reported without an associated measure of uncertainty. Therefore, ASG focused on the uncorrected estimates.

The presentation of a time series of abundance estimates in Jefferson and Moore (2020) also prompted the ASG to consider the question of how to summarise such abundance estimates (i.e., for the IWC's Table of Agreed Abundance Estimates). In the case of Jefferson and Moore (2020), the ASG noted that there were substantial fluctuations in the time series of estimates, and that these estimates might also be correlated over time. Therefore, endorsing only the final abundance estimate might be misleading, and endorsing the entire series would ignore potential correlation. The ASG agreed that, when possible, the Secretariat should include variance-covariance matrices when adding time series to the IWC Table of Agreed Abundance Estimates, and that such information should be solicited from authors when it is not presented in the paper. Further discussion concerning the presentation and use of time series of abundance estimates is planned for ASI during the 2022 Committee meeting.

For the purposes of summarising the abundance estimates in Jefferson and Moore (2020), the ASG agreed to calculate and recommend endorsement of inverse-variance weighted averages for three-year periods at the start, middle and end of the series, for both the wet and dry seasons, using the uncorrected estimates. The full time series of estimates is presented in Table 2 of the paper. By separating the start, middle and end periods of the series, it is hoped that these averages are not substantially correlated. The inverse-variance weighted average is a weighted mean where the contribution of each variable is weighted in inverse proportion to its variance. The appropriate standard error for a weighted mean was also calculated.

The ASG **recommended** that the following average uncorrected abundance estimates for Indo-Pacific finless porpoise in Hong Kong waters should be endorsed: during the wet season, 37 (CV =0.303) in 1996-1998, 67 (CV=0.184) in 2007-2009, and 77 (CV=0.207) in 2017-2019; and during the dry season, 65 (CV =0.223) in 1996-1998, 121 (CV=0.144) in 2007-2009, and 108 (CV=0.140) in 2017-2019. The ASG recommended that these averages be classified as Category 2.

3.2 North Atlantic common minke whales

Solvang *et al*. (2021) present abundance estimates of common minke whales in the northeast Atlantic based on survey data collected over the period 2014-2019. This is the fourth survey cycle which Norway has conducted after a synoptic survey of the area in 1995. The surveyed area includes the RMP *Medium Area* E and the *Small Management Area* (*SMA*) CM. Cetaceans were searched for by naked eye from two independent platforms each manned with two observers following the protocols established for these surveys and also used in previous survey cycles. One special feature of these surveys is the tracking procedure introduced for the survey target species minke whale. The analyses of the present survey used a similar approach as previous analyses presented and discussed within the Scientific Committee. The total estimate for the entire surveyed areas (i.e., E+CM) was 149,722 minke whales (CV = 0.15, including additional variance). The abundance estimate for the E *Medium Area* was 104,692 (CV = 0.17, including additional variance) covering the years 2014-2019; the estimate for the *SMA* CM was 37,020 (CV = 0.261) for the year 2016. Other abundance estimates for *SMA*s within *Medium Area* E are given in Tables 2 and 5 of Solvang *et al*. (2021). The point estimates of total abundance in the Eastern *Medium Area* E have been very similar over the survey periods 1996-2001, 2002-2007 and 2008-2013 but now show a 15% increase in the 2014-2019 survey period. The authors attribute this increase to *SMA* increases in the Barents and North Seas at the expense of decreases at Svalbard (ES) and in the Norwegian Sea (EW). Such shifts in overall distributions are also known from historical analyses of long-term series of catch statistics. The minke whale abundance in the total survey area (E+CM) is about 50% higher than in the previous survey cycle. The increased abundance in E accounts for some of this, but a major contribution comes from the increase observed in *SMA* CM, the Jan Mayen area, which had its highest recorded abundance over all the survey cycles in the 2014-2019 cycle. The large shifts also seen in CM over several survey cycles may indicate that the adjacent *Medium Areas* E and C share a common minke whale population.

The independent reviewers noted that the analyses are only briefly described by Solvang *et al*. (2021), with the authors instead referring readers to previous published papers and reports (a situation addressed in item 2 above). The reviewers generally viewed the analysis methods favorably, and noted particularly the unique Norwegian analysis approach (hazard probability model) that was specifically developed for North Atlantic common minke whales. However, description of the more recently developed variance estimation components of these analyses are in unpublished SC papers (e.g., Solvang *et al*. (2015)) or papers in press. A reviewer suggested that a comparison between the Norwegian approach and more conventional approaches that are widely accepted at the SC like mark-recapture distance sampling (with an availability correction based on time-in-view) would be interesting and might reveal strengths or weaknesses of either approach.

This reviewer also questioned why survey measurement error was not included in the final analysis, despite the authors demonstrating in Solvang *et al*. (in press) that it introduces negative bias in abundance estimates. The same applied to the authors ignoring clustering, despite it also likely introducing negative bias in abundance estimate. This reviewer also noted the reported increase in the abundance in the CM *SMA* as commensurate with a large decrease observed in adjacent Icelandic waters, as documented by Pike *et al*. (2020). The other reviewer noted a relatively small frequency of zero perpendicular distances for distances to minke whale groups, and questioned if that was typical of the unique Norwegian line transect survey analysis methods.

Givens thanked the authors of this paper for agreeing at short notice to prepare a presentation of the paper for this ASG meeting, as it was not presented last year.

In discussion, the ASG reflected on the long history of development for the hazard probability approach, much of which had been presented to, and reviewed by, the Scientific Committee over several decades (e.g., Skaug *et al*. 2004, Solvang *et al*. 2015), but that the variance estimation approach had not had as much review. The authors agreed to a request from the ASG to produce a short summary of how and when the Scientific Committee has previously reviewed the analysis methods developed since 1995 by Norway for the purposes of generating abundance estimates in the Northeast Atlantic, particularly including the newer variance estimation methods. This summary is to be presented during the 2022 meeting of ASI.

The ASG also discussed the implications of estimating abundance by area and not by stock or population, as has been presented in Solvang *et al*. (2021). It was noted that the boundaries of the North Atlantic Management Areas had been defined along older stock definitions, and that the Norwegian variant of the RMP used geographic areas instead of stocks. In addition, the Committee had previously noted that the abundance results in Solvang *et al*. (2021) would be useful for the *Implementation Review* for North Atlantic minke whales which is starting in 2022 (IWC 2022, section 11.1.11). In that context, the ASG recalled that the RMP was tested under a variety of assumptions regarding the bias and uncertainty of abundance estimates provided as input, the quality of the surveys providing the underlying sightings data, and other factors. The ASG considered that the implications of the reviewer concerns expressed above would not likely be of sufficient magnitude to prevent adequate performance of the RMP. The ASG therefore did not attempt to resolve every listed concern.

The ASG therefore **recommended** that the 2014-2019 abundance estimate for common minke whales across the northeast Atlantic (*Medium Area* E + *Small Management Area* CM) in summer of 149,722 (CV = 0.15) be endorsed as Category 1A. The separate *Small Management Area* estimates are also **recommended** for Category 1A endorsement, if they are needed for Committee work.

3.3 Eastern South Pacific humpback whales

Félix *et al*. (2021) describe a new population estimate for eastern South Pacific humpback whales (Breeding Stock G; BSG) based on mark-recapture models and fluke catalogues from 23 research groups. The sample includes 6,354 individuals: 1,698 (26.7%) from feeding areas and 4,656 (73.3%) from breeding areas, over the period 1991-2018. Mixture models with two different approaches (full likelihood and conditional likelihood) produced similar results of 11,784 (SE=266) and 11,786 (SE=266) whales, respectively. In both cases, a model with two mixtures (*Mth2*) provided the best fit. Sources of bias were associated with effort heterogeneity, population stratification, and the time scale.

Félix *et al*. (2021) was originally presented to the Committee in 2021 (items 8.4.1 and 11.1.9 of IWC (2022)). At the time, the Committee expressed an appreciation for the scale of the research effort to compile the many databases, and highlighted the commensurate value of the resulting dataset. Also noted were the challenges associated with the scale of the geographic area represented in the combined dataset, and that humpback whale movements throughout the area were not well understood. The Committee also recognised the benefit of incorporating these data into future circumpolar assessments of the species. Concerns were raised about the assumptions of a closed population, sources of the samples, and that some of the CVs seemed unrealistically small. The paper was referred to the ASG for review during the 2021/22 intersessional period, with a request from the authors for advice on how the analyses could be improved.

Both reviewers acknowledged the effort that went into assembling and analysing these data, and noted the value of the data for current and future population and trajectory estimates for BSG. The reviewers also noted that the task of obtaining abundance estimates using mark-recapture methods with such a large and complex data set was a substantial challenge, and that the analyses presented in Félix *et al*. (2021) should be considered an impressive initial attempt. Attempts to model annual capture probabilities were stymied by issues with optimisation, resulting in the authors using closed population models. This was a point of concern for the reviewers on account of the long timespan of the study, and the likely births, deaths and movements that would occur during that time. Abundance likely varied among years, and it is therefore difficult to interpret a single abundance estimate for the entire time period. It was also noted that the abundance estimate pertains to a superpopulation (i.e., an estimate of all animals alive at any point during the time period of the sampling, and not those alive at any one specific time point). Also, it is difficult to judge whether the data adhere to the required assumptions. Another problem identified was variation in sampling effort across all the collated data, and that such variability will affect capture probabilities, but that was not directly accounted for in the model. Finally, the reviewers were also unsure as to what the demographic parameters actually represented in the likely event that the assumption of a closed population was being violated.

In discussion, the ASG noted the extraordinary amount of work required to collect and collate the data, and the value if this effort to the work of the Committee. Particular reference was also made to the value of having unique identification data from both feeding and breeding grounds.

It was also noted that the scope and complexity of such mark-recapture analyses is something the Committee may need to consider again in the near future for other stocks and species. The ASG **recommended** that ASI raise this issue with the convenors of NH and SH, and seek their advice on the level of priority that might be assigned to developing better guidance for such analyses. For the specific paper under consideration here, the ASG **recommended** that ASI consider the formation of a small group to help the authors of Félix *et al*. (2021) improve their analyses, and also to develop expertise within the Committee for similar future work. Such a group should also include external participants with expertise in handling complex heterogeneity in capture probabilities. The establishment of such a small group was deferred to ASI to increase the opportunity to recruit participants and because convening this group may have budget implications.

The ASG **recommended** that the 1991-2018 abundance estimate for Eastern South Pacific humpback whales (Breeding Stock G) of 11,784 (SE = 266) be endorsed as Category 3. The ASG also **recommended** that ASI consider how best to treat abundance estimates like this one, derived from capture-recapture data over such a long time span, particularly since this is a superpopulation estimate. This particular case is also concerning because the closure assumption is violated.

3.4 Bering-Chukchi-Beaufort Seas bowhead whales

Ferguson *et al*. (2022) presented an abundance estimate for Bering-Chukchi-Beaufort Seas (BCB) bowhead whales (*Balaena mysticetus*) based on aerial line transect survey data collected in the Beaufort Sea and Amundsen Gulf during August 2019 and analyzed with a density surface model. To estimate transect detection probability, images were collected from a digital camera mounted to the belly port of an aircraft during a subset of the line-transect survey flights conducted in the study area in 2018 and 2019. To estimate availability of bowhead whales depending on their observed activity states, two additional sources of information were used: 1) bowhead whale behaviour data collected in the study area during aerial focal follow studies in the 1980s and 1990s (Robertson *et al*. 2013); and 2) estimates of the duration that an object at the surface is in an aerial observer's field of view. Estimates of bowhead whale abundance by activity state, fully corrected for availability and perception bias, were derived using a hierarchical generalized additive model, with group levels defined by three activity states: traveling; feeding in deep water; and cow-calf pairs or socializing whales. An estimate of uncertainty in the overall abundance estimate was derived using the analytical methods of Bravington *et al*. (2021), which propagated the uncertainty from the detection functions through the spatial model, and then incorporated the uncertainty in the estimates of availability using the delta method. The resulting estimate of abundance was 17,175 whales (CV=0.237; 95% confidence interval 10,793-27,330).

The two independent reviewers praised the paper for combining state-of-the-art methods for spatial statistics with mark-recapture line transect methods, and for the careful attention to detail at all steps of the analysis. They noted that, as a result of using this sophisticated approach, the CV of the estimate was greatly reduced compared to the previous, design-based estimate from Ferguson *et al*. (2021) using the same survey data. Assuming full independence among components would have increased the CV from 0.237 to 0.41, and conventional stratified analysis had yielded a CV of 0.54. The reviewers made suggestions to improve presentational clarity, which were addressed by the authors in their response (e.g., providing decomposition of the variance components, and additional discussion of caveats). The ASG thanked the reviewers for their particularly detailed comments and suggestions.

