REPORT OF A PANEL APPOINTED TO REVIEW RESEARCH AND RECOMMENDATIONS RELATED TO NORTH PACIFIC SEI AND BRYDE'S WHALES

28-30 August 2024

EXECUTIVE SUMMARY

The workshop discussed the papers presented, which included catch limit recommendations. The Review Panel **recommended** that catch limits of 56 whales for North Pacific sei whales and 154 whales for North Pacific Bryde's whales were in line with the provisions of the Revised Management Procedure (RMP), and hence acceptable on that basis. These catch limit recommendations rely on the assumption of full mixing of whales within the *Small Area* selected for each calculation; these extend beyond Japan's territorial waters and Exclusive Economic Zone (EEZ) within which the full catch is to be taken, so that priority needs to be given to analyses which investigate the extent to which this mixing assumption holds. Failing sufficient progress in this respect, it may be necessary in the future to adopt a more conservative approach to calculating catch limits.

1. Introductory items

1.1 *Proponents welcome and opening remarks*

Sakamoto welcomed panellists and other participants on behalf of Japan, and expressed his hope for a successful meeting. The Panel was comprised of scientists external to and independent of Japan, specifically:

Doug Butterworth, University of Cape Town, South Africa

Samba Diallo, Centre National des Sciences Halieutiques de Boussoura, Conakry, Guinea

Bjarki Elvarsson, Marine and Freshwater Research Institute, Hafnarfjörður, Iceland

Thomas Nelson, Department of Fisheries, Castries, Saint Lucia

Ralph Tiedemann, University of Potsdam, Germany

Lars Walløe, University of Oslo, Norway.

1.2 *Appointment of chair and rapporteurs*

Walloe was appointed chair. Rapporteurial duties were shared amongst Panel members.

1.3 *Objectives of the review workshop*

Walloe summarised that these were to review work presented on North Pacific sei and Bryde's whales, and in particular to scrutinise analyses related to the computation of catch limits for these two species, calculated using an RMP-based approach.

1.4 *Workshop procedures, time schedule and logistics*

These were explained by Kawai.

2. Review of available documents and reports

These are listed in Appendix 1.

3. Overview of previous recommendations

Pastene summarised these, as recorded in document RW/A24/01. It was noted that previous requests for items to receive attention had all been addressed.

4. North Pacific fin whale

Takahashi presented document RW/A24/06, which provides the results of analyses carried out in response to a recommendation made at the review workshop on North Pacific fin whales in September 2023 on the use of simple population models. These models incorporate dispersion with rates estimated from mark-recapture data in an attempt to better quantify the extent of mixing (movement) and how this impacts the possibility of localised depletion, and consequently on what are appropriate catch limits if whaling is restricted close to Japan. Results for simulated catches between 5 and 10 indicated that the population size in Block1 (the EEZ of Japan where whaling will be conducted) would not become extinct after 200 years if the annual catch is 8 whales or less per year in circumstances where MSY for the whole region was 10 whales. Results also showed that the total population size would stabilize at a higher level when the annual catch was set at 8 or less whales.

In discussion, it was suggested that this simple approach indicated that for sustainability, catches of fin whales in the North Pacific, if restricted to the Japanese territorial waters and EEZ (hereinafter both together indicated by 'EEZ'), would need to be reduced by about 30-40% from those that would apply if there was perfect mixing. Alternatives to the diffusion mixing model used were also mooted.

5. North Pacific sei whale

5.1 *Update on the information on stock structure and definition of management areas*

Taguchi presented RW/A24/03 in which the genetic analysis on the stock structure of North Pacific sei whales was updated by increasing the sample size, especially in the Japan's EEZ, as well as implementing further analytical approaches (i.e., Parent-Offspring (P-O) analysis and spatially explicit analysis) tailored to infer subtle population structure, should it exist. The dataset containing a total of 1,980 microsatellite genotypes (msDNA) at 17 loci and 1,979 mitochondrial control region sequences (mtDNA) was used for the analysis, which was divided into the three sampling areas: (1): Sub-area 1a inside of EEZ, (2): Sub-area 1a outside of EEZ (i.e., west of 170°E), and (3): Sub-areas 1b + 1c + 2 (i.e., east of 170°E) to examine possible additional stock structure in

the western North Pacific. mtDNA haplotype diversity in (1) was slightly lower than in other areas, and heterogeneity tests showed significant mtDNA differentiations in (1) from other areas. Additionally, the P-O analysis showed an overrepresentation of P-O inferences within (1). The number of P-O pairs inferred between (1) and (2) was not significantly different from random expectations. The statistically significant mtDNA differences between (1) and the other areas could be due to some stronger kinship-associations among whales in the coastal feeding ground (i.e., within the Japanese EEZ). In fact, several of the P-O pairs found in (1) corresponded to Mother-Daughter pairs, which could have influenced the heterogeneity test of mtDNA. The sPCA analysis showed different clustering pattern between the west and east of 180°, and the genetic statistics changed gradually between 180° and 160°W. These findings suggested the possibility that different genetic stocks exist in the western and eastern North Pacific (i.e., W-stock and E-stock, respectively). Further, the authors assumed a stock boundary located around at 170°W.

