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)

Japan's RMP Team

EXECUTIVE SUMMARY

Background
After withdrawal from the International Convention for the Regulation of Whaling (ICRW), Japan resumed commercial whaling from July 2019 within Japan's territorial waters and Exclusive Economic Zone (EEZ).

Under the Act for Ensuring Sustainable Use of Whales, enacted in 2017, the Government of Japan (GOJ) is required to support the sustainable development of whaling. For this purpose, and based on the best scientific information available, the GOJ specified baleen whale species for commercial whaling. The sea area of operations for the specified baleen whale species will remain within Japan's territorial waters and its EEZ.

Catch limits for western North Pacific sei and Bryde's whales were calculated in 2019 in line with the IWC's Revised Management Procedure (RMP), based on the Norwegian Catch Limit Algorithm (CLA) computer code and for a tuning level of 0.6, and the best scientific information on stock structure (essential to define management areas (*Small Areas*)), and abundance estimate available at that time.

As stated previously, catch limits will be revised from time to time to take account of the latest scientific information. A substantial amount of new scientific information, mainly on stock structure and abundance estimate, has been accumulated since 2019 for North Pacific sei and Bryde's whales. The present document revised the catch limit calculations for these two species based on the scientific information accumulated since 2019.

North Pacific sei whales
Stock structure hypotheses and Small Areas
New genetic and non-genetic studies on stock structure suggested the occurrence of two stocks in North Pacific, Western (W) and Eastern (E) stocks, with stock boundary around longitude 170°W. To consider uncertainties, two alternative boundaries were considered at 170°E and 180°. Then, three definitions of *Small Areas* were developed: i) waters between Japan coast and 170°W; ii) waters between Japan coast and 180°, and iii) waters between Japan coast and 170°E.

Abundance estimates for Small Areas
Abundance estimates were based on previous and recent Japanese dedicated sighting surveys and IWC-POWER surveys. Abundance estimates were standardized considering assumptions on the migration pattern of the species in the migratory corridors and feeding ground, and adjusted according to $g(0)$ estimates. In 2019 abundance estimates used for CLA calculations were based on the assumption of $g(0)=1$. The latest (2020) estimates of abundance for the *Small Areas* i), ii) and iii) above were 33,016, 24,620 and 15,455, respectively.

Historical catch series
Catch series used for CLA were updated based on IWC statistics and were assigned to the *Small Areas* above.

Catch limits
Based on the CLA, catch limit for the adopted *Small Area* iii) above was calculated as 56. The robustness of this catch limit was examined for some uncertainties through the *Implementation Simulation Trials* (*ISTs*). This catch limit was robust to alternative catch series, alternative stock boundaries, alternative productivity, and alternative

$g(0)$ values.

North Pacific Bryde's whales

Stock structure hypotheses and Small Areas

New genetic studies confirmed the 2019's two stock structure hypotheses, i.e. two stocks occurring in sub-areas 1 and 2, with mixing and non-mixing scenarios. Therefore, the same definitions of *Small Areas* used in 2019 were used this time: option i): sub-area 1 is a *Small Area*, and option ii) sub-area 1 is a *Combination Area* with 1W and 1E each being *Small Areas*. Mixing rates between the two stocks under the stock mixing scenario were updated based on updated genetic data.

Abundance estimates for Small Areas

Abundance estimates were based on previous and recent Japanese dedicated sighting surveys and IWC-POWER surveys. Abundance estimates as well as $g(0)$ estimates for sub-areas were updated for the 3^{rd} (2008-2015) period, and were newly estimated for the 4^{th} (2020-2023) period. The latest estimates of abundance for the *Small Areas* i) and ii) above were 16,518 (entire sub-area 1), and 11,504 (sub-area 1W); 5,014 (sub-area 1E), respectively.

Historical catch series

Catch series used for CLA were updated based on IWC statistics and were assigned to the *Small Areas* above.

Catch limit

Based on the CLA, catch limit for option i) was calculated as 154. The robustness of this catch limit was examined for some uncertainties through the *ISTs*. This catch limit was robust to alternative stock structure hypotheses, alternative catch series, alternative stock boundaries, alternative productivity, and alternative additional variance.