In discussion, the ASG was reminded that this estimate was being considered by the SC for the first time and that the methodology was developed, in part, to provide a viable alternative to ice-based surveys, whose feasibility might decrease in the future due to climate change. The ASG discussed the edge effects visible in the plots of density surface model predictions and queried whether the total abundance estimate would be affected if the predicted numbers of bowhead whales in the cells exhibiting edge effects were set to zero. It was concluded that these effects likely are not large enough to greatly affect the results. The ASG also asked whether spatial variability in group size was investigated. The authors referred to the five group size metrics presented in Table B1 of the paper that were considered as potential covariates in the detection function models, stating that none of these covariates were retained in the final detection function models during model selection. Additionally, residual analysis suggested that the Tweedie distribution used for the spatial model was appropriate to fit the number of whales as a response variable rather than the number of groups. In response to a question on the mark-recapture model, the authors stated that identification of duplicate whale sightings was performed without a fixed set of criteria but was unambiguous for this species due to the lack of clustering of sightings observed during the survey.

The ASG **recommended** that the 2019 abundance estimate of 17,175 (CV=0.237, 95% CI 10,793-27,330) be endorsed as Category 1A.

3.5 North Atlantic right whales

Pace *et al*. (2017) used a mark-recapture model to estimate abundance and trends of North Atlantic right whales (*Eubalaena glacialis*). Individuals are annually resighted at different rates, primarily due to varying stay durations among several principal habitats within a large geographic range. To better characterize changing abundance of North Atlantic right whales between 1990 and 2015, a state–space model with Jolly-Seber assumptions about population entry (birth and immigration) was fit to individual resighting histories using empirical Bayes methodology, accounting for the substantial individual capture heterogeneity. Estimates from this approach show that recapture rates have declined substantially in recent years. North Atlantic right whales' abundance increased at about 2.8% per annum from median point estimates of 270 individuals in 1990 to 483 in 2010, and then declined through 2015, when the final estimate was 458 individuals (95% credible intervals 444–471).

The independent reviewers agreed that the paper provides sufficient methodological detail for evaluation, and that the methods and conclusions are appropriate. In particular, the reviewers noted that the separate likelihoods for the biological and observation processes allowed the observed variability in resighting rates to be attributed to either changes in life history parameters or sampling effort. Moreover, the model allowed for heterogeneity in survival among individuals due to sex, age, and year with a combination of fixed and random effects. It was also noted that the authors explicitly tested the sensitivity of their results to their assumptions.

In discussion, the ASG noted that the approach's complexity and numerous random effects can make it difficult to assess model fit and validation. There was no evidence of any problem that would affect confidence in the estimates but the additional information on sensitivity using simulations from the paper's supplementary material would be useful for guiding future use of these estimates, such as for assessment and management.

The ASG agreed that the analysis of Pace *et al*. (2017) could be recommended for endorsement. However, it further noted that Pace (2021a) used the same methods while extending the data time series to 2019, thereby producing additional, more recent results. The ASG therefore **recommended** that the updated results in Pace (2021a) should be used instead and accepted as Category 1A. Specifically, the ASG **recommended** endorsing the median of the posterior distribution and the 95% credibility interval from Pace (2021a) and including the following in the IWC Table of Agreed Abundance Estimates: 262 (95% CI 259-262) in 1990, 308 (307-311) in 2000, 476 (472-478) in 2010 and 371 (359-381) in 2019. Pace *et al*. (2021a) also presented other information that was not discussed by ASG, including a newer version of the model with a different treatment of the process errors (the 'regime model'). The ASG **recommended** that the 'regime model' be reviewed by ASI.

Pace *et al*. (2021b) used generalized linear models to derive estimates of cryptic mortality for North Atlantic right whales and found that observed carcasses accounted for only 36% of all estimated death during 1990–2017. They also found strong evidence that observed carcass counts were poor predictors of annual mortality, and that cause of death determinations from detected carcasses were not necessarily representative of cause-specific mortality rates in right whales.

The independent reviewers agreed that the modelling approach was reasonable although sometimes lacking in details. However, Pace *et al*. (2021b) was not discussed further by the ASG because it does not provide estimates of population abundance. ASG will bring this paper to the attention of the Sub-Committee on Non-deliberate Human-Induced Mortality of Cetaceans (HIM) as it may be of interest.

3.6 Eastern North Pacific gray whales

Stewart and Weller (2021) provide updated results from shore-based surveys of eastern North Pacific (ENP) gray whales (*Eschrichtius robustus*) conducted by the Southwest Fisheries Science Center. Abundance estimates were obtained from visual survey data collected regularly off central California between December and February during the gray whale southward migration, adding to a time series that began in 1967 (see Laake *et al*. 2012, Durban *et al*. 2015; 2017). This report presents a new estimate of abundance for ENP gray whales migrating between December and February 2019/20. A 23.7% decline in abundance from 2016 to 2020 (26,960 whales in 2015/16 and 20,580 whales in the 2019/20) coincides with the unusual mortality event that started in 2019.

Reviewers noted that the analysis used well-tested, published methods to continue a time series of abundance estimates that have been endorsed by the SC for years.

In discussion, the ASG was reminded that the estimates for ENP gray whales also include individuals from the Pacific Coast Feeding Group and some animals that feed off Sakhalin. It was also noted that estimates from different years have some common variables (e.g., sighting probability of shore-based observers) and therefore cannot be considered completely independent. Covariance information is available for the first part of the time series (Laake *et al*. 2012) but not for recent years nor for the covariance between the Laake *et al*. (2012) and the Durban *et al*. (2015; 2017) series.

The ASG **recommended** that the 2019/20 abundance estimate of 20,580 (95% CI 18,700-22,870) be endorsed as Category 1A. It also **requested** Katara to inquire with the authors about whether the missing covariance information was available to add to the IWC Table of Agreed Abundance Estimates.

3.7 Southern Right Whales

Brandão *et al*. (2021) was presented to the Committee in 2021 (item 8.2.3.1 of IWC (2022)) and describes an update to a complex demographic model which was developed to explain patterns of southern right whale (*Eubalaena australis*) occurrence and calving rates in South African waters, and had recently been extended to include the possibility of an early abortion so that a receptive, pregnant whale can become pregnant again the following year (the 'delta-loop'). Abundance estimates were generated in the modelling effort, but these did not include measures of uncertainty, as the focus of the paper was on evaluating whether the new features included in the model were able to explain the higher variability (compared to the past) in recent survey counts, rather than generating abundance estimates for management purposes.

The independent reviewers noted the lack of standard errors reported in the document, as well as the fact that in some cases standard errors were not obtainable given that a Hessian had not yet been achieved in the minimisations. This may be due to model complexity, near over-parameterization, a coding error subsequently identified by the authors, and/or other factors.

In response to the reviewers, the authors explained that Brandão *et al*. (2021) is one of a series of papers that, ideally, should be considered in totality (a situation addressed in item 2 above). Earlier papers (e.g., Brandão *et al*. (2020)) had included uncertainty estimates, and a future paper will amend the model so that ad hoc penalty terms play a lesser role. Associated abundance estimates appropriate for management purposes will be presented to the Committee in the future. The authors also sought advice on suitable methods for uncertainty estimation, and the ASG recommended that this question be raised at ASI.

After considering this context for the research project, the ASG declined to make any recommendation on abundance estimates in this paper, as they had not been intended to be proposed for management purposes. The ASG looks forward to reviewing abundance estimates arising from this work in the future.

Smith *et al*. (2021) was presented to the Committee in 2021 (item 8.2.3.2 of IWC (2022)) and reported on long-running aerial surveys for southern right whales along the south-west coast of Australia (Cape Leeuwin to Ceduna). Between 1993 and 2020, surveys were undertaken to monitor the recovery of this species following commercial whaling. The aerial surveys provide counts of animals very close to the coastline, particularly focussing on cow-calf pairs in shallow, sheltered waters, in addition to being a platform to collect photo-ID data from all individuals detected. Smith *et al*. (2020) report on counts during the 2020 survey challenged by covid-19, and provide a simple analysis of counts between 1993 and 2020. Furthermore, by using a multiplier developed from Argentinian and South African data (IWC 2013), Smith *et al*. provide a rudimentary estimate of abundance for the Australian 'western' subpopulation of southern right whales, with no accompanying CV. Kelly reported that it is hoped more robust analysis methods can be applied to these data in the near future. The ASG encouraged such efforts.

The ASG did not make any recommendation to ASI regarding the abundance estimates presented in Smith *et al*. (2021). However, ASG **recommends** that ASI assign a suitable category if possible. The analyses of the count data in Smith *et al*. (2021) are simplistic, and the abundance estimate has no associated measure of uncertainty. However, the time series of relative abundance indices is potentially useful for assessment purposes. Finally, the ASG recognised the memory and outstanding contributions of John Bannister to this project, and cetacean science broadly, over many decades.

Renault-Braga *et al*. (2021) present a study of southern right whales wintering along the Brazilian coastline. This population was severely depleted by whaling which continued to the mid-1970s, and studies since the 1980s have suggested this population is now restricted to southern Brazil. Using photo-id data obtained from standardized aerial surveys running parallel along the coastline from Florianópolis/SC (27° 47.82` S 48° 31.98`W) to Torres/RS (29° 23.76`S 49° 45.78`W) for the years 2004-2018, mark-recapture methods were used to estimate survival, capture, recruitment, and population size using the POPAN model, and population growth rate using PRADEL models, although the POPAN model was used for the final assessment.

Renault-Braga *et al*. (2021) was discussed by the Sub-Committee on Conservation Management Plans, CMP, in 2021, where it was noted that this is the first update of the population trends for southern right whales in the Brazilian breeding ground since 2010. CMP therefore requested that ASI review the abundance estimate.

The independent reviewers acknowledged the great extent of work that went into this study and the value of the dataset, agreeing that the methods used were appropriate for the data collected. However, the reviewers felt that a lack of detail in the description of the methods made the authors' analysis difficult to assess fully, and expressed concern over the potential effect of heterogeneity in capture probability due to the failure to account for variation in individual behaviour. The reviewers also noted the low estimates of uncertainty associated with the capture probabilities, especially for adults, with the potential for some of the uncertainty to have been spuriously attributed to variation in other parameters, such as capture probability, which would influence the abundance estimate. Lastly, one reviewer felt that there was a lack of justification for choosing the POPAN model over the PRADEL model. Both reviewers recommended that the abundance estimates should currently be considered provisional.

In discussion, the ASG noted this was work in progress. The authors of this paper have expressed an interest in collaborating with other SC scientists to improve their analyses. ASG suggested that the authors might work with the independent reviewers, noting that addressing the reviewers' comments would be an excellent start. New agreed to facilitate this potential collaboration.

The ASG **recommended** that the abundance estimates which were stated as 569 (±38) for females and 2,626 (± 737) for adults during winter 2004-2018 (2011) be categorized as provisional, Category P. The ASG also noted that before finalized estimates are endorsed in the future, the "±" notation for uncertainty should be clarified by replacing it with a standard error, CV, or confidence interval.

3.8 North Pacific sei whales

Hakamada *et al*. (2009) report on abundance estimates for sei whales (*Balaenoptera borealis*) in the JARPN II offshore survey area (east of Japanese coast, west of 170°E, north of 35°N, south of Russian and US EEZ), based on ship-based multi-species sighting surveys with different timing in different years. Due to the migration pattern of sei whales in the area suggested by the sighting survey data, abundance was estimated separately for the early and late seasons. Furthermore, in some instances, data from surveys conducted during two consecutive years were incorporated into the abundance estimate for a season.

Similarly, Hakamada and Matsuoka (2016) presented abundance estimates for sei whales in the JARPNII survey area for years 2008, 2009, and 2011-2012. Considering the migration pattern of these whales in the area suggested by previous analysis, the number of the whales was estimated separately for the early and late seasons. The estimates assumed g(0)=1. It is important to note that these estimates represent only a part of the population considered.

The ASG was reminded that these documents were originally reviewed in the 2020-21 intersessional period, and considered by ASG and ASI at SC68C (item 11.1.6 of IWC (2022)). At that time, the SC concluded that additional information was required before the estimates could be fully evaluated and potentially endorsed. During the 2021-2022 intersessional period, ASG requested that the authors provide this information, which was subsequently reassessed by the original reviewer. A second, independent review, covering the original papers and the new information, was also solicited. Reviewers were directed to focus on sei whales and estimates for other species were not considered.

