Report of the

Scientific Committee

Virtual Meetings, 27 April-14 May 2021

Annex E: Report of the Abundance Steering Group

International Whaling Commission
Cambridge, UK, 2021

Annex E

Report of the Abundance Steering Group

1. INTRODUCTORY ITEMS
A virtual meeting was held 14-16 April, 2021. Participants were: Allison, Brownell, Butterworth, Cañadas, Esteban, Freitas, Givens, Jackson, Kelly, Kitakado, Palka, Porter, Punt, Robbins, Staniland, Sucunza, Suydam, Víkingsson, Walløe, 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, Status of Stocks, 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. Subsequently this had become even more of an issue during the pandemic. 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 Head of Science and Head of Statistics from the Secretariat, and the Convenors of the following SC sub-committees and standing working groups: ASI, ASW, EM, IST, IA, NH, SM and SH. Several independent experts also participated this year.

1.2 Election of the Chair
Givens was elected Chair.

1.3 Appointment of Rapporteurs
Kelly was appointed rapporteur.

1.4 Adoption of Agenda
The agenda, as finally adopted, is given as Appendix 1.

1.5 Documents available
The following documents were available to the ASG: Barlow *et al.* (2016), Barlow *et al.* (2018), Best *et al.* (2003), Frasier *et al.* (2020), Garrison *et al.* (2020), Hakamada and Matsuoka (2016), Hakamada *et al.* (2009), Jenner *et al.* (2008), Kato *et al.* (2007), McCauley and Jenner (2010), McCauley *et al.* (2018), Priyadarshana *et al.* (2016). Reviews of these documents were available to the ASG and have been archived by the Secretariat.

2. REVIEW OF ABUNDANCE ESTIMATES EVALUATED INTERSESSIONALLY
All of the abundance estimates considered at this meeting had been subject to the ASI intersessional review process. Specifically, independent reviews were solicited from relevant experts. The reviewers were told that this review process is notably different than reviewing a manuscript for a journal. For ASI, the review does not need to provide a detailed list of ideas to fine-tune the analysis, to explore alternative methods, or to list other technical matters of the sort that might be required for eventual publication, except as would be pertinent for the SC to evaluate whether it should use the estimate presented as a basis for providing management advice. Suggestions on writing and style are also unnecessary.

Reviewers were asked to consider the following goals:

(1) to determine whether there is sufficient information provided in the paper for evaluation and potential use of the estimate by the SC;

(2) to assess whether the method is broadly appropriate and potentially useful as a basis for conservation and management advice (not insisting that the analysis is 'optimal', 'perfect' or 'publishable as is');

(3) to confirm that the method was implemented as intended, with no critical errors;

(4) to assess whether the assumptions underlying the method are reasonably met; and

(5) to assess whether the conclusions are appropriate given the analysis.

Reviewer instructions also included the detailed guidance for review of abundance estimates given by IWC (2020a,

p.276). In addition, reviewers were asked to recommend a category (or 'not categorized'), using the system given by IWC (2018, p.390):

- Category 1: acceptable for use in in-depth assessments or for providing management advice.

- Category 2: underestimate – suitable for AWMP usage or other 'conservative' management but not reflective of total abundance.

- Category 3: while not acceptable for use in (1) or (2), adequate to provide a general indication of abundance.

- Category P: provisional or preliminary estimates.

During the meeting, recommendations were made to modify the categories and their descriptions (Item 4.3). The reviewer comments reflect the original categories.

The ASI intersessional review process is set up for the ASG, *inter alia*, to conduct an initial review of abundance estimates, based on the independent expert reviews solicited intersessionally. At its meeting, the ASG may recommend that the estimate is ready for consideration by ASI. In that case, the ASG may choose to suggest acceptance (and category) or rejection, highlighting issues for ASI to consider in either case. The ASG may also choose to make no specific recommendation to ASI, but rather provide a list of comments or concerns.

The ASG thanked the following independent experts for their reviews of abundance estimates this year: John Bickham, David Borchers, Trevor Branch, Mark Bravington, Ana Cañadas, Paul Conn, Justin Cooke, Megan Ferguson, Devin Johnson, Nat Kelly, Toshihide Kitakado, Russell Leaper, Tiago Marques, Brian Miller, Jeff Moore, Leslie New and Ana Širović. Their expertise and generosity in providing reviews of the abundance estimates discussed at the ASG meeting were invaluable.

The ASG **recommends** that the estimates for Rice's whale, southwest Pacific and Indian Ocean blue whales, and Eastern Canada-West Greenland bowhead whales presented in this report are deemed to have an extent of review designated as level 1: "estimate was examined in detail by the ASI subcommittee". The rationale for this designation is that, at the end of the current review process, the full extent of review intended by IWC (2020a) will have been completed.

2.1 Rice's whale (*Balaenoptera ricei*)

Rice's whale, also known as Gulf of Mexico Bryde's whales, are considered to be a distinct subspecies of Bryde's whales (Rosel and Wilcox, 2014) and possibly even a separate species entirely (with a proposed name of *Balaenoptera ricei*; Rosel *et al.*, 2021). They are the only resident baleen whale in the Gulf of Mexico, and have been found typically along the continental shelf break, between bathymetries of 100 and 400m (Rosel *et al.*, 2016); the population is considered to be critically endangered (Rosel *et al.,* 2021).

Garrison *et al.* (2020; Rice's whale was referred to as Bryde's whale therein) presents abundance estimates for Rice's whale in the Gulf of Mexico. The abundance estimates were derived from vessel-based zig-zag line transect surveys in the Gulf of Mexico, between the 100m bathymetric contour and the US EEZ, in the summers of 2017 and 2018. In the summer of 2017, 5,577km of survey effort was achieved, and 5,205 km in 2018. There was one verified sighting of a Rice's whale during the 2017 survey (despite adaptive sampling around that detection in the hope of locating other individuals), and two sightings during the 2018 survey (which were difficult to differentiate from sei or fin whales). Given the small sample size of Rice's whales during the 2017 and 2018 surveys, prior sightings of Bryde's whales in the Gulf of Mexico region, dating between 2003 and 2019, were used to estimate some of the parameters (e.g. effective search half-width) in a conventional distance sampling analysis, and it was assumed that $g(0) = 1$. These analyses derived a design-based abundance estimate of Rice's whale of 84 (CV 0.92) in 2017 for an area considered to be the core habitat (area ~49,200 km2), an estimate of 40 (CV 0.55) in 2018, and a weighted average of 51 (CV 0.50) across both years.