Japan's implementation of the RMP variants above will continue to be based on the best available science; hence, the catch limits will be revised from time to time to take account of the latest scientific information.

1. INTRODUCTION

After withdrawal from the International Convention for the Regulation of Whaling (ICRW), Japan resumed commercial whaling from July 2019 within Japan's territorial waters and Exclusive Economic Zone (EEZ).

Under the Act for Ensuring Sustainable Use of Whales, enacted in 2017, the Government of Japan (GOJ) is required to support the sustainable development of whaling. For this purpose, and based on the best scientific information available, the GOJ specified baleen whale species for commercial whaling. The sea area of operations for the specified baleen whale species will remain within Japan's territorial waters and its EEZ.

In 2019 catch quotas for North Pacific sei and Bryde's whales were set by the Fisheries Agency of Japan (FAJ), based on the calculation of catch limits conducted by a domestic specialist's group (Japan's RMP team: JRT) in line with the International Whaling Commission's (IWC's) Revised Management Procedure (RMP), with consideration of the reviewing results by an independent group of international scientists (Review Panel). In 2019 it was stated that the catch limits would be revised from time to time to take account of the latest scientific information.

IWC (2012a) mentions that 'To provide an uninterrupted series of catch limits, a new Catch Limit Calculation will normally be required not more than six years after the preceding one. In line with this, new catch limits should be calculated for North Pacific sei and Bryde's whales by 2024.

The objective of this document is to describe the process for the revision of the catch limit calculation for North Pacific sei and Bryde's whales in line with the RMP, by the JRT, together with an explanation of the data and analytical procedures used in the process. The process, data and analytical procedures summarized in this document will be reviewed by the Review Panel.

First, the previous and new genetic and non-genetic data are analyzed in detail to examine if stock structure hypotheses should be updated. Then sub-areas and management areas (*Small Areas*) are defined based on the information regarding the most plausible stock structure hypothesis. Secondly, the previous and new abundance estimates and data on removals in sub-areas and *Small Areas* are explained in detail. Finally, the revision of the calculation of catch limit in line with the RMP is explained together with analyses related to uncertainty based on *Implementation Simulation Trials* (*ISTs*).

2. JAPANESE CONCEPT FOR THE IMPLEMENTATION OF THE RMP FOR WESTERN NORTH PACIFIC BALEEN WHALES

Japan's implementation of the RMP has been and will be based on the best available science; hence the catch limits will be revised from time to time to reflect the latest scientific information. Therefore, Japan will continue to update abundance estimates and refine the stock structure hypothesis based on data and samples obtained from new surveys. It will also investigate other aspects of uncertainties such as the value of Maximum Sustainable Yield Rate (*MSYR*) based on the analyses of new data and samples to be obtained from commercial whaling operations. All these aspects will be duly examined at the assessment review planned tentatively after a six-year-period.

Also, the catch limits of western North Pacific sei, Bryde's, common minke and fin whales (JRT, 2019; JRT, 2021; JRT, 2023) have been calculated based on the Norwegian Catch Limit Algorithm (CLA) (Aldrin and Huseby, 2007; Aldrin *et al*., 2008), fixing a tuning level of 0.6. Acceptability of management variants was evaluated through the *ISTs* using the IWC program for western North Pacific Bryde's whales (Allison and de Moor, 2020) for the Bryde's whales and a modified version of the program for the sei whales. This was considered appropriate because the structure of the population dynamics model used in the Bryde's whale *IST* program, such as the number of the sub-areas and time interval, was similar to the North Pacific sei whale case.

Modifications to the Bryde's whale program were made to match the input data (e.g., historical catches, abundance estimates) for North Pacific sei whales, and to allow for management variants of catch limit being in proportion to abundance estimates and a $g(0)$ estimate to be incorporated into the robustness trials.