The reviewers determined that the authors' responses clarified all methodological questions they had raised. Concerns remained about the assumption that g(0)=1 and the lack of covariates in the detection functions. Both reviewers also commented on how the timing of surveys relative to migration patterns affects the estimation and complicates the potential use of these estimates by the SC.

The issue of the fluctuation in the numbers of whales observed among years, which ultimately affects the interannual variability in abundance estimates, was raised in discussion by the ASG. As Hakamada *et al*. (2009) noted, the survey vessels moved in the same direction as migrating sei whales in 2006, which could have caused the higher abundance estimate for that year. Conversely, in 2007, the timing of the surveys relative to migration dates may have caused abundance to be underestimated. The magnitude of these positive and negative biases is not well understood. To address this, the authors subsampled the data to include sightings in the peak migration areas in the early (May-June) and late (July-August) seasons, respectively. There was also discussion of heterogenous survey coverage: abundance estimates for sub-area

7 in 2006 were extrapolated to unsurveyed subdivision 7N and were only valid for early season (Hakamada *et al*. (2009), Table 6), but for late season the abundance estimates were based on data from 2007 (Table 5).

In considering these caveats, the ASG noted that the usefulness of these estimates depends on the objectives; they cannot be used for the entire North Pacific stock, but some operating models can account for spatial and temporal structure and thus make use of partial stock estimates. Since this review was requested by the Sub-Committee on In-depth Assessments (IA), the ASG noted that these estimates should be useable for an in-depth assessment if the areas and periods are clearly defined. It was also noted that if these estimates were ever combined with those of the POWER surveys, the result would cover a large part of the population's range.

The ASG initially proposed to recommend endorsement (as Category 1A) all of these estimates, including those given by subarea (e.g., SA9) and their subdivisions (e.g., SA9N), as well as the combined estimates for the entire study area, while emphasizing that these estimates are only representative of specific locations and periods. However, additional concerns were raised in discussion regarding the appropriateness of combining survey data from multiple years (e.g., 2002/2003, 2004/2005) when inter-annual variability is unknown but potentially high, particularly within relatively small areas (e.g., SA8 and SA9 had their subdivisions surveyed in different years). This discussion was not resolved within the time available to the ASG. Therefore, ASG **recommended** that ASI consider this concern more thoroughly when reviewing these estimates. In addition, it was noted that a table listing all estimates by year, period (early or late) and sub-area and any further spatial subdivisions for which abundance was estimated, is required. This information is given in Hakamada and Matsuoka (2016) for the 2008-12 estimates but there is insufficient information in Hakamada *et al*. (2009) to create such a table for the 2002-07 estimates.

3.9 North Pacific blue whales

Bradford *et al*. (2021) report on abundance estimates for 21 species of cetaceans in the U.S. Exclusive Economic Zone of the Hawaiian Islands (Hawaiian EEZ) using ship-based, line-transect surveys conducted in 2002, 2010, and 2017. Low encounter rates in the study area required that sightings of the same and similar species be pooled with sightings from previous line-transect surveys when estimating detection functions. Group size and Beaufort sea state were the most important factors affecting the detectability of cetacean groups. Only one blue whale sighting was made on effort over 3 years, resulting in abundance estimates of 0, 137 (CV 1.12), and 0 in 2002, 2010, and 2017, respectively.

The independent reviewers were directed to only consider the blue whale estimates, and both had strong praise for the survey and analytical methods. The main concern raised was with the scarcity of sightings, which likely reflects blue whale distribution and movement patterns in the area. The authors suggested using the highest of the estimates (i.e., 137) as the best estimate for blue whale abundance in the Hawaiian EEZ during the survey period. However, in discussion, the ASG disagreed. Instead, the average of the three estimates should be used (i.e., 46). Calculation of the CV of this average is sensitive to assuming that the variances for the years with zero abundance are either zero or equal to the estimated variance for 2010. While the missing variances are arguably non-zero, they are likely not as large as that of 2010. For simplicity, it was assumed that the 2002 and 2017 variances were equal to zero, recognizing that this may decrease the resulting CV in an artificial manner.

In discussion, it was clarified that the Sub-Committee on the other Northern Hemisphere whale stocks, NH, requires this estimate mostly to have general information about the distribution of blue whales and the proportion of the population that might have been missed by surveys conducted at higher latitudes. Some concern was expressed about the use of g(0)=0.55 in the estimate, which was informed by Barlow (2015) and seemed low for blue whales. Consensus was that this value was likely due to persistently high Beaufort sea states.

The ASG endorsed all three estimates for 2002, 2010 and 2017 as Category 3, and **recommended** that the average of 46 (CV 1.12, 95% CI 8-269) be considered the best estimate for the overall abundance of blue whales in the Hawaiian EEZ for the summer-fall period. The ASG did not specify a year to associate with this average abundance, but intended it to be broadly indicative of summer-autumn abundance during the span of the surveys. Late in the meeting, renewed attention was focused on the fact that the non-zero abundance estimate (137 for 2010) was based on a single on-effort sighting. The ASG **recommended** that ASI consider this issue more carefully before deciding on final endorsement of the annual estimates or the average.

Calambokidis and Barlow (2020) provide updated abundance estimates for blue and humpback whales on the US West Coast from mark-recapture estimates based on photo-identifications work conducted by Cascadia Research Collective (CRC) and collaborators through 2018. Several models were explored but the Chao estimate is the one that best accounts for heterogeneity of capture probabilities. Thus, for blue whales in the eastern North Pacific, the best estimate of abundance was 1,898 (SE=161) based on the most recent four years of data (2015-2018).

Reviewers expressed several concerns about the lack of details in the methods and thought that the estimates presented are best interpreted as "superpopulation" estimates (i.e., an estimate of the number of blue whales that spend some time along the U.S. west coast at some point during a 4-year period). In discussion, however, the ASG recognized that this report provides updated estimates using methods and data that have been thoroughly reviewed and used in previous assessments (Calambokidis and Barlow 2004, 2013, 2017, Calambokidis *et al*. 2017). Moreover, the new estimates are consistent with previous ones.

The ASG **recommended** that the abundance estimates for the entire time series be accepted as Category 1A, and that estimates of 1,422 (CV 0.093, 95%CI 1186-1705) for 1998, 1,397 (CV 0.075, 95%CI 1205-1619) for 2008 and 1,898 (CV 0.085, 95%CI 1607-2241) for 2018 be added to the IWC Table of Agreed Abundance Estimates. These years were chosen to reduce correlation among tabled estimates.

3.10 Southeast Pacific blue whales

Bedriñana-Romano *et al*. (2018) describe a study of blue whale (*Balaenoptera musculus*) abundance and distribution in Chilean Northern Patagonia, within 25 km of the coast. Bayesian hierarchical species distribution models (HSDMs) were constructed using: small boat-based line transect data from 2009 (summer), 2012 (autumn) and 2014 (autumn); presence-only data from 2009 to 2016 (summer-autumn); and a range of environmental and spatial covariates, such as chlorophyll α concentration, sea surface temperature, local oceanography and distance to coastline. The HSDMs involved combining a binomial *N*-mixture model (modified for zero-inflated Poisson data) of blue whale group counts from line transect data with a logistic regression for modelling presence-only data, allowing both models to share covariate parameters for improving estimation precision. The HSDMs were also used to derive abundance estimates. Based on the line-transect data only, precautionary minimum abundance estimates for 2009 (the year with most data) were provided in Table 1 of the paper as: 356 (median), with a 95% credibility interval of 191-652. An abundance estimate that used both the line-transect and presence-only data was also reported, but the authors expressed the view that there was the potential for spatial and temporal bias in the presence-only data to confound the covariate analysis.

The abundance estimates presented in Bedriñana-Romano *et al*. (2018) were discussed briefly by the SH subcommittee in 2018 (item 3.3.1 of IWC (2019)). The primary comments then were that the geographic area covered by the surveys was not likely to represent the whole Chilean blue whale population, and that the inter-annual fluctuations in blue whales in the study area are also observed in local mark-recapture data.

The independent reviewers felt that the analyses were generally appropriate, but that the paper lacked some detail about analysis methods. One reviewer noted the discrepancy between abundance estimates presented in Figure 2 of Bedriñana-Romano *et al*. (2018) when compared to those presented in Table 1 of the paper. The authors responded that the underlying environmental data used for Figure 2 comprised a single covariate only, whilst for Table 1, the environmental covariates included depended on model selection. The reviewers also noted a lack of information regarding which availability sample was used for the presence data, which had a noticeable effect on abundance estimates. However, the authors were of the view that the differences in abundance estimates between the models with and with-out the presence only data were instead due to the different environmental predicators used in the models. The authors also advised that they are undertaking more work to understand the biases arising from the presence-only data more fully. One reviewer also noted that the reported inter-year variability of blue whales in this study region makes it challenging to design surveys to estimate this population's abundance, distribution and habitat preferences. Finally, the ASG noted that the survey region was unlikely to cover the summer geographic extent for this stock.

Both the mean and median abundance estimates were reported in the paper, but because the analysis was undertaken in a Bayesian framework, the ASG decided that estimates of the median abundance would be the more appropriate to report. Hines queried whether the potential biological removal (*sensu* Wade 1998) calculated by Bedriñana-Romano *et al*. (2018) should be assessed, but ASG sought to limit ASG/ASI focus to the evaluation of the abundance estimate itself. How an estimate might be used by the SC, other organizations, or national management agencies fell outside the remit of ASI.

The ASG **recommended** that the 2009 summer abundance estimate of 356 (95% CRI 191-652) for blue whales in Chilean Northern Patagonia be endorsed as Category 2.

Williams *et al*. (2011) present a model-based abundance estimate of Chilean blue whales using effort and sightings from a survey along the Chilean coastline undertaken by the SOWER programme in December 1997-January 1998 during the southward transit leg to its Antarctic survey area. This project was first considered by SH in 2009 (item 3.1 of IWC (2010)), at which time only a preliminary estimate was available. Williams *et al*. (2011) describe the aim of the Chilean component of the 1997/98 SOWER survey as maximising encounters with Chilean blue whales in order to collect a variety of data and samples—and, as such, track placement and coverage did not adhere strongly to standard design-based protocols. Two vessels undertook the survey, each starting at opposite ends of the north-south extent of the survey area and meeting in the middle, with about 8.5% spatial coverage of the survey area. The 'count' method (*sensu* Hedley and Buckland 2004) formed the core of the model-based analysis, with a GAM used to model the variation in whale densities over space, with an offset term provided by the effective search area. Twenty-six blue whale sightings (30 animals) were included in the detection function. A simple half-normal detection function from binned perpendicular distances was fitted due to the small number of sightings. Twenty-three sightings were available for the spatial model. Mild overdispersion in the counts per segment was dealt with using a Tweedie distribution. Space was the only covariate, and a soap-film smoother was used to help dampen some extreme predictions near the survey area boundary The abundance estimate was given as 303, with a 95% CI of 176-625, for December 1997-January 1998 for the region bounded 18°30´S to 38°S, and between 12 nautical mile territorial boundary of Chile's coast out to a boundary delineated by a combination of historical catch limits, the 200 nautical mile exclusive economic zone (EEZ) and the time limits of the survey. Two errata have been issued for this paper since it was published in 2011, but neither describe errors that would change the abundance estimate presented (Errata 2012; Erratum 2017). Those corrections only changed the estimated pre-exploitation abundance (and hence inferences about recover and population trajectory).

The reviewers of Williams *et al*. (2011) noted that although the paper was brief, and did not contain some technical details which would have aided the review process, they believed that the overall methodology and abundance estimates presented were sound, with no critical errors. The reviewers also noted that given that the density surface models used to estimate abundance were based on spatial covariates only, there was no capacity to extrapolate into waters not surveyed. Further, since the survey region almost certainly did not cover the geographic extent of the population, neither the model nor the underlying data could support unbiased estimation of the population size. This was reiterated in discussion, when the ASG noted that the survey did not cover waters <12 nm from the coastline, which is where blue whales are typically found, nor did it cover areas further south where blue whales are typically found during the December-January period. As such, it was suggested that the mismatch between the survey area and the likely areas of higher blue whale densities meant the resultant abundance estimate for the Chilean blue whale population was probably substantially negatively biased. The ASG did not considered these points to be a criticism of the study, given the multiple factors influencing the original survey design and because the current understanding of where blue whales are at that time of the year was not achieved until after the survey was concluded. The abundance estimate for the actual area surveyed was considered reasonably sound.

The ASG **recommended** that the December 1997-January 1998 abundance estimate of 303 (95% CI 176-625) for the survey area be endorsed as Category 2. It is further **recommended** that when this estimate is included in the IWC Table of Agreed Abundance Estimates, a note should be added to indicate that the estimate is likely to be substantially negatively biased for this population of blue whales due to the location of the survey area.