The reviewers noted that the underlying Rice's whale sighting data were very sparse, and although the standard line transect distance analysis methods were competently applied, it was difficult to judge the associated assumptions due to the small sample size. Given the likely negative bias from the survey effort potentially not covering the full extent of the species' habitat, in addition to a possible negative bias of ~25% due to $g(0)<1$, and, finally, uncertainty in the species identification for a number of sightings recorded as 'unidentified', the abundance estimate is likely to be an underestimate.

In discussion, the ASG noted that small populations, as is likely the case with Rice's whales, will tend to yield small numbers of detections in surveys, leading to uncertain abundance estimates that often rely considerably on assumptions in the absence of more data. The existing abundance estimate categories (IWC, 2018, p. 390) are not well suited to such circumstances, because when a stock is so small, urgent management advice can be given despite

potential shortcomings in the abundance estimate (e.g., possibly large bias or variance, or heavy use of assumptions). Therefore, the ASG recommended the creation of a new category, 1B, for such estimates; see Item 4.3. The ASG considered that, despite the likely substantial negative bias in the weighted average abundance estimate, the high conservation concern for this species led to a **recommendation** of category 1B for the weighted 2017-2018 abundance estimate (51, with CV=0.50) for Rice's whale.

2.2 Eastern Canada-West Greenland bowhead whales (*Balaena mysticetus*)

Frasier *et al.* (2020) described an approach to estimating abundance based on Bayesian methods using genetic (microsatellite) mark recapture data, which attempts to account for 'missing' individuals from unsampled locations. The authors illustrate this method by estimating the abundance of Eastern Canada- West Greenland (EC-WG) bowhead whales over two timespans, and present the method as an alternative to aerial surveys, which often were not able to cover the putative summer distribution of this population. Over the period 1995-2013, 1,177 biopsy samples were collected at Canadian and Greenlandic sites representative of the range of movements observed for EC-WG bowhead whales. These samples resulted in the identification of 992 individuals, but only 75 recaptures were achieved between years and across different areas. Two abundance estimates for the population were offered: one spanning data collected over a 19-year period (1995-2013), which was 11,747 (highest posterior density interval 8,169-20,043); and another estimate spanning data collected over a 5-year period (2008-2013), which was 13,899 (highest posterior density interval 7,782-30,602).

An earlier version of this study (Frasier *et al.* 2015) had been presented to the SC in 2018, when discussion focussed on: the potential impact of both missing location information and asymmetric migration on the precision of estimates; to what degree the dataset spanning 19 years' of genetic samples violated the closed-population assumption, and because of this, the shorter five-year dataset being preferred; and that the Mth model (*sensu* Otis *et al.* 1978), with time-varying capture probability and individual heterogeneity in capture probability had been found through simulation studies to provide less biased estimates when there is reasonable heterogeneity in the population (Schwarz and Seber 1999), as compared constant capture probability M0 model used by the authors (IWC 2019a). In considering these factors, the SC in 2018 recognised the value of the methodological approach and encouraged authors to develop their models further and to submit their results in the future (IWC 2019a). It should also be noted that an aerial survey line transect abundance estimate exists for this population (Doniol-Valcroze *et al.* 2015), which had been accepted for the provision of management advice and for use in an SLA (IWC 2019a).

The new analysis (Frasier *et al.*, 2020) was considered by two reviewers. One reviewer commented that the use of genetics over photographs of natural markings to identify recaptures has a number of advantages, but most of these were not utilised in this study. For example, the authors could have provided an estimate of Ne (effective population size), which can be converted to a census population size, and they could also have estimated the number of first order relatives which can be used to estimate population size. Another reviewer expressed several misgivings about the underlying model mark- recapture model (including assumptions about animal movement), and that the simulation testing was inadequate, but also noted that the underlying data provided a promising basis for abundance estimation, and that it would be a great benefit to the work of SC if the modelling was improved.

Frasier was provided with these reviews intersessionally, and responded that they were very helpful. In his view, the analysis was still preliminary and the abundance estimates should be considered as Category 3.

In discussion, the ASG thanked Frasier for his response and commended the authors on their very promising and valuable work. Reflecting upon the likely complexity of the improvements to modelling and simulation testing suggested by one reviewer, the ASG noted that while improvements would be important as the authors advanced this project, an estimate using novel methods like theirs could be useful to the SC without reaching a level of "perfection". The ASG **agreed** that Kelly would distil the reviewers' comments into two or three main issues that represented the ASG's primary concerns and might help to focus future work.

At the current level of development, the ASG was of the view that the abundance estimates successfully provided a general indication of population size which would certainly be improved with subsequent advancements. The ASG also considered that the five-year abundance estimate would be the more appropriate, and more likely to correspond to the assumption of closure. The ASG **encourages** the authors to continue this modelling work, especially because the underlying data provide a promising basis for abundance estimation. A full mathematical description of the estimator, and an in-depth description of the simulation tests, would be greatly appreciated. The ASG **recommended** that the 2008-2013 abundance estimate of 13,899 (highest posterior density interval 7,782-30,602) be accepted as Category 3.

2.3 Franciscana (*Pontoporia blainvillei*)

Several abundance estimates for Franciscana dolphins were considered during a separate workshop (that preceded the ASG meeting) to advance the review of the status of this species. The review of these estimates was coordinated

by an interessional correspondence group. These reviews were discussed at the workshop and the available abundances were categorized as defined by the SC (IWC, 2018, p.390). The report of the workshop will be presented to ASI at the upcoming annual meeting.