3. WESTERN NORTH PACIFIC SEI WHALES

3.1 Stock structure and definition of *Small Areas*

3.1.1 Summary of updated genetic studies

Genetic analyses on the stock structure of North Pacific sei whales were updated by increasing the sample size as well as implementing further analytical approaches (i.e., spatially explicit analyses and Parent-Offspring (P-O) analysis) tailored to infer subtle stock structure, should it exist. Notably, genetic samples which have been collected since 2019 within the Japan's EEZ through the commercial whaling are now available, and this enabled us to address the possibility of a local stock of this species concerned by the Review Panel in the previous workshop. Details of the new genetic study are presented in Document RW/A24/03.

Background

In the workshop to review the catch limit calculations in 2019, previous genetic and non-genetic studies were examined. Based on the examination, the JRT concluded that the single stock structure hypothesis (Hypothesis 1) carried strong support while the evidence for the five-stock structure hypothesis (Hypothesis 2) was extremely weak. Therefore, only Hypothesis 1 was considered by the JRT in the definition of *Small Areas* for catch limit calculations in 2019 (JRT, 2019).

In 2019, the Review Panel pointed out the limited number of genetic samples from the western part of the North Pacific including the Japan's EEZ making the conclusion of a single genetic stock in the entire North Pacific somewhat uncertain (i.e., there was possibility of a separate stock in the western part of the study area). Taken this together with the mark-recapture data that sei whales appear to move freely west of 170°E, they proposed the calculation of a catch limit based on the abundance estimate and catch history for the region west of 170°E only (Review Panel, 2019).

New genetic samples

A total of 564 new genetic samples (Figure 1) was subjected to DNA extraction, microsatellite (msDNA) genotyping at 17 loci and mitochondrial (mtDNA) control region sequencing. The samples were collected from different sources: catch samples from commercial whaling during 2019-2022 (n = 100), biopsy samples from IWC-POWER survey during 2019-2022 (n = 45), biopsy samples from Japanese dedicated sighting survey during 2018-2022 (n = 66), biopsy samples from JASS-A in 2022 (n = 4), catch samples from NEWREP-NP during 2017-2018 (n = 268), biopsy samples from NEWREP-NP (n = 79) during 2012-2018, and samples from bycatches in 2019 and 2021 (n = 2). A genetic sample set of fetuses (n = 456) which was collected under the scientific special permit whaling during 2002-2018 (n = 437) and commercial whaling during 2019-2022 (n = 19) was also subjected to DNA extraction.

Final dataset

The dataset was divided into the three Areas for the data analysis (Figure 1): Area 1 (inside of the Japan's EEZ), Area 2 (outside of the Japan's EEZ and west of 170˚E) and Area 3 (east of 170˚E).

<u>Standard stock structure analysis and spatially explicit analysis</u>

A total of 1,980 complete msDNA genotype sets at 17 loci (Table 1) was prepared by combining msDNA data generated from the new genetic samples with msDNA data with genotypes for all 17 loci used in the previous work (Appendix 7 in Tamura *et al*., 2019) after the quality control. A total of 1,979 mtDNA sequences (Table 1) that were accompanied by the msDNA data was prepared after the quality control in the same manner as the msDNA.

<u>Parent-offspring analysis</u>

A total of 1,980 complete msDNA genotype sets at 17 loci (Table 1) was prepared by combining msDNA data generated from the new genetic samples genotyped for all 17 loci used in the previous work (Appendix 7 of Tamura *et al*., 2019) after the quality control. MtDNA haplotypes and biological information (i.e., sampling date, sex, sexual maturation) were used to confirm the P-O inferences biologically when available. Furthermore, the msDNA genotype sets for 453 fetal specimens that were successfully genotyped at all loci were included in the analysis to validate the P-O inferences.