Galletti Vernazzani *et al*. (2017) reported on photo-identification surveys conducted in the waters off Isla Grande de Chiloé, southern Chile from 2004-2012 and Isla Chañaral, northern Chile, in 2012. During surveys between late January through to late April, 1,070 blue whales were encountered yielding, after photo-quality control, 318 and 267 unique photographs of the left and right lateral flank, respectively. The data were analysed using mark-recapture analysis, and open population models were used to estimate that about 570-760 whales are feeding seasonally in this region. POPAN superpopulation abundance estimates for the feeding ground in 2012 are 762 (95% confidence intervals, CI = 638-933) and 570 (95% CI 475-705) for left and right aspect datasets, respectively. Results from closed population models were similar. Estimates of trend revealed strong annual variation in abundance, peaking in 2009 and suggesting a fluctuating use in the survey area over time, likely related to prey densities. High inter-annual return rates suggest a degree of site-fidelity of individuals to Isla Grande de Chiloé although the number of whales using this feeding ground is relatively small compared to the estimate using the single year data from Isla Grande de Chiloé and Isla Chañaral from 2012 (Galletti Vernazzani *et al*. 2012).

Preliminary results from Galletti Vernazzani *et al*. (2017) were presented to SH in 2016 (item 5.3.1 of IWC (2017a)). At that time, SH noted that, given most of the data was collected from the Chiloé feeding ground, the abundance estimate should only apply to this region and not the broader Chilean blue whale population. However, while the survey area described in Williams *et al*. (2011) was much further north, satellite telemetry suggested that Chiloé blue whales also travel through this area (Hucke-Gaete *et al*. 2016), making it unclear what proportion of the population is being estimated.

The independent reviewers of Galletti Vernazzani *et al*. (2017) noted that this paper represents an important, long-term photo-ID study of Chilean blue whales. One reviewer noted that the blue whale population on the Chiloé feeding ground was difficult to study, given the low resighting rate, but was also confused about how to reconcile such a low resighting rate with the suspected high site fidelity. The other reviewer noted the inferred heterogeneity in visitation rates to the archipelago and expressed concern that it would be difficult to account for this heterogeneity in a robust way due to the low detection probabilities (0.02 - 0.27). Coupled with the relatively small area being studied, this underscores the fact that these estimates are likely to be an underestimate of total number of whales in the subpopulation. In response to the reviews, the authors of Galletti Vernazani *et al*. (2017) stated that the presence of blue whales on the Chiloé feeding ground is quite dynamic and, furthermore, their reported abundance estimates do not represent a broader population, but only the survey region.

The ASG commended the authors for collecting and processing this valuable long-term dataset. Jackson added that while there was no change in apparent abundance through time, there was considerable fluctuation in the use of the feeding ground, probably due more to environmental variation, and not to fluctuations in the biological parameters of the population itself. In discussion, the ASG noted that whale transience would negatively impact abundance estimation, but that the severity of the impact remained unclear. The ASG also believed that more consideration of how to summarise POPAN superpopulation estimates like this one would be helpful.

In determining the category, it was noted that the authors summarised their work as follows: "nine years of data reveal that the Chiloé feeding ground is used by a small number of whales in the mid-hundreds which have high inter-annual fidelity to this region", which would seem to match the definition of a Category 3 estimate, in that it gives only a broad impression of the abundance. The ASG **recommended** that the superpopulation abundance estimates of 762 (95%CI 638-933; left side) and 570 (95%CI 475-705; right side) for the survey area for the period 2004-2012 be endorsed as Category 3.

Cooke and Jackson (2017) present a reanalysis of data described in Galletti Vernazzani *et al*. (2017), which was undertaken during the 2016 SC meeting (item 5.3.2 of IWC (2016)). Given the inter-annual fluctuation in abundance seen in the Isla de Chiloé dataset, the resightings data showed a skew typical of a transient/resident mixture. Therefore, the abundances of blue whales from Chiloé area might be more appropriately modelled using a mark-resighting framework that explicitly accounts for residency and transience. An individual state-space model previously used for gray (Cooke *et al*. 2016) and right whales (Cooke *et al.*, 2015) was applied. Each whale was assigned a probability of being either a resident or a transient, and the sampling and availability model accounted for side of the animal that would be photographed. Both open and closed models were attempted, although details of these were not provided. The authors preferred an open model fit, which gave an abundance estimate of 450 (CV=0.17), which applied to the middle of the timespan, being approximately mid-way through 2008. The resident proportion was estimated at 41-45%. The left/right ratio was estimated to be 51:49. This is close enough to the true population value of 50:50, so the 'error' that results from not forcing this ratio to be 50:50 can be assumed to be negligible.

One independent reviewer suggested that it was difficult to properly appraise Cooke and Jackson (2017) due to the lack of detail in the paper. They further doubted whether the transient animal issue was particularly severe or even worth addressing. The other independent reviewer felt transience issue was present and a serious concern for abundance estimation, as the SC had highlighted previously (item 5.3.1 of IWC (2017a)). This reviewer thought the analyses in Cooke and Jackson (2017) went some way to resolving concerns about transience. The reviewers also noted there was equal support for both the open and closed population models, but that these led to quite different abundance estimates.

In discussion, Givens asked whether the state-space model approach used for gray whales had been independently reviewed. There seemed to be no specific SC review of the modelling for the previous southern right whale and gray whale applications of this approach, although IWC (2016; item 4) and IWC (2017b; item 3.2.2) discuss modelling outputs. Comments highlighted that previous use of the state-space modelling approach faced a similar critique when the approach was applied to Sakhalin gray whales (Cooke *et al*. 2017b). When ASI reviewed that analysis in 2017, they noted that there was insufficient detail in the paper to judge the modelling and requested more information, including "full details of the likelihood function and how posterior samples were generated", and further details on the time series data, before it could be used in management advice (item 3.1.1.7 of IWC (2018a)). The ASG considered how it might be possible to facilitate further methodological review, and whether this it would be advisable to postpone conclusion of the assessment of SH blue whales until such a review was obtained. Jackson suggested that a review of the state-space modelling methods would be valuable for the work of SH, and of the Committee more broadly, and that it would be worth waiting another year if a review was possible. However, it was further noted that such a review is not imminent. Consequently, ASG believed that ASI should categorise the existing abundance estimate, with the understanding further information on the modelling may be available in the future. It was noted that since the Committee has experience with the application of the approach for several species, the underlying model and methods have been discussed repeatedly. Such familiarity with the approach is reassuring, although it falls short of full evaluation and endorsement. Finally, advice was given that a similar model had been fully specified in the appendices of Brandão *et al*. (2021), and that those appendices might prove useful in reviewing the approach.

The ASG **recommended** that the abundance estimate of 450 (CV=0.17) for the survey area be endorsed as Category 2, but that it should be given an Evaluation Extent of 4 (estimate was partially considered by the sub-committee and a new method was used). Review of the full details of the modelling should be required before this abundance estimate might be used for management advice.

3.11 Antarctic blue whales

Matsuoka and Hakamada (2014) describe abundance estimates for Antarctic blue whales (*Balaenoptera musculus intermedia*) south of 60°S for regions across the IWC Management Areas IIIE+IV+V+VIW (i.e., 35°E-145°W) using sighting data collected from 1995/96-2008/09 from Antarctic sighting surveys from the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) and JARPAII. Blue whales were encountered throughout the surveys, and were widely distributed without apparent aggregation. Abundance estimates were obtained using standard line transect analysis methods under assumption of $g(0)=1$. Several abundance estimates are given in Matsuoka and Hakamada (2014) according to: season-level survey strata for the years 2005/06-2008/09 (Table 3a), IWC Management Area (Table 4a), and combinations thereof (Table 5). Blue whale abundance estimates for the period 1995/96-2004/05 at the level of IWC Management Area were first given in Tables 5a-5d of Matsuoka *et al*. (2006), which were then reproduced in Matsuoka and Hakamada (2014). In summary, the blue whale abundance estimate for the 1995/96 summer season for the combined IWC Management Areas IIIE+IV+V+VIW was reported as 300 (CV=0.308); the corresponding estimate for the 2008/09 summer season was 1,223 (CV=0.345). Neither CV accounts for potential additional variance.

The results in Matsuoka and Hakamada (2014) were originally presented as part of review of the JARPAII Special Permit Research Programme (item 6.3.1 of IWC (2014b)). During the 2014 discussion, the review panel noted the 2005/06-2008/09 surveys probably covered the peak of blue whale abundances south of 60°S. The panel also made several recommendations for improvement to analyses for estimating abundance of blue whales including: a more thorough description of methods and assumptions; more consideration of issues around small sample sizes; and a clearer explanation of differences between ideal and realised tracklines, and the implications thereof. Various abundance estimates arising from the 1995/96-2004/05 surveys (Matsuoka *et al*. 2006) were reviewed in 2006, but the blue whale abundance estimates were not mentioned specifically (items 2.4.2 and 2.5.2 of IWC (2007))

Considering Matsuoka and Hakamada (2014), the independent reviewers noted that the data collection and survey designs have been well described. They considered these to be the standard methodology for abundance estimation adopted by the Committee, and essentially the same as those used for estimates generated from IDCR/SOWER data. The reviewers also noted that while there was poor coverage in some areas and years, the analytical solutions described to combine abundances across areas were reasonable.

In discussion, the ASG considered whether blue whale abundance estimates should be evaluated at the area-level or for all areas combined (e.g., across IWC Management Areas IIIE+IV+V+VIW). Branch reported that in the past (e.g., Branch 2008; IWC 2009, section 3.2), he had used the abundances reported in Matsuoka and Hakamada (2014), and that he tended to favour the combined IIIE+IV+V+VIW estimates, including tracking these through time to study trend. A question was raised as to whether Antarctic blue whales have any population structure and, if so, whether it coincided with the IIIE+IV+V+VIW area boundaries. Branch reported that it is thought that there is only one circumpolar population of Antarctic blue whales, but that there were differences of opinion among researchers, and some hotspots are known to exist. It was also noted that while there was no doubt that the combined survey region of IIIE+IV+V+VIW did not cover the entire circumpolar distribution of Antarctic blue whales in the austral summer, the IIIE+IV+V+VIW survey region is still a very large proportion of the area south of 60°S. Furthermore, this region also covered many degrees of latitude, from the coastline up to 60°S, arguably making it representative of (despite not fully covering) the entire circumpolar region.

The ASG **recommended** that the abundance estimate of 300 (CV=0.308) for the 1995/96 summer season, for the combined IWC Management Areas IIIE+IV+V+VIW (i.e., 35°E-145°W, south of 60°S), and an abundance estimate of 1,223 (CV=0.345) for the IWC Management Areas IIIE+IV+V+VIW for the 2008/09 summer season, be endorsed as Category 1A. The separate IWC *Management Area* estimates are also **recommended** for Category 1A endorsement, if these are required for Committee work.

Branch (2007) presents a study of Antarctic blue whale (*Balaenoptera musculus intermedia*) sightings during the three complete circumpolar surveys of IWC's IDCR/SOWER programme. The IDCR/SOWER ship-borne surveys have completely circled the Antarctic three times: 1978/79-1983/84 (CPI); 1985/86-1990/91 (CPII); and 1991/92-2003/04 (CPIII), covering strata totalling 64.3%, 79.5% and 99.7% of the ocean surface between the pack ice and 60°S. During the surveys, blue whale sightings were rare but were recorded in all regions. Respective circumpolar abundance estimates were 453 (CV=0.40), 559 (CV=0.47) and 2,280 (CV=0.36), with corresponding mid-years of 1981, 1988 and 1998 for the areas surveyed. (Alternative estimates of 'comparable areas' are also offered in Table 4 of the paper.) The CPIII estimates are the most complete and recent for this subspecies. These abundance estimates are negatively biased because some Antarctic blue whales may have been north of 60°S or in the pack ice at the time of the surveys and because a small number of blue whales on the trackline were probably missed. Furthermore, a small proportion of pygmy blue whales, probably less than 1%, may have been included in the sightings. Preliminary results from the study were presented to SH in 2007 (items 7.3 and 7.4 of IWC (2008)), but no specific discussion was reported.

Independent reviewers noted that the field protocols and survey designs for the IDCR/SOWER sighting surveys were well described, and that the analysis methods were standard and accepted by the Committee. One reviewer suggested the assumption of $g(0)=1$ was probably appropriate, but observed that the detection functions for CPI and CPII show unusual shapes and poor fit. As noted by Branch (2007), this has been observed elsewhere in the IDCR/SOWER data and may have been a function of the small number of sightings prior to use of the process of 'smearing' to deal with heaped distance and angle estimates. The reviewer also offered evidence of concentrations of Antarctic blue whales observed north of 60°S during the summer months (Calderan *et al*. 2020), and so suggested that the abundance estimates presented here might be negatively biased. Furthermore, this reviewer felt that due to the problems in the detection function fit, that the abundance estimate from CPIII was the only result adequate for conservation and management advice.