In discussion, the two stock hypothesis was considered highly plausible, yet the exact location of the boundary between these stocks was considered not unequivocally resolved by the data presented and 170°W did not appear specifically supported, rather the boundary could be somewhere in the range between 170°E and 170°W. It was further noted that the area from 160°E to 180° (midpoint 170°E) exhibited an elevated inbreeding coefficient (F_{IS}). This could be indicative of admixture and/or of a stock boundary within this longitudinal range. The Panel acknowledged that a sensitivity test was performed in the *Implementation Simulation Trials* (*ISTs)*, evaluating the effect of different putative stock boundaries between 170°E and 170°W.

Konishi presented RW/A24/05 on movements of sei whales examined by satellite-monitored tags deployed in the western and central North Pacific between 2017 and 2023. The results of track records throughout the years clarified their migration patterns, presumed breeding area (the Marshall Islands) and seasonal movement in the feeding area. The sei whale winter migration occurred during November and February with a wide longitudinal range of the southward corridors, arriving at a low-latitude breeding ground south of 20°N and west of 180°. The sei whales tagged in spring dispersed longitudinally in the feeding area.

In discussion, it was noted that tagged animals did not move through the entire area of the North Pacific region. The dataset for the movement of tagged animals was for each individual; they were different in each case and the movement recorded was from the point of tagging to the point where the transmission of data ended and hence did not necessarily cover the entire region. However, the information presented in the paper seems to confirm the two stocks hypothesis with a boundary between 170°E and 170°W, although the dataset collected was not very large. It was further noted that most of the animals tagged moved directly south although some also moved south and then westward during migration. It was also noted that the exact location of breeding or conception may be difficult to determine based on the biology of marine mammals.

5.2 *Update of the information on abundance*

Takahashi presented RW/A24/07 on abundance estimates for North Pacific sei whales based on new sighting data collected from Japanese dedicated sighting surveys conducted in 2020-2021 and the IWC-POWER surveys conducted in 2019-2022. Revised abundance estimates for this species based on a 2008 JARPNII survey in the western North Pacific were also presented. Abundance was estimated by conventional distance sampling method using R package “Distance” and assuming g(0)=1. All survey data were assigned to either two geographical regions, the western North Pacific

(west side of 180°) and the eastern North Pacific (east side of 180°) for fitting the detection function. The MRDS method was used to estimate *g*(0). The probabilities of detection on the trackline from either TOP or IO barrel, as well as the detection from at least one platform were estimated. The effect of survey season on the design-based abundance estimate was examined by a Generalized Linear Model (GLM) analysis. Based on this, the number of observations was standardized to the high-density season, and abundance estimates were adjusted accordingly. The adjusted and *g*(0) corrected abundance estimates for each geographical region were 24,620 (CV = 0.219) for WNP and 31,309 (CV = 0.250) for ENP for the latest period.

In discussion, it was noted that some uncertainties about the detection function were evident, and it was also noted that detection function changes to some extent when using the MRDS method. The Panel accepted the results presented from the MRDS models, and that there are different factors that would affect the result, including the platform used and season.

5.3 *Update on the information on catch history*

Miyashita presented RW/A24/09, which updated the catch series for the North Pacific sei whales with the aim of catch limit calculation in line with the RMP. The original catch series has been developed using the International Whaling Commission (IWC)'s individual and summary database Version 6.1 compiled for the recent in-depth assessment by the IWC/SC. Using the latest IWC database Version 7.0 and additional information from 2019 to 2023, the catch series was updated to match hypotheses on stock structure.

The catch series reported matched the stock areas shown in Figure 2 of the paper, whose boundaries had been based on genetic analyses. The workshop noted that with the completion of this work, there were no gaps in distribution which had earlier suggested a possible boundary at 170°E.