2.4 Southwest Pacific and Indian Ocean blue whales (*Balaenoptera musculus*)
Four subspecies of blue whales are currently recognized by the Committee on Taxonomy for the Society for Marine Mammalogy: northern blue whales, Antarctic blue whales, pygmy blue whales, and northern Indian Ocean blue whales (Committee on Taxonomy 2020), but south-east Pacific blue whales are not classified into any subspecies, and may constitute a fifth subspecies. The current classification is the source of some controversy since northern blue whales are in the North Pacific and North Atlantic (an unlikely geographic grouping), while no morphological or genetic evidence exists to separate northern Indian Ocean blue whales and pygmy blue whales.

Two sub-species of blue whale occur in the Southern Hemisphere: the Antarctic blue whale (*Balaenoptera musculus intermedia*) and the non-Antarctic Southern Hemisphere ("pygmy") blue whale *B. musculus brevicaudata* (Branch *et al.* 2007). The latter is composed of three populations, found in the southwest and southeast Indian Ocean and southwest Pacific Ocean, which each produce unique and acoustically distinct calls (McDonald *et al.* 2006; Širović *et al.,* 2018). At this meeting, the ASG reviewed several estimates of blue whales from different parts of the Indian Ocean and southwest Pacific.

In 2018, ASI reviewed an estimate of abundance for New Zealand blue whales (paper SC/67b/SH/05, now published as Barlow *et al.*, 2018). The discussion of that paper is outlined in IWC (2019a; section 3.1.1.9), but see also IWC (2019b; section 3.3). Barlow *et al.* (2018) describe a mark-recapture abundance estimate of New Zealand blue whales using photo-ID data collected in the South Taranaki Bight (STB) region during January and February 2014-17. The abundance of New Zealand blue whales was estimated as 718 (SD 433; 95% CI 279-1,926), using all samples from the 2014-2017 period. The package *multimark* in R developed by McClintock (2015) was used to generate a closed population abundance estimate using a Bayesian approach. The model included covariates of sampling period to account for heterogeneity in capture probability, and survey effort to account for variation in capture effort. A closed population estimate was generated due to a lack of information on immigration and emigration rates and because it should provide a conservative abundance estimate of blue whales in the vicinity of New Zealand.

During the 2018 SC review (IWC 2019a), ASI formed an intersessional correspondence group to coordinate an external review of the analyses presented in the subsequently published Barlow *et al.* (2018). One independent review was solicited. Briefly, the reviewer considered that: the sampling of a 'hotspot' was a concern as it might introduce bias; the assumption that the Southern Taranaki Bight (STB) region can be considered 'closed' was not realistic; and the assumptions about demographic closure were also questionable.

ASI returned to this study during the 2019 SC meeting (IWC 2020b; section 2.1.3) and concluded that sampling of a hotspot for mark-recapture analyses was less of a concern as regards potential sampling bias. ASI also noted that the four year-span of the sampling period described in Barlow *et al.* (2018) was a relatively short time in the lifespan of a blue whale, and that the assumption of demographic closure was consequently a reasonable approximation. However, ASI did agree that assumption of closure in the spatial population was not supported as immigration/emigration was likely. ASI encouraged the authors to explore alternative modelling approaches.

In 2020, the authors of Barlow *et al.* (2018) were requested to address the concerns raised by the 2018 reviewer. In summary, their response suggested that: targeting of hotspot areas was a common way to maximise the number of samples for identification data; over the four year timespan of the sampling in this study, STB animals were representative of the New Zealand population given an assumption of mixing around New Zealand; and given the low pregnancy rates and high survival probabilities that might be typical of blue whales, the four-year timespan could be assumed to have ensured demographic closure. Furthermore, the authors pointed out that some of the technical improvements recommended by the 2018 reviewer are not currently supported by the *multimark* package.

In response, ASG sought the opinion of a second reviewer, which was considered by ASG at this meeting. This second reviewer concluded that the spatial distribution of photo-IDs was adequate to cover the whole New Zealand blue whale population, and the number of individual identifications was reasonable. The reviewer also drew attention to the fact that the unique identification discovery curve was still increasing steeply, indicating a much larger population; furthermore, given the spatial concentration of the samples in the STB, the abundance estimate presented in Barlow *et al.* (2018) is likely to be an underestimate.

In discussion, the ASG noted that the Barlow *et al.* (2018) estimate has had quite a long history of consideration by the SC, and that views had evolved following additional review. The ASG considered that most of the SC's original concerns had been resolved through this process. The primary concern of the SC - questioning the assumption of spatial closure - was considered to have been reasonably addressed by the authors explanation that they had

assumed that sampling in STB draws from a larger, well-mixed New Zealand population. Nevertheless, the abundance estimate presented in Barlow *et al.* (2018) is almost certainly an underestimate, and any subsequent users of this estimate will need to consider which stock/population is represented. There was also discussion about to which year in the 2014-2017 timespan the multi-year abundance estimate would apply for the purposes of population assessments. However, the ASG declined to offer definitive conclusion on that point, and instead **recommended** that such a decision be made based on specific analysis needs. In conclusion, the ASG **recommended** that the Barlow *et al.* (2018) estimate be accepted as Category 2.

Jenner *et al.* (2008) outlines a mark-recapture estimate of non-Antarctic blue whales from Western Australia (Perth Canyon). Photo-IDs were collected during 2000-2005, and were used to identify 208 individuals. Twenty-three individuals were re-sighted once and two individuals were sighted in three or more of the six years. An open population POPAN model was considered the best model by the authors, providing an abundance estimate of 791 (95% CI 569- 1,147). (Note, however, that the abundance point estimate was not given in Jenner *et al.* (2008), but subsequently appeared in IWC (2009).)

The reviews were generally supportive of the analysis. The reviewers considered that the POPAN model seemed to have a better fit than the alternative closed models which the authors had also considered. They also remarked that the abundance estimate may be an underestimate due to detection probability heterogeneity, in addition to the fact that the Perth Canyon region likely does not reflect the whole population.