In discussion, the ASG reflected on the suggestion by an independent reviewer to consider only the CPIII abundance estimate. It was noted that the odd detection function fits, particularly for CPI, might have also been driven by protocols focused on Antarctic minke whales, particularly because most sightings of blue whales occurred closer to the ice edge when the vessel was seeking to maximize minke sightings for Discovery marking purposes. It was further suggested that it was unlikely that the poorly fitting detection functions in CPI and CPII would have substantially altered the abundance estimates. The ASG also noted the tracklines during CPI did not typically extend fully to 60°S, but Branch suggested that since the peak of blue whale density was near the ice edge, the northern limits of the trackline during CPI was not likely to introduce substantial negative bias. To determine the potential for negative bias from animals north of 60°S, it was noted that data from the JSV series (e.g., Miyashita *et al*., 1995; Butterworth and Geromont, 1996) might be informative, although those data may be too geographically coarse for such use. Another potential source of information is the commercial catch series for blue whales, however, that ended long before the IDCR/SOWER surveys were undertaken, so its use is also limited. Regarding the survey protocols and track design for CPI, it was agreed that whilst these were focussed on Antarctic minke whales, overall CPI was still capable of supporting reliable estimates of Antarctic blue whale abundance.

The ASG **recommended** that the circumpolar (and south of 60°S) abundance estimates of 453 (CV=0.40) for CPI (1978/79-1983/84; mid-year 1981), 559 (CV=0.47) for CPII (1985/86-1990/91; mid-year 1988) and 2,280 (CV=0.36) for CPIII (1991/92-2003/04; mid-year 1998) be endorsed as Category 1A. These estimates should also be footnoted with a suggestion that the survey designs and sighting protocols for CPI differed somewhat from those of CPII and CPIII. Furthermore, separate 'comparable areas' abundance estimates (Table 4), and IWC Management Area estimates (Table 5), are also **recommended** for Category 1A endorsement, if these are required for Committee work.

3.12 North Atlantic humpback whales

Leonard and Øien (2020a) report on shipboard line-transect surveys of the northeast Atlantic. Minke whales were the target species, but abundance estimates were also presented for other species, including humpback whales. A multiyear mosaic survey design was used, with two independent observer platforms operating in passing mode, and estimates were derived using mark-recapture distance sampling techniques, correcting for perception bias. Abundance of humpback whales was estimated as 9,749 (CV=0.34, 95% CI: 4,947–19,210) for the 2002-2007 period and as 12,411 (CV=0.30, 95% CI: 6,847–22,497) for the 2008-2013 period.

Leonard and Øien (2020b) report on surveys of the same area in 2014-2018 using the same design and analysis as above. Estimated abundance for humpback whales was estimated to be 10,708 (CV=0.38, 95% CI: 4,906–23,370).

All independent reviewers for the two papers were in agreement as to the high quality of the survey and analytical methods, and the exemplary application of mark-recapture distance sampling analysis methods. Consensus was that the abundance estimates are suitable for use in assessment and management. It was noted that the data were separated in three long time periods (2002-2007, 2008-2013, 2014-2018) to ensure that enough detections existed to fit the detection functions, which means that any population change that may have occurred within each of these survey periods will not be detected. One reviewer noted the need to be careful regarding the apparent increase in abundance between the first two time periods due to a 10% increase in the area covered by the second survey, and suggested that using density measures for comparisons between periods might be a better option than using estimated absolute abundance.

In discussion, the ASG noted that although estimates were provided for small geographical blocks (that had been optimized for minke whales), it would be more appropriate, and consistent with previous assessments, to report the humpback whale estimates at the scale of the entire survey area.

The ASG **recommended** that these estimates be endorsed as Category 1A. The three time periods were analysed separately (no pooling of data) and thus can be considered independent.

Wenzel *et al*. (2020) reported on photographic sighting histories of humpback whales in the Cape Verde Islands to estimate population size, survival and recruitment using a Jolly-Seber mark-recapture model. The data spanned the winter/spring months between 1990 and 2018 and include a compilation of several formal survey efforts as well as a large amount of citizen science observation (e.g., whale watching trips). The results suggested strong site fidelity to this breeding ground. Only the data from 2010 to 2018 was used in the abundance estimate, and the estimated total number of humpback whales occurring in this area in this time period was 272 (SE 10).

Both independent reviewers highlighted the potential for bias in the estimates due to issues with detectability (mentioned by the authors) and spatial and temporal heterogeneity in sampling effort that cannot be accounted for by the Jolly-Seber model. This could lead the population estimate to be biased low, and the lack of clarity in the data pre-selection process also contributes to the potential for bias.

In discussion, the ASG noted that humpback whales breeding in the Cape Verde Islands likely represent the remnants of a historically larger breeding population and that this region is difficult to survey. Stock identification questions still need to be resolved, but there was consensus that despite some caveats, this estimate represents a valuable improvement over previously available information that could be useful for an in-depth assessment.

Therefore, the ASG recommended that the estimate of 272 (CV 0.037, 95%CI 253-292) be endorsed as Category 1B.

Lawson and Gosselin (2018) report on a wide-scale aerial survey of the Canadian waters of the Atlantic in Aug-Sept 2016. The survey had not focused on any one species, and was timed to coincide with expected peak abundance of the cetacean species of greatest interest. One of the researchers' goals was to compare the 2016 survey estimates to those obtained from an earlier wide-scale aerial survey conducted in 2007. To allow for this, and other comparisons, the survey methodology remained as similar as possible to that used in 2007 and to that used by the US National Oceanographic and Atmospheric Administration (NOAA) for similar surveys. A dual-observer approach was taken to collect data appropriate for estimating perception bias using the mark-recapture distance sampling framework, and estimates of availability were derived using methods described by Laake *et al*. (1997) combined with published surfacing rates. Abundance estimates were generated in two strata: 1) Newfoundland and Labrador (NL), and 2) Gulf of St Lawrence, Scotian Shelf and Bay of Fundy region (Gulf+SS+BoF). For the Newfoundland and Labrador region, a corrected humpback whale abundance estimate was given as 8,439 (CV = 0.494); for the Gulf of St Lawrence, Scotian Shelf and Bay of Fundy region, a corrected abundance estimate of 1,854 (CV = 0.400) was provided.

The independent reviewers both considered the study to constitute a well-designed and extensive aerial survey, and the resulting data to be very valuable. The reviewers considered the double-observer approach to be appropriate and welcome, with nothing to indicate the presence of major errors. They noted, however, that the results were difficult to interpret on account of there being multiple aircraft, detectability corrections, survey regions, and species. Furthermore, both reviewers noted that whilst the humpback whale abundance estimate presented for the Newfoundland and Labrador region was quoted as being corrected for both availability and perception bias, it seemed that the availability component may have been left out.

In discussion, the ASG considered how much of the population was covered by the survey region at the time of year it was undertaken. Robbins reported that the two survey regions would each be considered to have partial coverage of the eastern Canadian feeding stock, which in turn are one subset of the North Atlantic Population. The NL survey area would have achieved full coverage of the Newfoundland and Labrador areas. The Gulf+SS+BoF survey area is more complicated in that it covers a portion of the eastern Canadian feeding grounds in the Gulf of St Lawrence and the Scotian Shelf and a portion of the Gulf of Maine feeding grounds. One reviewer had suggested scoring the two surveys separately and Robbins commented that, of the two, she considered the NL survey region to provide the most important result from this study for the North Atlantic humpback assessment planned by NH. In discussion, others agreed that those results are especially valuable because they represent complete coverage of a large portion of the eastern Canadian feeding area for which there are relatively little other recent or historical abundance data.

The ASG **recommended** that the abundance estimate of 8,439 (CV = 0.494) for Aug-Sept 2016 for the Newfoundland and Labrador region be endorsed as Category 1A, and the abundance estimate of 1,854 (CV = 0.400) for the Gulf of St Lawrence, Scotian Shelf and Bay of Fundy region be endorsed as Category 2. However, this recommendation should be considered further by ASI after clarification about whether an availability correction was actually used for the Newfoundland and Labrador region. Doniol-Valcroze volunteered to enquire with the authors and report back to ASI.

3.13 Franciscana

Crespo *et al*. (2021) present new abundance estimates for franciscana, but the document was submitted after the deadline for ASG review. Relevant convenors have agreed that this paper will be noted by the Sub-

Committee on Conservation Management Plans, CMP, who may request that the paper be reviewed by ASG in the next intersessional period for future consideration by ASI at SC69.

4. CONSIDERATION OF STATUS OF STOCKS

The Scientific Committee, through the work of ASI, has been developing an approach to present information on the status of whale stocks to the Commission and to the general public (IWC 2018b, 2020, 2021b, 2022). Originally planned as a biennial document, a Status of Stocks Website was deemed more practical and useful in recent Committee discussions, and ASI has begun developing methods and website content.

Last year the Committee requested a more detailed website proposal, and an intersessional correspondence group (ICG) was formed to progress this work (items 11.4 and 11.6 of IWC (2022)). The goal of the proposed Status of Stocks Website is not to replace or contradict existing IWC web pages, nor to replicate either the intent of, or material contained in, information sources such as the IUCN Red List. Instead, the Committee wishes to highlight its quantitative assessments, which provide a view of status that is different in character to those provided elsewhere. Specifically, the Committee intends that the information provided in the Status of Stocks Website should be based on the stock assessment modelling work conducted for the Committee's in-depth assessments, AWMP and RMP development, some *Implementation Reviews*, and so forth. There remains a question as to whether the information on the Status of Stocks Website should include information about stocks not assessed via population modelling, and if so, what sort of information would be provided.

On behalf of the ICG, Givens, Punt and Allison developed a detailed proposal that included examples for three assessed stocks (eastern North Pacific gray whales, North Atlantic minke whales, and Bering-Chukchi-Beaufort Seas (BCB) bowhead whales), as well as for several unassessed stocks such as the vaquita and eastern Canada – West Greenland (ECWG) bowhead whales. This proposal was shared with communications and IT specialists from the Secretariat. A team from the Secretariat volunteered to present their vision for how such content could be interwoven with the IWC website, www.iwc.int; see section 4.2.

4.1 The ICG proposal

The proposal suggested organizing the website into three levels of increasing technicality.

(1) A Welcome Page providing summary indicators of status for all assessed stocks at a glance,
(2) Status Summary Pages providing plain language status assessments for individual species or stocks, and
(3) Status Details Pages providing technical information about how the results in each Status Summary Page were derived, and a single Methods Page that provides a general description of the Committee's approach to assessment modelling and the calculation of the statistics reported on the proposed website.

The proposal is very dependent on an Abundance Page summarizing abundance estimates for assessed stocks. The IWC website already includes a page with abundance information, so the proposal addressed modifications to the that page; see below.

The proposal makes no appreciable changes to the mathematical modelling and statistical summary of the assessments that ASI has developed for the Status of Stocks project in recent years. These technical details are given by IWC (2018b; 2020; 2021b; 2022).

The aim of the Welcome Page is to provide an overall summary of status for all assessed stocks that could be understood at a glance without reference to technical detail. This information would be displayed in a tabulated format, displaying simple indicators of the level to which abundance has been reduced (referred to as depletion in SC discussion and 'relative abundance' in the proposed website content) and population change for each stock or species. A new feature is radial color 'thermometer' graphs for indicating (on a continuous scale) the estimated values and uncertainty ranges for relative abundance and change, which supplement the discrete categories and labels discussed last year. While those category labels are still displayed below the thermometer, the new graph emphasizes the continuum of the estimates and their uncertainty. The proposal noted that numerical summaries of depletion are not without problems, given that populations may grow beyond pre-exploitation levels (original carrying capacity)—as may be the case, for example, for BCB bowheads—and given that some SC assessments use current carrying capacity as a reference level, instead of the pre-exploitation level, often for the pragmatic reason that the latter is difficult to reconcile with estimates of historical catches and the dynamics models employed. A plain language explanation of carrying capacity, depletion, and these potential problems is essential. Other new additions in the proposal include renaming the status summary statistics to 'Relative Abundance and '30-Year-Change', as well as changing the names for the discrete categories associated with them.