5.4 *Update on the in information on biological parameters*

Maeda presented RW/A24/11 on biological parameters of sei whales, with a particular focus on age at sexual maturity for use in the RMP's *ISTs*. The analysis incorporated new information obtained from current commercial whaling. The recent trend in age at sexual maturity had varied between 8 and 9 years of age, with no significant trends. Results for recent year classes and of the mean age at first ovulation individuals suggested an age at sexual maturity of about 8. This value is used in current *ISTs*.

5.5 *Revised calculation of catch limit by the Catch Limit Algorithm (CLA) and examination of uncertainties by ISTs*

Hakamada introduced RW/A24/02 which provided a revision of the catch limit for the North Pacific sei whale using an RMP-based approach. This document first discussed the pertinent stock structure hypotheses, with the associated *Small Areas* together with estimates of abundance for these. It continued by specifying historical catch series, going on to calculate a catch limit, and then to check the robustness of this limit to uncertainties. The two underlying stocks, the W-stock and the E-stock, were distributed amongst four sub-areas whose boundaries had been selected taking account of the various genetic analyses. Three different options for *Small Areas* were considered,

which were based on four sub-areas which underlay the Operating Models' dynamics. Application of the CLA with a 0.6 tuning level, and input of the selected abundance estimates (including the chosen *g*(0) value) and historical catch series, yielded annual catch limits for the three *Small Area* options of 219, 130 and 56 (respectively for W/E boundaries of 170°W, 180° and 170°E). Examination of uncertainties was based on *ISTs* which spanned two values for MSYR, two catch series, two *g*(0) values and three options for the eastern boundary of the W-stock – 10 trials in all were considered. A future survey pattern was specified. All *ISTs* fitted the available abundance estimates reasonably. Using the standard IWC acceptability criteria, only the management variant corresponding to the *Small Area* with a boundary at 170°E was deemed acceptable, with the associated annual catch limit of 56 whales consequently recommended.

5.6 *Discussion, conclusions and recommendations*

In discussion, it was noted that this recommendation was certainly precautionary, being based on the most conservative assumption for the eastward extent of the W-stock. It was also probably overly conservative, being based on a simple stock-structure approach without mixing. In future, alternatives allowing for mixing of stocks across the W/E boundary should be considered. This would be facilitated by estimating mixing rates based on historical mark-recapture data.

The Panel **recommended** that the catch limit of 56 whales (as output by the RMP-based CLA/IST process described above) was in line with the provisions of the RMP, and hence acceptable on that basis.

6. North Pacific Bryde's whale

6.1 *Update on the information on stock structure and definition of management areas*

Sugimoto presented RW/A24/04 in which the genetic analyses on the stock structure of North Pacific Bryde's whales were updated to confirm the plausibility of the stock structure hypotheses used in the 2019 domestic assessment. For the analyses, a total of 759 new samples collected during 2019–2022 were combined with the original sample set (collected during 1979–2016), resulting in a total of 1,953 mitochondrial DNA control region sequences (mtDNA) and 1,931 microsatellite genotypes (msDNA) at 17 loci. The authors first examined the degree of genetic differentiation between sub-areas (i.e., 1W (–165°E), 1E (165°E–180°) and 2 (180°–)) based on F_{ST}, which showed the largest and the smallest estimates between sub-areas 1W and 2 and between sub-areas 1W and 1E, respectively, with an intermediate estimate between sub-areas 1E and 2 for both markers. A heterogeneity test revealed significant genetic differences in all pairs of sub-areas in mtDNA and all but one (sub-areas 1W and 1E) pairs in msDNA. The sPCA did not clearly discriminate among whales in the three sub-areas, suggesting a low degree of differentiation. A longitudinal cline of multiple genetic statistics changed gradually within sub-area 1E, suggesting mixing of stocks in this area. The results found in this study are consistent with the previous findings in 2019, which suggested the presence of two stocks weakly differentiated between sub-areas 1W and 2 with mixing of the two stocks in sub-area 1E.

In discussion, it was noted that two stock structure hypotheses are currently accorded high plausibility, i.e. hypothesis 2 (stock 1 (western stock) in sub-areas 1W and 1E; stock 2 (eastern stock) in sub-area 2; no mixing), and hypothesis 5 (stock 1 in sub-area 1W, stock 2 in sub-area 2, mixing of both stocks in sub-area 1E). Given the data presented, hypothesis 5 fits the observed

genetic patterns slightly better, as an elevated F_{IS} in sub-area 1E could be indicative of admixture between the two stocks. However, the majority of whales in sub-area 1E apparently belongs to stock 1 (the western stock), as these two sub-areas are not differentiated in terms of microsatellite F_{ST}. Conversely, sub-areas 1E and 2 are diffentiated by numerous genetic measures in both mtDNA and microsatellites.