In ASG discussion, it was pointed out that model parameter estimates were not presented in Jenner *et al.* (2008), so that it is unclear as to whether these were in fact estimable (which is distinct from being able to decide the best model, for example). It was also unclear whether the interval estimates provided in the paper were statistical confidence intervals. The ASG **recommended** that the Jenner *et al.* (2008) estimate be categorized as P (provisional). Accordingly, the estimate should not be included on the IWC website.

Kato *et al.* (2007) describe a study involving line transect surveys and blue whale detections from SOWER vessels operating south of Australia in the summers of 1993 and 1995/96. Pooled data from two ships in the different years were used to estimate a blue whale detection function based on 27 sightings. The only estimate considered by the authors to be reliable is that for 1993, based on 12 sightings within the region bounded 35-45°S and 115-125°E, which was 671 (CV 0.45; 95% CI 279-1,613).

The reviewers commented the survey and analysis methods used by Kato *et al.* (2007) were those typically used by the SOWER programme and, as such, had been previously developed and approved by the SC. However, the reviewers also pointed out some potentially substantial biases for this abundance estimate, including that: most South East Indian Ocean blue whales are likely to found outside of the region covered by the 1993 survey; and given the small number of detections used to estimate the detection function, the CV reported for the abundance estimate likely did not reflect all uncertainty associated with that estimate.

In discussion, the ASG noted that the sightings data reported in Kato *et al.* (2007) were 28 years old, and that the 1993 survey region was too small to extrapolate meaningfully to surrounding areas. The issue of spatial coverage was also raised in the context of how to sum abundance estimates from the various areas in the southeast Indian Ocean that had been surveyed for blue whales. In addition there was recognition that the implications of uncertainties regarding which species or populations are represented in individual surveys would be discussed at length during the Comprehensive Assessment of non-Antarctic Southern Hemisphere blue whales. The ASG **recommended** that the Kato *et al.* (2007) estimate should be categorized as NS using the new categories given in Item 4.3.

McCauley and Jenner (2010) present a study of blue whale acoustic data collected along the West Australian coast, accompanied by an attempt to use passive acoustic monitoring data to derive an estimate of abundance. The overall approach was to attempt to relate the number of calls to the number of individuals transiting through the area of the recorder during these whales' southbound migration. The abundance estimate is based on the assumption that 8.5-20% of animals call, and integrated over an entire season. The resulting abundance estimate was 1,100 (with the authors proposing a 'range' of 662-1,559). This study was presented to the SH sub-committee in 2010 (IWC 2011; section 3.1).

Similar to the view expressed by the SH sub-committee in 2010, the reviewers considered that the analysis relied heavily on a number of assumptions, many of which were unsupported. Furthermore, they questioned the use of single-site measures of abundance due to potential changing whale behaviour in space and time, and the lack of consideration of various sources of uncertainty. The reviewers also pointed out that it was unclear what proportion of the stock/population might be being detected. However, one reviewer also commented that with more development of the assumptions used in this study, the approach used could eventually be made broadly appropriate for use by IWC-SC; a similar positive view about the future of this approach was also expressed by the SH sub-committee in 2010 (IWC 2011).

In discussion, the ASG expressed deep discomfort with assumption that 8.5-20% of animals call, noting the lack of sufficient justification for these values, both with respect to their magnitude and range. The ASG concluded that whilst acoustic data are potentially promising for use to provide abundance estimates, appropriate methods and support for the underlying assumptions are still in development. The ASG looks forward to when such methods could be used to estimate blue whale abundance more accurately. The ASG **recommended** that the estimate of McCauley and Jenner (2010) should be categorized as NS, using the new categories given under Item 4.3.

McCauley *et al.* (2018) describe a study of blue whale acoustics data collected at 32 sites around the coastline of Australia from 2004 to 2016. The acoustic data allowed for identification of calls from New Zealand blue whales, eastern Indian Ocean blue whales and Antarctic blue whales. The authors focused on a site near Portland, Victoria, to study the trend in call rates over time in an attempt to derive a trend in abundance, whilst also accounting for dynamics in the seasonal upwelling index. They report an apparent 4.3% growth rate in the proportion of the eastern Indian Ocean population visiting the Portland area. This study was also reviewed by the SH subcommittee in 2020 (IWC 2021; section 8.2.1.2).

The reviewers questioned the underlying assumptions of the analysis, especially that of a constant detection area. The reviewers were also concerned that various uncertainties were not propagated through to the final trend estimates. It was also concerning that a trend in sex ratio had not been considered (since only the males sing). Nevertheless, one reviewer considered that the paper contained a wealth of information about the distribution, temporal occupancy and acoustic trends of eastern Indian Ocean blue whales and Antarctic blue whales, and that the dataset represents an impressive set of acoustic recordings collected over a long time and wide geographic area.

The ASG noted that whilst there no abundance presented in this study, trend information may certainly still be useful if based on solid data and well-supported assumptions. The ASG recognised that possible reservations concerning many of the assumptions used in this study may preclude the use of its trend estimates at this time, but nevertheless given the impressive volume of data collated by the authors, and the length of time over which these data had been collected, the ASG encouraged further work. In conclusion, the ASG made no recommendation about this manuscript because no abundance estimate was presented, and was sceptical that the trend estimate could be considered sufficiently reliable for SC assessment or modelling purposes.

Best *et al.* (2003) describes a zig-zag line transect survey of blue whales on the Madagascar Plateau in late 1996 by vessels transiting to the Southern Ocean to undertake research for the SOWER programme. Within the survey region 25°-35°S, 40°-45°E, two vessels achieved a combined 1,544 nm of effort, which yielded 95 sightings of 110 animals which observers classified as 'pygmy' blue whales; there were also another 26 sightings of 34 individuals classified as 'unidentified' or 'like' blue whales. No sightings were classified as Antarctic blue whales. Using CDS methods, and an assumption of $g(0)=1$, a design-based abundance estimate of 424 (CV 0.42) was produced; a second abundance estimate which included the 'like blue' sightings of 472 (CV 0.48) was also presented.