The Status Summary Pages would provide a brief summary of the status of individual stocks/populations. A page for a stock would include:

- an image of the species and a map of approximate stock boundaries;
- comments about stock definition;
- information regarding any current or recent exploitation;
- the most recent direct abundance estimate (i.e., from a survey, not an assessment model);
- links to pages on www.iwc.int where additional information about the species can be found;
- a table of pooled assessment results (Relative Abundance and 30-Year Change);
- a trajectory plot, potentially followed by a summary statement on recovery; however, the ASG has noted potential issues with standardising language about recovery across different stocks/populations;
- a list of known threats to the stock;
- a statement about data quality and date of last update; and finally
- links to more technical details in the corresponding Status Details Page and the Methods Page.

The proposal recommended that technicalities and citations should be avoided on a Status Summary Page.

When there are multiple stocks of a species, the Status Summary Page has the potential to be confusing, especially if not all stocks had been assessed using the SC's assessment modelling approach. This would lead to inconsistencies in the information displayed and how it was derived. More generally, it was noted that the development of Status Summary Pages would require careful consideration of exactly what the assessment should cover, e.g., stocks, aggregations, and/or areas, and this aspect becomes even murkier when stocks mix. The general approach adopted by ASI in previous years was that when an assessment covered a large region having potentially multiple stocks or substocks, results from selected highly plausible stock scenarios are pooled, and the results for each stock are then reported individually and in total. That approach would be continued here.

The most technically detailed level of the Status of Stocks Website would be found on the Status Details Pages. Given the nature of the information required to specify an assessment fully and summarize the results, the Status Details Pages might be PDFs rather than webpages. A Status Details Page would contain a description of the trials, MSYR values, the reference population level (pre-exploitation or current carrying capacity), and more details on the modelling exercise. The assessment results would be tabled per trial, as well as pooled over all trials in the manner previously agreed by ASI. Citations of published papers and SC documents would be required to explain the assessment framework fully.

For both the Status Summary Pages and the Status Details Pages, the proposal emphasized the importance of obtaining advice and review from species/stock experts. Modelling experts would also be required to explain the trial specifications in plain language on the website and to provide references to background documents.

The proposed Methods Page is also highly technical, explaining the basic principles of assessment modelling; concepts such as carrying capacity and depletion; the Relative Abundance and 30-Year Change statistics used to summarise status in simple terms; how to calculate statistics and combine them over trials; thresholds for categorizing depletion and change, and the labels for those categories. Given the level of detail, the Methods pages might also be better in PDF format.

As mentioned previously, an Abundance Page already exists on the IWC website (iwc.int/about-whales/estimate), and the Status of Stocks website would link to it frequently. However, the page does not currently mirror (or link to) the IWC Table of Agreed Abundance Estimates. That Table includes more estimates, more recent estimates, and estimates for more diverse areas/stocks/species, than are listed on the Abundance Page. The proposal recommended that the Abundance Page should be updated to provide access to the Table, or that some attention be paid to making the two sources of information more comparable.

4.2 The Secretariat proposal

On behalf of the Secretariat, Kate Wilson, Communications Officer for the Secretariat, explained a proposal to integrate the new pages being developed by the SC with the existing content on status at www.iwc.int. The intent was to build on the existing introductory level information, developing this into a new sub-section on status which comprised an introduction, background information section and stock assessment pages.

Noting that this is an evolving project and that the number of assessments available would grow gradually, the Secretariat proposed short- and longer-term approaches to the stock assessment pages. In the short term, the content would be divided into separate pages containing status summaries, status tables and assessment details. In the longer term, they proposed that all the available stock assessment information for each stock would be merged onto a single page, beginning with the simple summary and graphics, and moving through to the more detailed and technical content. The aim of this longer-term approach is to simplify the site, assist user navigation and encourage users towards the more technical information.

The Secretariat highlighted that status is one of the most frequently sought topics on the website, and the aims of the Status of the Stocks initiative appear entirely compatible with the Secretariat aim of updating and improving existing website content. The Secretariat welcomed the opportunity to work with the SC on this initiative.

4.3 Discussion of proposals

Givens thanked the Secretariat for engaging with the ICG and ASI so comprehensively at this early stage of the development process, and for providing a demonstration of how the Status of Stocks Website could be integrated into www.iwc.int. In his view, the demonstration showed that the Secretariat and ASI shared largely compatible visions for the final product, and that this should energize the development process in ASI.

Staniland commented that the ICG and Wilson had done an enormous amount of work so far, both for the separate proposals, and then in the subsequent work to demonstrate their compatibility. In the Secretariat's view, the IWC website would benefit from more information about the status of stocks, which is a matter of very high concern among the public.

Wilson advised that the current content pages of the IWC website mirror language from SC reports. This was deliberate to ensure clarity and consistency because the public has access to the SC reports through the website. More detailed content, like that which the ICG has proposed, could also be presented in a similar way, but this would require careful presentation to avoid confusion. Wilson also stated that the IWC website currently presents information about whales at three levels, from introductory through to 'practitioner' level, with the latter including technical reports, endorsed protocols, and guidelines. Givens noted that the three-level design of the ICG proposal intentionally mimicked this strategy.

The ASG noted that Wilson's demonstration appeared to include essentially all the content from the ICG proposal, with the Welcome Page being separated by species initially but reconstituted as a single page in the long term. The existing status information (where portions of the Welcome Page would initially be inserted) on www.iwc.int is currently is quite basic. While this provides the level of information many members of the public are seeking, the Status of Stocks project offered the opportunity for readers with deeper interest to obtain information with far greater scientific detail. Wilson added that the two-stage treatment for the Welcome Page was recommended because the Status of Stocks project represented ongoing work; it will take several years to accumulate sufficient information to warrant a single Welcome page. She added that the existing status information was last updated in 2019, and would soon be due for revision.

The Secretariat also thought it important to include text on how the SC's assessments differ from those of other organisations. This is particularly important for the IUCN, given that IUCN Red List statuses are currently referenced in many places on www.iwc.int.

ASG supported this idea, and Givens asked a small group (Donovan, Butterworth, Punt) to provide a presentation to ASI at the SC meeting to articulate how the SC assessments differ from assessments based on the IUCN Red List categories and criteria. It was noted that the IUCN Red List was originally intended to provide rapid assessments of as many species as possible in order to identify any potential problems and to flag the need for further investigation, especially for species where less information may be available than is typically the case for fisheries and marine mammals. Another point of difference between IUCN and SC status assessments is that IUCN usually focusses on species instead of stocks. Furthermore, it was noted that IUCN criteria are applied uniformly across species, leaving little room for more nuanced interpretations. Butterworth expressed concern that labels such as 'endangered' are designed to be attention grabbing. Information sources for IUCN are subject to different levels of scrutiny, and can involve expert opinion, whereas formal SC assessments are almost wholly empirical modelling exercises. Representatives from the IUCN were not present at the pre-meeting and unable to present their views; further discussions on this are planned for SC68D, including ASI consideration of the small group presentation comparing SC assessments and the IUCN Red List.

Givens asked the ASG to consider whether the Status of Stocks website should also address species/stocks for which comprehensive population models are not available, noting that such situations can be quite diverse, ranging from the vaquita (for which the concept of status is extremely important) to ECWG bowheads (for which there are good data available, but no SC assessment, and the stock is not depleted). Jackson added that it would also be important to consider whether model-based status assessments developed and published outside of Committee's work should be included on the Status of Stocks Website. If so, the evaluation of such assessments and the priority for their inclusion would require discussion.

Different suggestions were made to address this issue, including noting on the website that the Committee has considered such unmodeled stocks, but only including information there that had been fully reviewed by the Committee. This would particularly pertain to assessments conducted and published outside the SC. Alternatively, available information and external assessments could be reviewed by relevant SC subgroups to synthesize expert judgment. For data-limited stocks, a qualitative assessment might be sufficient, and the status information would not need to be more detailed than what is displayed on the proposed Welcome Page and Status Summary Page, absent the assessment modelling results. Givens noted that the ICG proposal included the use of the "Suspected…" qualifier for such cases on the Welcome Page, and the status of "Unknown" for cases even more poorly understood. He also pointed out that the proposal included a system for rating data quality, which would be noted on the Status Summary page.

Givens also advised that in the initial phases of the Status of Stocks project, a list of candidate stocks was produced (Table 14 of IWC, 2021b), with priority given to stocks for which assessments have been completed. The ASG considered whether cases like the vaquita should also be prioritized highly. The ASG concluded that ASI should prioritize both types of situations, particularly given that the Committee has made strong statements about the need to take action to reduce human-induced mortality to zero for stocks such as North Atlantic right whales and various smaller cetaceans. Butterworth cautioned against prioritizing too many at risk stocks for initial inclusion because users of the website might understand the frequency of such listings to suggest the IWC has grave concerns for a consequently artificially high proportion of the world's cetacean populations. It is not yet clear how stocks that are neither data poor nor have been formally assessed by the Committee (e.g. ECWG bowheads) should be prioritised.

In choosing stocks to assess, ASG noted that there are probably three levels of preparedness for assessment: 1) stocks for which in-depth assessments, *Implementations* or *Implementation Reviews*, have already been conducted 2) stocks that are currently in the process of undergoing an in-depth assessment, or for which one is planned in the future; and 3) populations with potentially little available information, but for which there is no need for detailed modelling because the status is already clear, such as vaquita. Givens noted that it was not necessarily easy to compile assessment results even for stocks in the first category. For example, for the BCB bowhead assessment in the ICG proposal, he and Punt had relied on some ad hoc assumptions and best guesses about technical specifications, since the abundance and catch data as well as the assessment modelling approach itself had changed since the early 2000s when the development process for the bowhead SLA had fully documented an assessment approach. Thus, even the notion of 'completed' work is not straightforward. A comment was offered that accepted robust assessments, management approaches, and evaluations were not meant to be updated, but the case of the BCB bowhead whales suggested that requirement may have to change. Givens added that, in his view, assessment results on the proposed website should be updated regularly, both as new data are obtained and as methodology changes. A rolling schedule, similar to the regular *Implementation Reviews* for the AWMP, was suggested.

Further ASG discussion focused on details of summarizing assessment results. It was noted that the Schedule within the International Convention for the Regulation of Whaling contains a framework for classification of stocks (para. 10), and ASG considered whether that was relevant for summaries on the proposed Status of Stocks Website. In the view of the ASG, the Schedule language was outdated, and the Committee should work with scientific languages and practices currently in use.

Concern was expressed about uncertainties inherent in assessing the status of a stock, and the potential that displays of results could lead to a false impression of high precision for a reader not well versed as regards scientific uncertainty. There are considerable uncertainties, for example, in models of stock structure and hypotheses for the trials and sensitivity tests chosen for assessments. The overall conclusion about status must acknowledge this uncertainty. To address this, ASI's agreed status assessment approach integrates over disparate trials, and the proposed thermometers display a range of uncertainty. The inclusions of introductory text highlighting the nature of uncertainty in science, especially as applicable to whale stock assessment, was suggested. However, the ASG also noted the public's potential misinterpretation of 'uncertainty' as 'ignorance'. Care would be needed to avoid degrading the Committee's work through over-emphasis of uncertainty. The Secretariat's communication and information experts would help ensure that explanation of scientific uncertainty was well balanced.

Attention was drawn the difficulty of distilling a complex stock assessment down to an interpretable and scientifically defensible one- or two-dimensional metric to present to the public. Two thermometers and single-word descriptors summarizing population status are proposed, recognizing that stock status is a two-dimensional concept: how many whales are there (relative to some reference level), and how is that abundance changing? For the trajectory plots on Status Summary Pages, it was suggested that a short, simple sentence describing the depletion, recovery and trend shown in the plot might also be helpful in conveying status in plain language.

There was disagreement as to the extent to which the language summarizing status should adopt a 'bland' scientific tone or advocacy language. It was noted that some members of the Committee might wish to see advocacy language, particularly in when stocks/populations are facing dire outcomes; others were concerned, however, that use of such language might decrease respect for the authoritative nature of the science-based results provided. In the ICG proposal, advocacy language about the vaquita was taken verbatim from past SC reports. This disagreement about tone will be particularly relevant in cases where assessment would be based more on judgment than model results.

Wilson mentioned challenges associated with including maps to delineate population distributions, including the cost of copyrights, and how existing maps might not necessarily be accurate, visually appealing, or otherwise suitable. She suggested that ASI might approach members of the Committee who could contribute their time and technical skills to producing tailored maps in the future. Alternatives would likely require funding, although eliminating maps from the website design is an option as well.