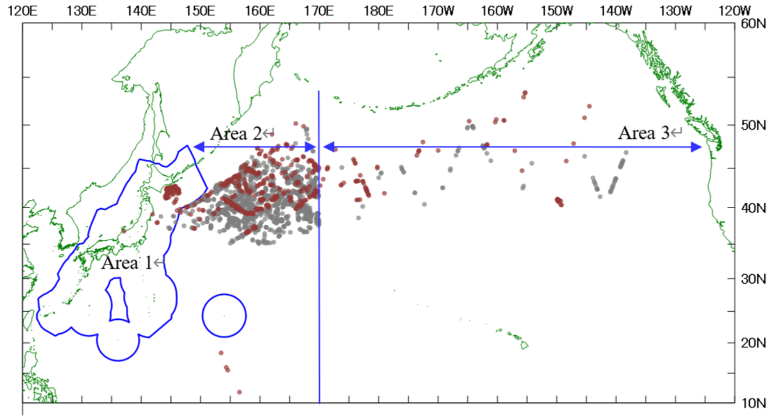

Figure 1. Sampling location of specimens collected during 2002-2022, which was used in the data analysis for either stock structure and Parent-Offspring analysis, or both. Blue solid line indicates Area definition (Area 1 = inside of Japan's EEZ; Area 2 = outside of Japan's EEZ and west of 170˚E; Area 3 = east of 170˚E). Specimens newly added in this analysis are indicated by red symbols.

Table 1. Number of genetic data used in the analyses on stock structure of North Pacific sei whale.

Area	Standard stock struture analysis Spatially explicit analysis (msDNA, mtDNA)	Parent-Offspring analysis (non-fetal msDNA, fetal msDNA)
Area 1	114 / 114	111 / 20
Area 2	1,713 / 1,712	1,714 / 433
Area 3	153 / 153	155 / 0
Total	1,980 / 1,979	1,980 / 453

Analytical approaches

Standard stock structure analysis

Standard stock structure analyses (i.e., summary genetic statistics for each and combined Areas, and pairwise F_{ST} estimates and heterogeneity test between Areas) were conducted using both mtDNA and msDNA data.

Parent-offspring analysis

The P-O pairs were inferred using a Maximum-Likelihood approach (Tiedemann *et al*., 2014). The following parameters were set in the analysis: False Discovery Rate (FDR) of 0.1, 0.05, 0.01, and 0.001, genotyping error rate per allele of 0.0014 which was estimated by re-genotyping on randomly selected samples, number of random individuals simulated of 5,000 for FDR, and number of related pairs simulated of 100,000 for Detection Power. Mother-Fetus pairs were considered as biologically validated 'True Positives', and all inferred P-O pairs were independently checked for compatibility of the inference against the mtDNA haplotypes and biological data when available.

The observed and expected numbers of non-fetal P-O pairs excluding Mother-Calf pairs within and between Areas were compared using χ^2 test after the biological validation.

Spatially explicit analysis

A spatial Principal Component Analysis (sPCA, Jombart *et al*., 2008) was performed to investigate the spatial patterns in genetic variability. Changes in genetic variation represented by the three genetic statistics (i.e., global scores of the sPCA, inbreeding coefficient and haplotype diversity) were examined along a longitudinal cline in the North Pacific.

Results and conclusions of the genetic analyses
The mtDNA haplotype diversity in Area 1 (0.881) was slightly lower than other Areas (0.927-0.935), and heterogeneity tests showed significant mtDNA differentiations between Area 1 and other Areas. Nevertheless, pairwise F_{ST} estimates showed an overall weak differentiation for both mtDNA (0-0.008) and msDNA (0-0.001) markers, and significant genetic differentiation was not found in msDNA.

Several P-O pairs were found between Areas 1 and 2 (Figure 2). The analysis also indicated that the observed number of P-O pairs between Areas 1 and 2 was not significantly different from the expected under the assumption that all pairs are randomly distributed. The P-O analysis showed an overrepresentation of P-O inferences within Area 1 at some FDRs (i.e., FDR of 0.1 and 0.05), although it should be noted that this observation was not so strong evidence given that the expected numbers of inferences for all but one of the FDRs were below 1.