The reviewers considered the survey methods and subsequent analyses were generally competent (albeit now slightly dated), and also noted the particular effort to consider violations to various modelling assumptions. Furthermore, they pointed out that the survey region probably covered only a part of the spatial distribution of the population, and that the survey data were now over 24 years old.

In discussion, the ASG considered the uncertainty as to which stock this estimate might apply. Jackson stated that the animals detected in this survey are likely to be southwest Indian Ocean blue whales, but also that acoustic evidence suggests that southeast Indian Ocean and Antarctic blue whales may occasionally visit the Madagascar Plateau region (Branch *et al.*, 2021). The likely blue whale species in this region is an active topic of discussion in the SH subcommittee relevant to its comprehensive assessment of non-Antarctic southern hemisphere blue whales. In conclusion, the ASG **recommended** that the estimate of 424 (CV 0.42) be accepted as Category 2.

Priyadarshana *et al.* (2016) present a study of blue whales off the southern coast of Sri Lanka in 2014- 15, which aimed to explore the distribution patterns of blue whales (derived from a line transect survey) in relation to the density of shipping traffic over an area of about 7,500 km². The surveys covered 3,268km, and yielded 193 blue whale sightings (281 individuals), from which a design-based CDS abundance estimate of 270 (CV 0.09; 95% CI 226-322), assuming $g(0)=1$, had been produced.

The reviewers commented that this study was primarily about shipping interactions, not abundance estimation, and therefore some important details about the abundance estimate were lacking. The reviewers also pointed out that uncertainty in the abundance estimate did not seem to account for spatial variation in the density across the survey area, and that this may be why the CV of the abundance estimate was quite low. Furthermore, they noted that distances to detections were often estimated by eye, so that there may be errors in those distances which have not been taken into account. The reviewers also held the view that the assumption of $g(0)=1$ is not well supported, but that the resulting bias is likely to be small. Finally, they drew attention to the fact that the survey covered only a

relatively small proportion of the area known to be visited by blue whales in Sri Lankan waters.

In discussion, the ASG recognised that although the survey region itself was relatively small, these estimates may still provide an indication of minimum abundance for population assessments. The ASG considered that there was insufficient information to evaluate the abundance estimate fully, and was concerned that no explanation was offered for the remarkably small CV. The ASG **agreed** to contact the authors of Priyadarshana *et al.* (2016) for further information regarding the abundance estimates, especially associated error estimates. Until a response is received, the ASG **recommended** that this estimate be categorized as P (provisional).

2.5 North Pacific sei whales (*Balaenoptera borealis*)
Three papers providing abundance estimates for north Pacific sei whales were reviewed intersessionally. The ASG did not have time to consider these estimates and the reviewers' comments fully during the meeting. However, it was apparent that additional information would be needed to complete the review of two papers (SC/J09/JR15 and SC/F16/JR/12), so Zerbini contacted Hakamada to request such information. The ASG **agreed** that the estimates should be reviewed by ASI during its upcoming meeting, to the extent possible given the information available then.

3. CONSIDERATION OF STATUS OF STOCKS
The SC has been asked to provide broad information on the status of whale stocks for the Commission and general public. Recent work on this project is summarized by IWC (2019c, p. 281-2; 2020c, p61-3). During the intersessional period, Punt and Allison had worked to generate some of the simulation results needed to assess status for certain stocks.

3.1 Current status of table development
During the ASG meeting, Givens used the results for eastern north Pacific gray whales to draft an initial example of a status report. He envisioned a collection of web pages, one per stock or region, summarizing abundance, depletion and population growth rate. Each case would include a link to a second page with detailed simulation results, and a link to a general background page explaining the SC's process for assessing status. Other information on the primary page would include information about stock structure, possible substocks, threats to the population and the quality of the data available.

In discussion of this example, a variety of suggestions about content and style were made. It was suggested that information about substocks be limited to specific groups of concern to the Commission, such as the Pacific Coast Feeding Group and Western Feeding Group/ Western Breeding Stock for eastern north Pacific gray whales. Aside from these, status should be reported on an area or population basis. Porter commented that the use of web pages for this purpose allowed the SC to exploit dynamic, colourful, interactive features of modern HTML, and hence she suggested that the Committee should strive for something better than plain documents with text and numeric tables.

3.2 Future workplan
The ASG asked Givens and Punt to develop a second draft of the example, incorporating input from the meeting. This would be considered by ASI during the SC meeting this year. After feedback from ASI, and corresponding revisions, the ASG recommended that the Chair of the SC show the example(s) to the Bureau of the Commission to solicit feedback on whether the approach met Commission objectives.

Givens noted that Greg Donovan had been a major force behind advancing this project. However, considering Donovan's retirement from the Secretariat, it was critical that ASI form a small working group to facilitate further progress. The ASG **recommended** that ASI establish such a group, whose members should include at least Givens, Punt, and Allison, and provide instructions on how to proceed.

4. REVIEW OF HOW THE NEW ASI/ASG PROCESS IS WORKING
4.1 Background
ASI was established in 2016 to formally review abundance estimates submitted to the SC across all the Committee's sub-committees and working groups to improve consistency (IWC 2019a). In 2019, ASI established new procedures for evaluating abundance estimates submitted to and used by the SC (IWC, 2020a). However, the large number of requests to review estimates received by ASI, the Covid-19 pandemic and the subsequent move to virtual meetings of the Committee had presented serious challenges to the work of ASI. In many cases, the Convenors were unsure how to proceed. ASI is a relatively new and evolving entity, and is seeking to improve and streamline its work. Whilst **reaffirming** the procedures and guidelines outlined by IWC (2020a), the ASG discussed the following challenges and potential solutions.

4.2 Organisation and Priorities

Since the ASI was established, it has received more requests to review abundance estimates than could be accommodated, and many reviews have been delayed, some by several years. For example, in the 2020-21 intersessional period, Zerbini and Givens solicited nearly 50 reviews, but this represents only a portion of what was sought from ASI. In an attempt to work through the list of requests for review, a number of different pathways for review were employed. Some estimates were reviewed intersessionally and were then considered by ASG at this meeting. Other estimates were reviewed intersessionally and considered at a dedicated workshop for Franciscana dolphins (Item 2.3). Others will be reviewed at SC68C by ASI, in the same way papers are typically presented and reviewed during annual meetings. Finally, review of a number of other estimates has been postponed to the next intersessional period, and perhaps even beyond.