The ASG asked Wilson how the Committee and the Secretariat might most effectively work together on this initiative, noting particularly that this will involve: species-level experts; experts from both the SC and the Secretariat for designing and wordsmithing content; a different collaborative team from the SC and Secretariat to undertake all the analysis and computing; and periodic updates (e.g., every 5-10 years). Wilson offered to assist with honing accessible language once there was some agreement on content. In terms of timelines, a relevant milestone for the Secretariat is delivery of the Intersessional Report[2], which the Secretariat publishes roughly one month before an upcoming Commission meeting. Staniland asked the

[2] https://archive.iwc.int/pages/view.php?search=%21collection24481+&k=&modal=&display=list&order_by=title&offset=0&per_page=240&archive=&sort=DESC&restypes=&recentdaylimit=&foredit=&ref=6977

Committee to help identify key experts within the Committee or beyond, who could help develop the first draft of a Status Summary Page for each chosen stock. This could then be sent to the Committee, or some subset thereof, for approval. The ASG considered that an editorial group comprised of convenors could identify and work with species-experts within their individual subcommittees; this would avoid the Secretariat having to liaise with too many people.

Givens expressed concern about the degree to which progress on this project was currently contingent on very heavy contributions from the ASI convenors, Punt, and Allison. One or more other Committee members are needed to champion this project and serve as "content creation editors" who would recruit species experts, supervise work to draft Status Summary Pages, coordinate work with assessment modelling experts, and help interface with the Secretariat. Without a broader and deeper commitment of effort from Committee members, the project was, in his view, unlikely to be completed. He also suggested that the two intersessional correspondence groups established last year to support the Status of Stocks Website project be re-organized to better clarify their roles.

5. WORKPLAN

The ASG identified the following tasks for its workplan:

- Finalize a draft proposal for potential edits to category descriptions (item 2.1), supplemental wording and examples to explain category selection (item 2.2), and for clarification of how the context of stock definition, survey area, and intended use of an estimate should (or should not) influence category choice. Donovan and Butterworth agreed to provide this document sufficiently in advance of the upcoming ASI meeting for participants to review and discuss.
- Contact the authors of Lawson and Gosselin (2018) to check whether their estimate of humpback whale abundance in the Newfoundland and Labrador stratum had a correction for availability (item 3.12). Doniol-Valcroze agreed to inquire and report back to ASI.
- Contact the authors of Bedriñana-Romano *et al*. (2018) to confirm which is their preferred abundance estimate for 2009 (item 3.10). Kelly agreed to inquire and report back to ASI.
- Contact the authors of Stewart and Weller (2021) about whether the missing covariance information was available to add to the IWC Table of Agreed Abundance Estimates (item 3.6). Katara agreed to inquire, and add such information to the table if it is available.
- Contact the second reviewer of Renault-Braga *et al*. (2021) to inquire whether he would be willing to join Ferguson in helping those authors improve their abundance estimate (item 3.7). The authors have already expressed an interest in such collaboration. New agreed to inquire.
- Prepare brief information for presentation at ASI regarding the differences between the IUCN Red List and the SC's planned Status of Stocks Website (item 4). Donovan, Butterworth, and Punt agreed to provide this in advance of the relevant ASI session.
- Clarify the role of ASI and which papers are most suitable for convenors to request ASI to review (item 2). Givens agreed to initiate such discussions with other convenors.
- Bring Pace *et al*. (2021b) to the attention of HIM (item 3.5). Givens will do this.
- Request the authors of Hakamada *et al*. (2009) to provide a table of estimates by year, period (early or late) and sub-area and any further spatial subdivisions for which abundance was estimated, for the 2002-07 estimates, so that the results are tabled at the same resolution as similar results from such cruises (e.g., Hakamada and Matsuoka (2016)) (item 3.8). Katara agreed to make this request.

6. ADOPTION OF REPORT

Givens thanked the rapporteurs, Kelly and Doniol-Valcroze, for their key contributions to the success of the pre-meeting. He also thanked the independent reviewers who generously contributed their time and expertise: Anonymous, L. Bedriñana-Romano, T. Branch, A. Cañadas, R. Chandler, P. Conn, C. Donovan, T. Eguchi, M. Ferguson, R. Fewster, M. Fujiwara, A. Gilles, D. Johnson, R. Leaper, N. Kelly, L. New, C. Oedekoven, H. Okamura, D. Pike, J. Potts, J. Roberts, J.A. Royle, D. Sigourney, B. Stevenson, and R. Williams.

The report was adopted by email on 2 May 2022.

REFERENCES

Barlow J. (2015). Inferring trackline detection probabilities, g(0), for cetaceans from apparent densities in different survey conditions. *Marine Mammal Science* 31(3):923-943.

Bedriñana-Romano, L., Hucke-Gaete, R., Viddi, F.A., Morales, J., Williams, R., Ashe, E., Garcés-Vargas, J., Torres-Florez, J.P. and Ruiz, J. (2018). Integrating multiple data sources for assessing blue whale abundance and distribution in Chilean Northern Patagonia. *Diversity and Distributions*, 2018: 1-14. doi: 10.1111/ddi.12739

Bondaroff, P. and Stokes, G. (2021). Indo-Pacific finless porpoise (*Neophocaena phocaenoides*) conservation in Hong Kong SAR. Paper SC/68C/SM/04 presented to the Scientific Committee of the International Whaling Commission, April 2021. Available from www.iwc.int.

Bradford, A.L, Oleson, E.M., Forney, K.A., Moore, J.E. and Barlow, J. (2021). Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Branch, T.A. (2007) Abundance of Antarctic blue whales south of 60° from three complete circumpolar sets of surveys. *J. Cetacean Res. Manage* 9: 253-262.

Branch, T.A. (2008). Current status of Antarctic blue whales based on Bayesian modeling. Paper SC/60/SH7 presented to the IWC Scientific Committee, June 2008, Santiago, Chile. 10pp. Available from www.iwc.int

Brandão, A, Vermeulen, E., Ross-Gillespie, A., Findlay, K. and Butterworth, D.S. (2020). Updated application of a photo-identification based assessment model to southern right whales in South African waters, focussing on inferences to be drawn from a series of appreciably lower counts of calving females over 2015 to 2017. Paper SC/67B/SH/22 presented to the Scientific Committee of the International Whaling Commission, April, 2020. Available from www.iwc.int.

Brandão, A, Ross-Gillespie, A., Vermeulen, E. and Butterworth, D.S. (2021). Updated extension of a photo-identification based assessment model to southern right whales in South African waters to allow for the possibility of an early abortion of the calf in the model. Paper SC/68C/SH/05 presented to the Scientific Committee of the International Whaling Commission, April, 2021. Available from www.iwc.int.

Bravington, M.V., Miller, D.L. and Hedley, S.L. (2021). Variance Propagation for Density Surface Models. *Journal of Agricultural, Biological and Environmental Statistics* 26: 306-323. doi: 10.1007/s13253-021-00438-2

Butterworth, D.S. and Geromont, H.F. (1996). On the consequences of longitudinal disaggregation of the Japanese scouting vessel data in the northward extrapolation of IWC/IDCR cruise estimates of abundance of some large whale species in the Southern Hemisphere. Rep. int. Whal. Commn 46: 663-664.

Crespo, E.A., Arias, M., Sueyro, N., Florencia Grandi, M. and Coscarella, M.A. (2022). Abundance estimation of franciscana dolphins by means of aerial surveys in Buenos Aires Province, Argentina. Paper SC/68D/CMP/17 presented to the Scientific Committee of the International Whaling Commission, April 2022. Available from www.iwc.int.

Calambokidis, J. and Barlow, J. (2004). Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. *Marine Mammal Science* 20(1):63-85.

Calambokidis, J. and Barlow, J. (2013). Updated abundance estimates of blue and humpback whales off the US West Coast incorporating photo-identifications from 2010 and 2011. Final Report for contract AB-133F-10-RP-0106. PSRG-2013-13R. 8pp.

Calambokidis, J., and Barlow, J. (2017). Trends in abundance humpback whales in the North Pacific Ocean. IWC Report SC/A17/NP/10 for the Workshop on the Comprehensive Assessment of North Pacific Humpback Whales. 18-21 April 2017. Seattle, WA. Available from www.iwc.int.

Calambokidis, J., Barlow, J., Flynn, K., Dobson, E. and Steiger, G.H. (2017). Update on abundance, trends, and migrations of humpback whales along the US West Coast. IWC Report SC/A17/NP/13 for the Workshop on the Comprehensive Assessment of North Pacific Humpback Whales. 18-21 April 2017. Seattle, WA. Available from www.iwc.int.

Calambokidis, J. and Barlow, J. (2020) Updated abundance estimates for blue and humpback whales along the U.S. West Coast using data through 2018, U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-634.

Calderan, S. V., A. Black, T. A. Branch, M. A. Collins, N. Kelly, R. Leaper, S. Lurcock, B. S. Miller, M. Moore, P. A. Olson, A. Sirović, A. G. Wood and J. A. Jackson (2020). South Georgia blue whales five decades after the end of whaling. Endangered Species Research 43: 359-373. doi: 10.3354/esr01077

Cooke, J., Rowntree, V. and Sironi, M. (2015). Southwest Atlantic right whales: interim updated population assessment from photo-id collected at Península Valdés. Paper SC/66a/BRG23 presented to the IWC Scientific Committee, May 2015, San Diego, CA, USA. 9pp. Available from www.iwc.int.

Cooke, J.G., Weller, D.W., Bradford, A.L., Sychencko, O., Burdin, A.M., Lang, A.R. and Brownell, R.L., Jr. (2016). Updated population assessment of the Sakhalin gray whale aggregation based on a photoidentification study at Piltun, Sakhalin, 1995-2015. Paper SC/66b/BRG25 presented to the IWC Scientific Committee, June 2016, Bled, Slovenia. 14pp. Available from www.iwc.int.

Cooke, J. and Jackson, J. (2017). Report of the Scientific Committee, Annex H, Appendix 6: Reanalysis of Chiloé Island blue whale mark recapture data 2006-2011. *J. Cetacean Res. Manage* 18(Suppl): 263.

Cooke, J.G., Weller, D.W., Bradford, A.L., Sychencko, A.O., Burdin, A.M., Lang, A.R. and Brownell, R.L. Jr. (2017b). Population assessment update for Sakhalin gray whales, with reference to stock identity. Paper SC/67a/NH11 presented to the IWC Scientific Committee, May 2017, Bled, Slovenia. 9pp. Available from www.iwc.int.

Durban, J., Weller, D., Lang, A. and Perryman, W. (2015). Estimating gray whale abundance from shore-based counts using a multilevel Bayesian model. *J. Cetacean Res. Manage* 15, 61-68.

Durban, J., Weller, D. and Perryman, W. (2017). Gray whale abundance estimates from shore-based counts off California in 2014/15 and 2015/16. Paper SC/A17/GW/06 presented to the International Whaling Commission, Scientific Committee. Available from www.iwc.int.

Errata. (2012). Conservation Biology, 26(2), 378-378. doi:https://doi.org/10.1111/j.1523-1739.2012.01852.x

Erratum. (2017). Conservation Biology, 31(2), 490-491. doi:https://doi.org/10.1111/cobi.12880

Félix, F., Acevedo, J., Aguayo-Lobo, A., Ávila, I.C., Botero-Acosta, N., Calderón, A. Cáceres, B., Capella, J., Carnero, R., Castro, C., Cheeseman, T., Rosa L.D. *et al*. (2021). Humpback whale Breeding Stock G: Updated population estimate based on photo-id matches between breeding and feeding areas. Paper SC/68C/ASI/02 presented to the Scientific Committee of the International Whaling Commission, April, 2021. Available from www.iwc.int.

Ferguson, M.C., Clarke, J.T., Willoughby, A.L., Brower, A.A. and Rotrock, A.D. (2021). Geographically stratified abundance estimate for Bering-Chukchi-Beaufort Seas bowhead whales (*Balaena mysticetus*) from an August 2019 aerial line-transect survey in the Beaufort Sea and Amundsen Gulf. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-428. 54 p.

Ferguson, M.C., Miller, D.L., Clarke, J.T., Brower, A.A., Willoughby, A.L. and Rotrock, A.D. (2022). Spatial modeling, parameter uncertainty, and precision of density estimates from line-transect surveys: as case study with Western Arctic bowhead whales. Paper SC/68D/ASI/01 presented to the Scientific Committee of the International Whaling Commission, April 2022. Available from www.iwc.int.

Galletti Vernazzani, B., Jackson, J.A., Cabrera, E., Carlson, C.A. and Brownell Jr., R.L. (2017). Estimates of abundance and trend of Chilean blue whales off Isla de Chiloé, Chile. *PLOS ONE* 12(1): e0168646. doi: 10.1371/journal.pone.0168646

Garrison, L.P., Ortega-Ortiz, J. and Rappucci, G. (2020). Abundance of marine mammals in waters of the US Gulf of Mexico during the summers of 2017 and 2018. *National Marine Fisheries Service* 56.