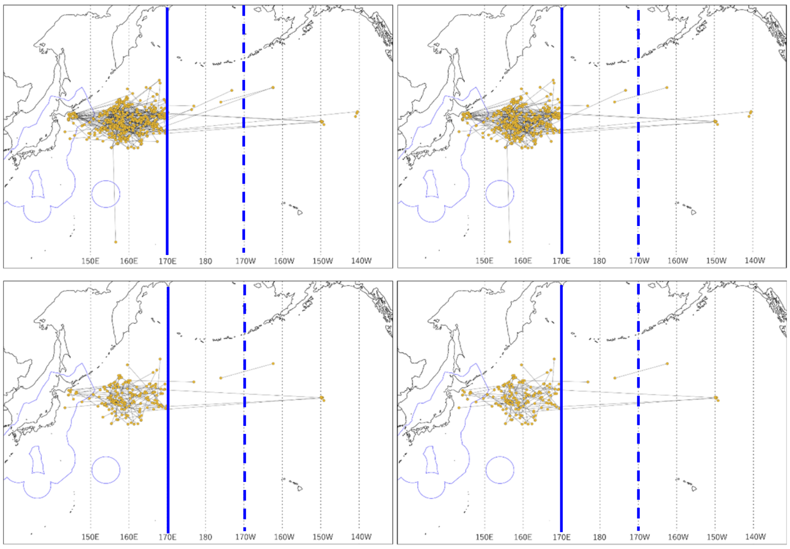

Figure 2. Distribution of Parent-Offspring pairs without fetuses inferred at FDR = 0.1 (*n* = 338: top left), 0.05 (*n* = 270: top right), 0.01 (*n* = 108: bottom left) and 0.001 (*n* = 91: bottom right). Solid and dashed blue lines indicate the lines at 170E and 170W considered in the genetic analysis, respectively (see details in Document RW/A24/03).

The statistically significant mtDNA differences between Areas 1 and the other Areas could be due to some stronger kinship-associations among whales in the coastal feeding ground (Area 1). In fact, more P-O pairs involving female-female pairs were found in Area 1, which could have influenced the heterogeneity test of mtDNA.

The sPCA analysis showed different clustering patterns west of 180˚, and two (global score 1 generated in sPCA analysis and haplotype diversity) changed gradually between 180˚ and 160˚W (Figure 3).

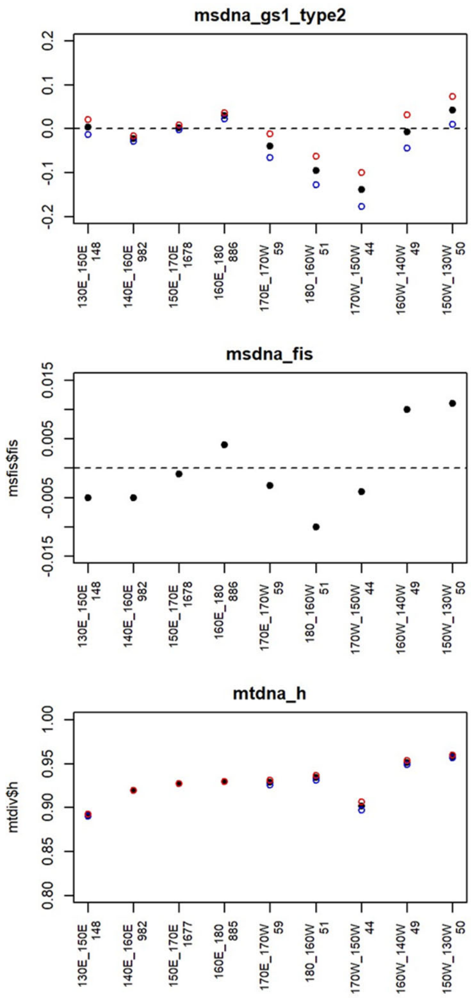

Figure 3. Longitudinal changes of the first global score in sPCA analysis in North Pacific sei whales, inbreeding coefficient and haplotype diversity which were calculated for 20° longitudinal intervals and plotted as moving averages over 10° intervals. Blue and red symbols indicate the lower and upper margin of errors represented by standard errors. Figures in the second column of each x-axis label indicate sample size in each longitudinal zone.