Givens and Zerbini raised a number of issues and concerns arising from the intersessional review process this year. They noted the high demand for reviews, which could not be fulfilled, and the sometimes unclear prioritization criteria. It may be necessary for other members of the ASG to coordinate some reviews. Furthermore, the reviewers have disproportionately been experienced SC members, whose subject matter expertise and SC experience are extremely valuable, but this may be unsustainable in the long term. They recommended that ASI consider the instructions provided to reviewers (see Item 2) and how the ASG/ASI review process worked this year. They recommended that guidelines be developed for interacting with authors whose papers are reviewed, especially for authors who may be unfamiliar with the SC and its review process. Authors should receive the reviews, have an opportunity to respond, and, if possible, be invited to participate in the ASG or ASI meeting where their estimate is considered. Finally, they reaffirmed that robust intersessional work and the annual ASG pre-meeting are essential to make sufficient progress on ASI objectives.

In response to the concerns raised, the ASG offered the following comments.

- Allocation of particular abundance estimate to a given review pathway may inadvertently confer either a perceived benefit or disadvantage to the authors. For example, an estimate presented by authors at a SC meeting may receive a more immediate or conversational review given the relative speed of such an Annual Meeting. In contrast, an intersessional review does not provide the authors with an opportunity to respond immediately, thus slowing the progress of the estimate through the review process, but allowing the authors more time for a considered response. The ASG **agreed** that the pathways should be standardized as far as possible so that papers receive equivalent levels of review, and authors receive equivalent opportunities for response.

- The ASG **agreed** that only Chairs of subcommittees and standing working groups, or the Secretariat's Head of Statistics, may request ASI to review an abundance estimate.

- The ASG **recommended** that ASI consider a process to make review of abundance estimates at the annual SC meeting more similar to the intersessional process. Specifically, for papers to be presented at the annual SC meeting, two experts could be asked to produce a written review prior to or during the early stages of that meeting. To ensure a reasonable timeframe for those reviewed at the annual meeting, the abundance estimates should be submitted reasonably well in advance of the annual meeting. Those reviews would be given to the authors, who would be provided an opportunity to respond during the ASI session where the paper is discussed.

- Many of the abundance estimates which ASI has been asked to review are fairly old. The ASG **agreed** that such estimates should receive higher priority when they are needed for the work of the SC (as specified by IWC (2020a)), or when they are the only ones that exist for a given stock/area.

- Whilst requirements for submission of data and code have not been followed strictly in the recent past, it **reaffirmed** the importance of this process, especially when abundance estimates are to be used in generating management advice.

- There is uncertainty around the procedure for updating abundance estimates already included in the IWC Table of Accepted Abundance Estimates. Oftentimes, abundance estimates are improved or modified to a small degree, and possibly do not warrant another full review. The ASG **agreed** that where abundance estimates undergo minor revisions, such alterations can be managed by the Head of Statistics, who would revise the table and subsequently notify the ASI. In the event that an abundance estimate undergoes more noteworthy revisions, ASI must conduct another review. If the Head of Statistics is unsure which case applies, she should refer the revised estimate to ASI for a decision.

- The ASG **agreed** that it is common courtesy to inform authors that their paper is being considered for review for addition to the IWC Table of Accepted Abundance Estimates. Authors should be provided the reviews and an opportunity to respond, either in writing or during a meeting of ASI.

- Some authors may not be familiar with the procedures of the SC and ASI. The ASG **agreed** that ASI should develop a 'friendly introduction' to the process that explains procedures in a non-confrontational manner and expresses appreciation for the value of the authors' work. This would include mention of the opportunity to respond and/or to attend a future ASI meeting.

- Following discussion of how written reviews should be handled, both in the context presentation to a meeting and how they are to be archived, the ASG **agreed** that reviews should not be presented as official meeting documents, and should not be broadly available outside the ASI review process. (At this meeting, for example, the reviews were presented as Working Papers.) The ASG **agreed** that the written reviews should be archived by the Head of Statistics but generally not be made accessible to members of the SC. Such reviews can be accessed at a later time if necessary, such as to avoid duplication of review effort, or to understand the decision to categorise an abundance estimate in a certain way more fully.

- The ASG **agreed** that an abundance estimate that has been published in a peer-reviewed journal does not automatically qualify for acceptance by ASI. The SC sets its own standards for judging abundance estimates.

- The SC does important outreach work in providing guidance to developing countries with cetacean survey design and data analysis, and that should continue to be part of the work of the ASI.

4.3 Updating the abundance estimate categories

The ASG considered the existing definitions of categories for abundance estimates (IWC, 2018, p. 390), in light of its experiences at this meeting. There had been considerable confusion about the differences between categories 2 and 3, especially for some blue whale estimates (Item 2.4). Also, it was unclear how to categorise estimates of small, critically endangered populations/stocks where only imprecise abundance estimates may be feasible (such as for Rice's whale, Item 2.1).

In the context of category 2, there was confusion as to what entity the negative bias might apply—the population or the area being surveyed—in the case where a survey does not cover the entire putative habitat of a population, or when a survey was undertaken when there is mixing on a feeding ground. Therefore the ASG **agreed** that it was important to document the justification of the categorisation fully, including noting to what geographic area and stock the abundance estimate applies.

After discussion, the ASG **recommended** that ASI revise its list of categories to the following:

- Category 1A: An estimate which is acceptable for use in in-depth assessments or for providing management advice using the RMP, AWMP SLAs, or other modelling or analysis. This (and category 1B) may include estimates with minor or possibly competing small biases (e.g., assuming $g(0)=1$ when it may be slightly less).

- Category 1B: An estimate which pertains to a very small stock and is acceptable for providing management advice in that context, including situations where no sophisticated modelling or analysis is required.