6.2 *Update of the information on abundance*

Takahashi presented paper RW/A24/08 on abundance estimates for Bryde's whales in the North Pacific Ocean based on Japanese and IWC-POWER dedicated sighting surveys conducted in the summer season (July-September) over the period 2020-2023. This paper also updates abundance estimates based on data from previous surveys. Abundance estimates were assigned to sub-areas used for the management of Bryde's whale in the North Pacific: Sub-area 1 (eastern, E, and western, W, parts) and Sub-area 2. Abundance estimates were estimated by the standard distance sampling methodology and the guidelines adopted by the IWC SC under the assumption that g(0) = 1. Estimates of g(0) were also made based on sighting data obtained from Independent Observers (IO) survey and the mark-recapture distance sampling method (MRDS) for the latest period, and abundance estimates were adjusted accordingly. The *g*(0)-corrected abundance estimates for 2020-23 in Sub-areas 1W, 1E and 2 were 11,504 (CV = 0.189), 5,014 (CV = 0.223) and 3,901 (CV = 0.521), respectively. Furthermore, the updated *g*(0)-corrected abundance estimates for 2008-15 in Sub-areas 1W, 1E and 2 in the previous surveys were 17,307 (CV = 0.241), 10,551 (CV = 0.189), and 5,506 (CV = 0.270).

It was noted that there were improvements in the calculations to derive the abundance estimates by using inverse variance weighted average to estimate *g*(0); therefore CVs were smaller. It was noted that for the 4th period, the *g*(0) corrected abundance estimates was lower. The inverse-variance weighted averaged probability of detection by at least one observer was used and therefore a higher *g*(0) of 0.940 (CV = 0.027) resulted and was used to estimate abundance. For the previous periods, the g(0) corrected abundance estimates was higher, in part reflecting the lower g(0) estimate for those. This earlier probability of detection on the trackline by observers on one platform corresponded to a lower *g*(0) of 0.760 (CV = 0.067) for both barrels $\hat{p}top$ and $\hat{p}io$.

The Panel noted the lower (though not significantly lower) recent abundance estimates compared to the previous period and the prevailing factors that were considered to derive the results. The analysis used the AIC model selection criterion in estimating abundance; the Panel suggested that BIC-based model selection also be considered because AIC can tend to favour over-parametrization.

6.3 *Update on the information on catch history*

Maeda introduced RW/A24/10 which reported an update of the catch series for Bryde's whales in the North Pacific based on the latest IWC individual and summary catch database Version 7.1. For data after 2020, which are not included in the IWC database version 7.1, catch series through 2023 were prepared by referring to the IWC Progress Reports for large cetaceans and other reliable sources.

In discussion, it was noted that nearly all the catches prior to the Moratorium came from Japanese commercial whaling.

6.4 *Update on the information on biological parameters*

Maeda presented RW/A24/11 which reported that for Bryde's whale with readable earplugs, the number of individuals recorded with first ovulation information had been five, and the average age at first ovulation was 8.6 years. This value is the same as the value used in the current *ISTs*. There had been no change in the values of biological parameters since the previous management procedure testing process.

In discussion, it was suggested that transition phase data should be examined to check for possible changes in the age at first parturition in the past; however, possible comparability problems with JARPNII having operated partly in different areas to those where the current commercial whaling occurs were noted.

6.5 *Revised calculation of catch limit by the CLA and examination of uncertainties by ISTs*

Hakamada introduced RW/A24/02 which provided a revision of the catch limit for the North Pacific Bryde's whale using an RMP-based approach similar to the one used for the 2019 workshop. In a similar manner to sei whales, this document first discussed the pertinent stock structure hypotheses, with the associated *Small Areas* together with estimates of abundance for these. The paper continued by specifying historical catch series, going on to calculate a catch limit, and then to check the robustness of this result to uncertainties. The two underlying stocks, stock 1 and stock 2, were distributed amongst three sub-areas whose boundaries had been selected taking account of the various genetic analyses and was unchanged from the 2019 workshop. Similarly, two options for the *Small Areas* were considered, which were based on the three sub-areas which underlay the Operating Models' dynamics, were the same as in the prior workshop. The main difference between the two options is how the catch should be allocated; one option treats the whole of sub-area 1 as a *Small Area* whereas the other options treat it as *Combination Area* and applies *Catch Cascading* to the sub-areas 1E and 1W. Application of the CLA with a 0.6 tuning level, and input of the selected abundance estimates (including $g(0)$ value) and historical catch series, yielded annual catch limit for the two *Small Area* options of 154, and when *Catch Cascading* is applied 53 and 101 for sub-areas 1W and 1E respectively. As a result of the revised abundance time series estimates from RW/A24/08 this catch limit is lower than the previously recommended catch limit of 187. Examination of uncertainties was based on *ISTs* which spanned two values for MSYR, two catch series, two $g(0)$ values, additional survey variance and two stock structure hypotheses – 14 trials in all were considered. A future survey pattern was specified. All *ISTs* fitted the available abundance estimates reasonably. Using the standard acceptability criteria, all the management options were deemed acceptable, with the associated annual catch limit of 154 whales (the maximum amongst the options) consequently recommended.