The standard stock structure analysis and χ^2 test for the number of P-O pairs were thus repeated based on the new Area definition (i.e., Area 1 = inside of the Japan's EEZ; Area 2R = outside of the Japan's EEZ and west of 170°W; Area 3R = east of 170°W) derived from this observation. These analyses did not strongly support the results of spatially explicit analyses but also did not contradict them. Nevertheless, given the small sample size in the eastern part of study area (i.e., Area 3R), it would be appropriate at this stage to consider a new hypothesis that at least two stocks of sei whales are present in the North Pacific which stock boundary located around 170°W. This inference did not contradict the non- genetic study described in the following section.

3.1.2 Summary of updated non-genetic studies

Sei whale tracks using satellite-monitored tags are the major update for non-genetic information on the stock structure of this species in the North Pacific. Since the 2019 review workshop considerable new information on movement and distribution of sei whales in the North Pacific has been achieved using satellite tracking technology. The track results are described in Document RW/A24/05 and in Konishi *et al*. (2024).

The tags were deployed in the western and central North Pacific demonstrating their migration patterns, the presumed breeding area, and seasonal movements in the feeding area (Figures 4-6). The sei whale migration occurred over a wide longitudinal range of the southward corridors, arriving at low-latitude breeding grounds south of 20˚N and west of 180˚ (Figure 5). The sei whales tagged in spring dispersed longitudinally in feeding areas, and some animals tagged in the western area moved to areas east of 180˚. Some sei whales tagged in the central North Pacific reached the waters in the eastern side of the Pacific (Figure 6). These results do not indicate the separation of the sei whale stock in the North Pacific.