- Category 2: An estimate for a stock or study area for which conservative management is acceptable (e.g., as could be the case for an AWMP SLA). The estimate may be subject to considerable negative bias for reasons such as limited spatial coverage or lack of correction factor(s).

- Category 3: An estimate which is potentially informative but not acceptable for use in (1A), (1B) or (2). This category includes estimates with a bias which is too severe to allow inclusion in Category 2, as well as relatively unbiased estimates that are adequate to provide some general indication of abundance while not qualifying for (1A) or (1B).

- Category P: A preliminary estimate, not suitable for use at the time of review but which may provide an acceptable estimate once finalized.

- Category X1: Category 1A or 1B estimates that have been superseded by newer estimates. They will be omitted from published tables.

- Category ND: An estimate which was not discussed. Used to show other estimates which have not been discussed by the Scientific Committee, but which may be discussed in future. They will be omitted from published tables

- Category NS: An estimate reviewed by the Scientific Committee but agreed not to be suitable for acceptance due to factors like: insufficient data; insufficient methodological information presented; concerns about analysis design, conduct or interpretation; failure to account for very large potential biases; or assumptions that are unreasonable or clearly violated.

The ASG **recommended** that ASI undertake a review of estimates in the IWC's Table of Agreed Abundance Estimates

so as to reclassify them as necessary to adhere to the new categories given above.

5. WORKPLAN
The ASG identified the following tasks to be conducted in the future:

- Provide Frasier *et al.* with a summary of two or three main issues which the ASG considers might improve the genetic capture-recapture estimate of EC-WG bowhead whales. Kelly will distil the reviews for this purpose, and Givens will write to the authors to provide this summary and explain the outcome of the ASG review.

- Provide ASI with a new example of how to report status of stocks, based on the eastern north Pacific gray whale case. Punt, Givens and Palka will draft this and present it to ASI.

- Request that Priyadarshana *et al.* provide more information on their abundance analysis for blue whales off Sri Lanka. Givens has forwarded this request to Leaper, who will provide a response for the ASI meeting.

- Recategorize estimates in the IWC's Table of Agreed Abundance Estimates as necessary to adhere to the new proposed categories. This should be undertaken intersessionally by ASI, led by a small group including Zerbini, Butterworth, Jackson, Givens, Allison and possibly other members identified during the ASI meeting.

- Provide Garrison *et al.* with the reviews of their abundance estimate for Rice's whale, and a summary of how the ASG process developed. Givens will do this, and invite Garrison to respond at the ASI meeting.

6. ADOPTION OF REPORT
The report was adopted by email on 26 April 2021. The ASG thanked Givens and Zerbini for coordinating the intersessional review process, and also Kelly for producing an excellent draft report.

REFERENCES
Barlow, J. 2016. Cetacean abundance in the California Current estimated from ship-based line transect surveys in 1991-2014. NOAA Administrative Report LJ-16-01.

Barlow, D.R., Torres, L.G., Hodge, K.B., Steel, D., Baker, C.S., Chandler, T.E., Bott, N., Constantine, R., Double, M.C., Gill, P., Glasgow, D., Hamner, R.M., Lilley, C., Ogle, M., Olson, P.A., Peters, C., Stockin, K.A., Tessaglia-Hymes, C.T. and Klinck, H. 2018. Documentation of a New Zealand blue whale population based on multiple lines of evidence. *Endangered Species Research* 36: 27-40.

Best P.B., Rademeyer R.A., Burton C., Ljungblad D., Sekiguchi K., Shimada H., Thiele D., Reeb D., Butterworth D.S. 2003. The abundance of blue whales on the Madagascar Plateau, December 1996. *J. Cetacean Res. Manage.* 5(3): 253-260.

Branch T.A., Stafford K.M., Palacios D.M., Allison C., Bannister J.L., Burton C.L.K., Cabrera E., Carlson C.A., Galletti Vernazzani B., Gill P.C., *et al.* 2007. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. *Mamm. Rev.* 37(2): 116-175.

Branch, T.A., Monnahan, C.C., Širović, A., Al Harthi, S., Allison, C., Balcazar, N.E., Barlow, D., Calderan, S., Cerchio, S., Double, M.C., Dréo, R., Gavrilov, A.N., Gedamke, J., Hodge, K. and Cu, K. 2021. Monthly movements and historical catches of pygmy blue whale populations inferred from song detections. Paper SC/68C/SH/17 presented to the 2021 meeting of the Scientific Committee, April, 2021.

Committee on Taxonomy. 2020. List of marine mammal species and subspecies. Society for Marine Mammalogy, *www.marinemammalscience.org*, consulted on 26 April, 2021.

Doniol-Valcroze, T., Gosselin, J.F., Pike, D., Lawson, J., Asselin, N., Hedges, K. and Ferguson, S., 2015. Abundance estimate of the eastern Canada - west Greenland bowhead whale population based on the 2013 high arctic cetacean survey. *DFO Can. Sci. Advis. Sec. Res. Doc.* 2015/058. v +27pp.

Frasier, T.R., Petersen, S.D., Postma, L., Johnson, L., Heide-Jorgensen, M.P. and Ferguson, S.H. 2015. Abundance estimates of the Eastern Canada-West Greenland bowhead whale (*Balaena mysticetus*) population based on genetic capture-mark-recapture analyses. *DFO Can. Sci. Advis. Sec. Res. Doc.* 2015/008. iv + 21 p.

Frasier, T.R., Petersen, S.D., Postma, L., Johnson, L., Heide-Jørgensen, M.P. and Ferguson, S.H. 2020. Abundance estimation from genetic mark-recapture data when not all sites are sampled: an example with the bowhead whale. *Global Ecology and Conservation* 22. https://doi.org/10.1016/j.gecco.2020.e00903

Garrison, L.P., Ortega-Ortiz, J. and Rappucci, G. 2020. Abundance of marine mammals in waters of the U.S. Gulf of Mexico during the summers. NOAA Southwest Fisheries Science Center Reference Document PRBD- 2020-07.