6.6 *Discussion, conclusions and recommendations*

The Panel **recommended** that the catch limit of 154 whales (as output by the RMP-based CLA/IST process described above) was in line with the provisions of the RMP, and hence acceptable on that basis.

7. Summary

The Review Panel **recommended** that catch limits of 56 whales for North Pacific sei whales and 154 whales for North Pacific Bryde's whales were in line with the provisions of the RMP, and hence acceptable on that basis.

These catch limit recommendations rely on the assumption of full mixing of whales within the *Small Area* selected for each calculation; these extend beyond the EEZ of Japan within which the full catch is to be taken, so that priority needs to be given to analyses which investigate the extent to which this mixing assumption holds. Further, mark recapture data can be used to estimate mixing rates for sei whales, and then apply the results to develop *ISTs* which allow for mixing across the W/E boundary. Failing sufficient progress in this respect, it may be necessary in the future to adopt a more conservative approach to calculating catch limits.

The Panel also suggested that Japanese scientists give consideration to analyses of historical transition phase data for Bryde's whales to investigate the possibility of changes in age at first parturition.

Appendix 1
List of documents

Primary documents

RW/A24/01. Pastene, L.A. and Hakamada, T. Overview of previous recommendations on North Pacific Bryde's and sei whales and responses from Japanese scientists.

RW/A24/02. Japan RMP Team. A revision of the catch limits for western North Pacific sei and Bryde's whales calculated in line with the IWC's Revised Management Procedure (RMP).

RW/A24/03. Taguchi, M. and Sugimoto, T. An update of the genetic analyses on stock structure of sei whales in the North Pacific based on mitochondrial and microsatellite DNA.

RW/A24/04. Sugimoto, T. and Taguchi, M. An update of the genetic analyses on stock structure of Bryde's whales in the North Pacific based on mitochondrial and microsatellite DNA.

RW/A24/05. Konishi, K. Satellite tracks of North Pacific sei whales during 2017 to 2023.

RW/A24/06. Takahashi, M., Maeda, H. and Hakamada, T. Preliminary analysis of population dynamics incorporating movement information of North Pacific fin whale.

RW/A24/07. Takahashi-Katayama, M., Hakamada, T. and Matsuoka, K. Abundance estimates of sei whales in the North Pacific based on dedicated sighting surveys conducted in the period 2017-2022, including considerations on g(0).

RW/A24/08. Takahashi-Katayama, M., Hakamada, T. and Matsuoka, K. Abundance estimates of Bryde's whales in the North Pacific Ocean based on dedicated sighting surveys conducted in the period 2020-2023, including considerations on g(0)

RW/A24/09. Miyashita, T., Maeda, H. and Matsuoka, K. An update of the catch series for North Pacific sei whales based on the IWC database.

RW/A24/10. Maeda, H and Hakamada, T. An update of the catch series for North Pacific Bryde's whales based on the IWC database.

RW/A24/11. Maeda, H. Bando, T., Kuno, T. and Hakamada, T. A review of the availability of relevant biological parameters of North Pacific sei and Bryde's whales.

For information documents

Konishi, K., Minamikawa, S., Kleivane, L. and Takahashi, M. 2024. Annual phenology and migration routes to breeding grounds in western-central North Pacific sei whales. *Sci. Rep.* 14. 10.1038/s41598-024-61831-8.

Taguchi, M., Goto, M., Matsuoka, K., Tiedemann, R. and Pastene, L.A. 2022. Population genetic structure of Bryde's whales (*Balaenoptera brydei*) on the central and western North Pacific feeding grounds. *Canadian Journal of Fisheries and Aquatic Sciences*. dx.doi.org/10.1139/cjfas-2022-0005.