Hakamada, T. and Matsuoka, K. (2016) The number of western North Pacific common minke, Bryde's and sei whales distributed in JARPNII Offshore survey area. Paper SC/F16/JR12 presented to the Expert Panel Workshop of the Final Review on the Western North Pacific Japanese Special Permit Programme (JARPN II), 22-26 February 2016, Tokyo, Japan (unpublished). Available from www.iwc.int.

Hakamada, T., Matsuoka, K. and Miyashita, T. (2009) Distribution and number of western North Pacific common minke, Bryde's, sei and sperm whales distributed in JARPN II Offshore component survey area. Paper SC/J09/JR15 presented to the Expert Workshop to Review Results of JARPN II, 26-30 January 2009, Tokyo, Japan (unpublished). Available from www.iwc.int.

Hedley, S. L., Buckland, S. T., & Borchers, D. L. (1999). Spatial modelling from line transect data. Journal of Cetacean Research and Management, 1:255-264.

Hucke-Gaete, R., Viddi, F.A., Bedriñana-Romano, L. And Zerbini, A. Satellite tracking of blue whales (*Balaenoptera musculus*) from Patagonia (Chile) to Galapagos (Ecuador): novel insights into migratory pathways along the Eastern South Pacific. Paper SC/66b/SH16 presented to the IWC Scientific Committee, June 2016, Bled, Slovenia, 11pp. Available from www.iwc.int.

International Whaling Commission. (2007). Report of the Intersessional Workshop to Review Data and Results from Special Permit Research on Minke Whales in the Antarctica, Tokyo, 4-8 December, 2006. *J. Cetacean Res. Manage*. *(Suppl.)* 10: 411-445.

International Whaling Commission. (2008). Report of the Scientific Committee. Annex H. Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetacean Res. Manage*. *(Suppl.)* 10: 207-224.

International Whaling Commission. (2009). Report of the Scientific Committee. Annex H. Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetacean Res. Manage*. *(Suppl.)* 11: 220-247.

International Whaling Commission. (2010). Report of the Scientific Committee. Annex H. Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetacean Res. Manage*. *(Suppl.)* 11-2: 218-251.

International Whaling Commission (2013). Report of the Workshop on the Assessment of Right Whales. *J. Cetacean Res. Manage* 14 (Suppl.), 437-462.

International Whaling Commission (2014a). Report of the Scientific Committee. Annex Q. Report of the Ad hoc Group to Develop a List of 'Accepted' Abundance Estimates. *J. Cetacean Res. Manage*. (Suppl.) 15: 416-7.

International Whaling Commission (2014b). Report of the Expert Workshop to Review the Japanese JARPAII Special Permit Research Programme. Meeting held Tokyo, Japan, 24-28 February 2014. Document SC/65B/REP02. Available from www.iwc.int.

International Whaling Commission. (2016). Report of the Scientific Committee. Annex F. Report of the Sub-Committee on Bowhead, Right and Gray Whales. *J. Cetacean Res. Manage*. *(Suppl.)* 17-2: 204-223.

International Whaling Commission. (2017). Report of the Scientific Committee. Annex H. Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetacean Res. Manage*. *(Suppl.)* 18: 230-263.

International Whaling Commission. (2017b). Report of the Scientific Committee. Annex F. Report of the Sub-Committee on Bowhead, Right and Gray Whales. *J. Cetacean Res. Manage*. *(Suppl.)* 18: 185-202.

International Whaling Commission. (2018a). Report of the Scientific Committee. *J. Cetacean Res. Manage* 19(Suppl.): 1-101.

International Whaling Commission. (2018b). Report of the Scientific Committee. Annex Q. Report of the Ad hoc Working Group on Abundance Estimates, Status and International Cruises. *J. Cetacean Res. Manage*. *(Suppl.)* 19: 376-398.

International Whaling Commission. (2019). Report of the Scientific Committee. Annex H. Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetacean Res. Manage*. *(Suppl.)* 20: 211-238.

International Whaling Commission. (2020). Report of the Scientific Committee, Annex Q: Report of the Standing Working Group on Abundance Estimates, Stock Status, and International Cruises (ASI). *J. Cetacean Res. Manage* 21(Suppl.): 277-299.

International Whaling Commission (2021a). Report of the Workshop on the Review of the Status of the Franciscana, virtual meeting, 7-9 April 2021. Document SC/68C/REP/02 available from www.iwc.int.

International Whaling Commission. (2021b). Report of the Scientific Committee. *J. Cetacean Res. Manage 22(Suppl.)*: 1-122.

International Whaling Commission (2022). Report of the Scientific Committee of the International Whaling Commission. *J. Cetacean Res. Manage* 23 (Suppl.): 1-198.

Jefferson, T. A., & Moore, J. E. (2020). Abundance and Trends of Indo-Pacific Finless Porpoises (*Neophocaena phocaenoides*) in Hong Kong Waters, 1996–2019. *Frontiers in Marine Science, 7*. doi: 10.3389/fmars.2020.574381

Laake, J. L., Calambokidis, J., Osmek, S. D., & Rugh, D. J. (1997). Probability of detection harbour porpoise from aerial surveys: estimating *g*(0). *Journal of Wildlife Management, 61*, 63-75.

Laake, J.L., Punt, A.E., Hobbs, R., Ferguson, M., Rugh, D. and Breiwick, J. (2012). Gray whale southbound migration surveys 1967-2006: An integrated re-analysis. *J. Cetacean Res. Manage* 12, 287-306.

Lawson, J. and Gosselin, J.-F. (2018). Estimates of cetacean abundance from the 2016 NAISS aerial surveys of eastern Canadian waters, with a comparison to estimates from the 2007 TNASS. Paper NAMMCO SC/25/AE/09. Available from NAMMCO.

Leonard, D.M. and Øien, N.I. (2020a) Estimated abundances of cetacean species in the northeast Atlantic from two multiyear surveys conducted by Norwegian vessels between 2002-2013. *NAMMCO Scientific Publications* 11. https://doi.org/10.7557/3.4695

Leonard, D.M. and Øien, N.I. (2020b) Estimated abundances of cetacean species in the northeast Atlantic from Norwegian shipboard surveys in 2014-2018. *NAMMCO Scientific Publications* 11. https://doi.org/10.7557/3.4694

Matsuoka, K., T. Hakamada, H. Kiwada, H. Murase and S. Nishiwaki. (2006). Distributions and standardized abundance estimates for humpback, fin and blue whales in the Antarctic Areas IIIE, IV, V and VIW (35oE -145oW), south of 60oS. IWC paper SC/D06/J7 presented to the IWC workshop on JARPA review. 33pp. Available from www.iwc.int.

Matsuoka, K. and Hakamada, T. 2014. Estimates of abundance and abundance trend of the blue, fin, and southern right whales in the Antarctic areas IIIE-VIW, south of 60° S, based on JARPA and JARPAII sighting data (1989/90 – 2009/09). Paper SC/F14/J05 presented to the Scientific Committee of the International Whaling Commission. Available from www.iwc.int.

Miyashita T, Kato H, Kasuya T (1995). Worldwide map of cetacean distribution based on Japanese sighting data (Volume 1) National Research Institute of Far Seas Fisheries, Shizuoka, Japan.

Pace R.M. 3rd, Corkeron P. and Kraus S.D. 2017. State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. *Ecology and Evolution* 7(21): 8730–8741.

Pace, R.M 3rd. (2021a). Revisions and further evaluations of the right whale abundance model: improvements for hypothesis testing. NOAA Technical Memorandum NMFS-NE-269. US Dept. of Commerce, NOAA, NMFS, Northeast Fisheries Science Center, Woods Hole MA 02543-1026.

Pace, R.M. 3rd, Williams R., Kraus S.D., Knowlton A.R. and Pettis, H.M. 2021b. Cryptic mortality of North Atlantic right whales. *Conservation Science and Practice* 2021:e346. https://doi.org/10.1111/csp2.346.

Pike, D. G., Gunnlaugsson, T., Sigurjónsson, J. and Víkingsson, G. (2020). Distribution and Abundance of Cetaceans in Icelandic Waters over 30 Years of Aerial Surveys. *NAMMCO Scientific Publications*, *11*. doi: 10.7557/3.4805

Priyadarshana, T., Randage, S.M., Alling, A., Calderan, S., Gordon, J., Leaper, R. and Porter, L. (2016) Distribution patterns of blue whale (*Balaenoptera musculus*) and shipping off southern Sri Lanka. *Regional Studies in Marine Science* 3: 181-88.

Renault-Braga, E.P., Groch, K.R. and Simões-Lopes, P.C. (2021). Numerical population estimates update for Southern Right Whales in Brazil. Paper SC/68C/CMP/10 presented to the Scientific Committee of the International Whaling Commission, April 2021. Available from www.iwc.int.

Robertson, F.C., W.R. Koski, T.A. Thomas, W.J. Richardson, B. Würsig, and A.W. Trites. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. *Endangered Species Research* 21(2): 143-160.

Skaug, H. J., Oien, N., Schweder, T., & Bothun, G. (2004). Abundance of minke whales (*Balaenoptera acutorostrata*) in the Northeast Atlantic: variability in time and space. *Canadian Journal of Fisheries and Aquatic Sciences* 61(6), 870-886. doi:10.1139/f04-020

Smith, J.N., Kelly, N., Double, M. and Bannister, J.L. (2021). Population trend in right whales off southern Australia 1993-2020. Paper SC/68C/SH/18 presented to the Scientific Committee of the International Whaling Commission, April, 2021. Available from www.iwc.int.

Solvang, H. K., Skaug, H. J. and Oien, N. (in press). Consideration of measurement errors for the Norwegian common minke whale (*Balaenoptera acutorostrata acutorostrata*) surveys. *J. Cetacean Res. Manage 22*.

Solvang, H.K., Skaug, H.J. and Øien, N. (2015). Abundance estimates of common minke whales in the Northeast Atlantic based on survey data collected over the period 2008-2013. Paper SC/66a/RMP/8 submitted to the Scientific Committee of the International Whaling Commission, May, 2015. Available from www.iwc.int.

Solvang, H.K., Skaug, H.J., and Øien, N.I. (2021). Abundance of common minke whales in the Northeast Atlantic based on survey data collected over the period 2014-2019. Paper SC/68C/ASI/04 presented to the Scientific Committee of the International Whaling Commission, April, 2021. Available from www.iwc.int.

Stewart, J.D. and Weller, D.W. (2021). Abundance of eastern North Pacific gray whales 2019/2020. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-639.

Wade, P. R. (1998). Calculating limits to the allowable human-caused mortality of cetaceans and Pinnipeds. *Marine Mammal Science*, *14*, 1–37. https://doi.org/10.1111/j.1748-7692.1998.tb00688.x

Wenzel, F.W., Broms, F., López-Suárez, P., Lopes, L., Veiga, N., Yeoman, K., *et al*. (2020). Humpback whales (*Megaptera Novaeangliae*) in the Cape Verde Islands: Migratory patterns, resightings abundance. *Aquat. Mamm.* 46:21-31

Williams, R., Hedley, S.L., Branch, T.A., Bravington, M.V., Zerbini, A.N. and Findlay, K.P. (2011). Chilean blue whales as a case study to illustrate methods to estimate abundance and evaluate conservation status of rare species. *Conservation Biology* 25(3): 526-535. doi: 10.1111/j.1523-1739.2011.01656.z

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 and online schedule.
2. ASG PROCESS AND ICG RECOMMENDATIONS
    - 2.1. Edits to category descriptions
    - 2.2. Supplemental wording and examples to explain category selection
    - 2.3. Process for reviewing author revisions (may defer to ASI)
3. REVIEW OF ABUNDANCE ESTIMATES
    - 3.1. Indo-Pacific finless porpoise near Hong Kong
    - 3.2. North Atlantic common minke whales
    - 3.3. Eastern South Pacific humpback whales
    - 3.4. Bering-Chukchi-Beaufort Seas bowhead whales
    - 3.5. North Atlantic right whales
    - 3.6. Eastern North Pacific gray whales
    - 3.7. Southern hemisphere right whales: Australia, South Africa, and Brazil
    - 3.8. North Pacific sei whales
    - 3.9. North Pacific blue whales
    - 3.10. Southeast Pacific blue whales
    - 3.11. Antarctic blue whales
    - 3.12. North Atlantic humpback whales
    - 3.13. Franciscana
4. CONSIDERATION OF STATUS OF STOCKS
    - 4.1. Review proposals
    - 4.2. Future workplan
5. WORKPLAN
6. ADOPTION OF REPORT