Hakamada, T., Matsuoka, K. and Miyashita, T. 2009. Distribution and the 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 available from the IWC Secretariat, www.iwc.int

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/JR/12 available from the IWC Secretariat, www.iwc.int

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

International Whaling Commission. 2011. Annex H. Report of the Subcommittee on Other Southern Hemisphere Whale Stocks. *J. Cetacean Res. Manage.* 12 (Suppl.): 203-226.

International Whaling Commission. 2018. Report of the Scientific Committee, Annex Q: Ad hoc Working Group on Abundance Estimates, Status and

International Cruises. *J. Cetacean Res. Manage.* 19 (Suppl.): 376- 398.

International Whaling Commission. 2019a. Report of the Scientific Committee. Annex Q. Report of the Standing Working Group on Abundance Estimates, Status of Stocks and International Cruises *J. Cetacean Res. Manage.* 20 (Suppl.): 394-412.

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

International Whaling Commission, 2019c. Report of the Scientific Committee. *J. Cetacean Res. Manage.* 20 (Suppl.): 1-101.

International Whaling Commission. 2020a. Report of the Scientific Committee. Annex P. Report of the Standing Working Group on Abundance Estimates, Status of Stocks and International Cruises *J. Cetacean Res. Manage.* 21 (Suppl.): 273-276.

International Whaling Commission. 2020b. 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, 2020c. Report of the Scientific Committee. *J. Cetacean Res. Manage.* 21 (Suppl.): 1-91.

Jenner, C., Jenner, M.N., Burton, C., Sturrock, V., Salgado Kent, C., Morrice, M., Attard, C., Möller, L. and Double M.C. 2008. Mark recapture analysis of pygmy blue whales from the Perth Canyon, Western Australia 2000-2005. Paper SC/60/SH16 presented to the IWC Scientific Committee, May 2008 (unpublished). 9pp. Available from www.iwc.int.

Kato, H., Matsuoka, K., Nishiwaki, S. and Bannister, J.L. 2007. Distribution and abundance of pygmy blue whales and southern right whales in waters off the southern coast of Australia, based on data from the JAPAN/IWC blue whale cruise 1995-96. Paper SC/59/SH10 presented to the IWC Scientific Committee, May 2007 (unpublished). 14pp. Available from www.iwc.int.

McCauley, R.D., Gavrilov, A.N., Jolliffe, C.D., Ward, R. and Gill, P.C. 2018. Pygmy blue and Antarctic blue whale presence, distribution and population parameters in southern Australia based on passive acoustics. *Deep Sea Res. (II Top. Stud. Oceanogr.)* 157-158: 154-168.

McCauley, R.D. and Jenner, C. 2010. Migratory patterns and estimated population size of pygmy blue whales (*Balaenoptera musculus brevicauda*) traversing the Western Australian coast based on passive acoustics. Paper SC/62/SH26 presented to the IWC Scientific Committee, May 2010 (unpublished). 9pp. Available from www.iwc.int.

McClintock, B.T. 2015. Multimark: An R package for analysis of capture-recapture data consisting of multiple 'noninvasive' marks. *Ecol. Evol.* 5(21):4920-31.

McDonald, M.A., Mesnick, S.L. and Hildebrand, J.A. 2006. Biogeographic characterisation of blue whale song worldwide: using song to identify populations. *J. Cetacean Res. Manage.* 8(1): 55-66.

Otis, D.L., Burnham, K.P., White, G.C. and Anderson, D.R. 1978. Statistical inference from capture data on closed animal populations. *Wildlife Monographs*. 62: 3-135.

Priyadarshana, T., Randage, S.M., Alling, A., Calderan, S., Gordon, J., Leaper, R. and Porter, L. 2016. Distribution of blue whales (*Balaenoptera musculus*) and shipping off southern Sri Lanka. *Regional Studies in Marine Science* 3: 181-188.

Rosel, P.E. and Wilcox, L.A. 2014. Genetic evidence reveals a unique lineage of Bryde's whales in the northern Gulf of Mexico. *Endanger. Species Res*. 25:19–34. doi: 10.3354/esr00606

Rosel, P.E., Corkeron, P., Engleby, L., Epperson, D., Mullin, K.D., Soldeville, M.S. and Taylor, B.L. 2016. Status Review of Bryde's Whales (*Balaenoptera edeni*) in the Gulf of Mexico under the Endangered Species Act. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-SEFSC-692.

Rosel, P.E., Wilcox, L.A., Yamada, T.K. and Mullin, K.D. 2021. A new species of baleen whale (*Balaenoptera*) from the Gulf of Mexico, with a review of its geographic distribution. *Marine Mammal Science* **37**(2): 577-610.

Schwarz, C.J. and Seber, G.A.F. 1999. Estimating Animal Abundance: Review III. *Stat. Sci.* 14(4) 427-56.

Širović, A., Branch, T., Brownell Jr, R. L., Cerchio, S., Lang, A., Buchan, S., Findlay, K., Miller, B., Olson, P., Rogers, T., *et al.* 2018. Blue whale song occurrence in the Southern Hemisphere. Paper SC/67b/SH11 presented to the IWC Scientific Committee, May 2018 (unpublished). 13pp. Available from www.iwc.int.

Appendix 1

AGENDA

1. INTRODUCTORY ITEMS

      1.1 Opening remarks, and review of ASG purpose and procedures

      1.2 Election of the Chair

      1.3 Appointment of Rapporteurs

      1.4 Adoption of the agenda

      1.5 Documents available

2. REVIEW OF ABUNDANCE ESTIMATES EVALUATED INTERSESSIONALLY

      2.1 Rice's whale

      2.2 Eastern Canada – West Greenland bowhead whales

      2.3 Franciscana

      2.4 Southwest Pacific and Indian Ocean blue whales

      2.5 North Pacific sei whales

3. CONSIDERATION OF STATUS OF STOCKS

      3.1 Current status of table development

      3.2 Future workplan

4. REVIEW OF HOW THE NEW ASI/ASG PROCESS IS WORKING

      4.1 Suggested improvements to ASG working methods

5. WORKPLAN

6. ADOPTION OF REPORT