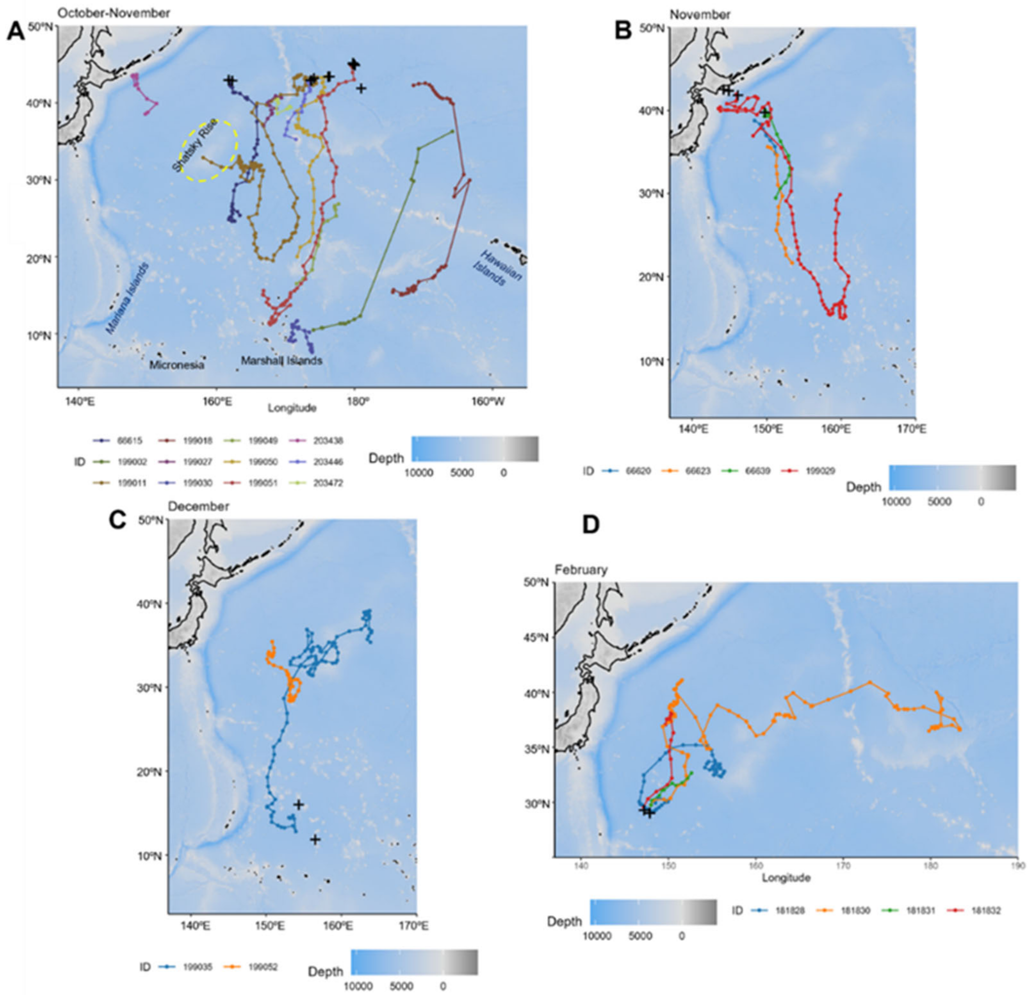

Figure 4. Tracks of sei whales tagged in the western and central North Pacific. Satellite-tracked data were fitted to the state-space model and estimated the locations at 24-h intervals. A: Offshore tagging in October to November; B: Coastal tagging in November; C: Tagging at low latitude in December; D: tagging in February (after Konishi *et al*., 2024).

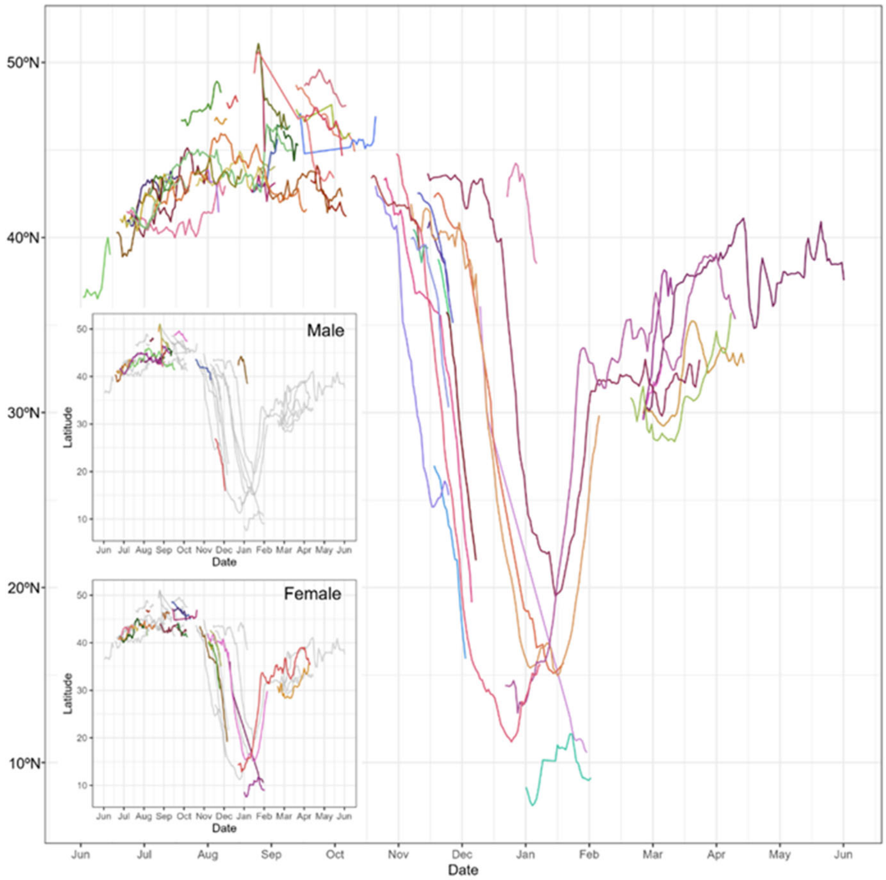

Figure 5. Latitudinal movements of North Pacific sei whales throughout the year from the satellite-monitored tags between 2017 and 2022. Left-bottom plots represent tracks for each sex (highlighted) determined by genetic from biopsy samples. No sex information is available for whales with no biopsy sampled (after Konishi *et al*., 2024).

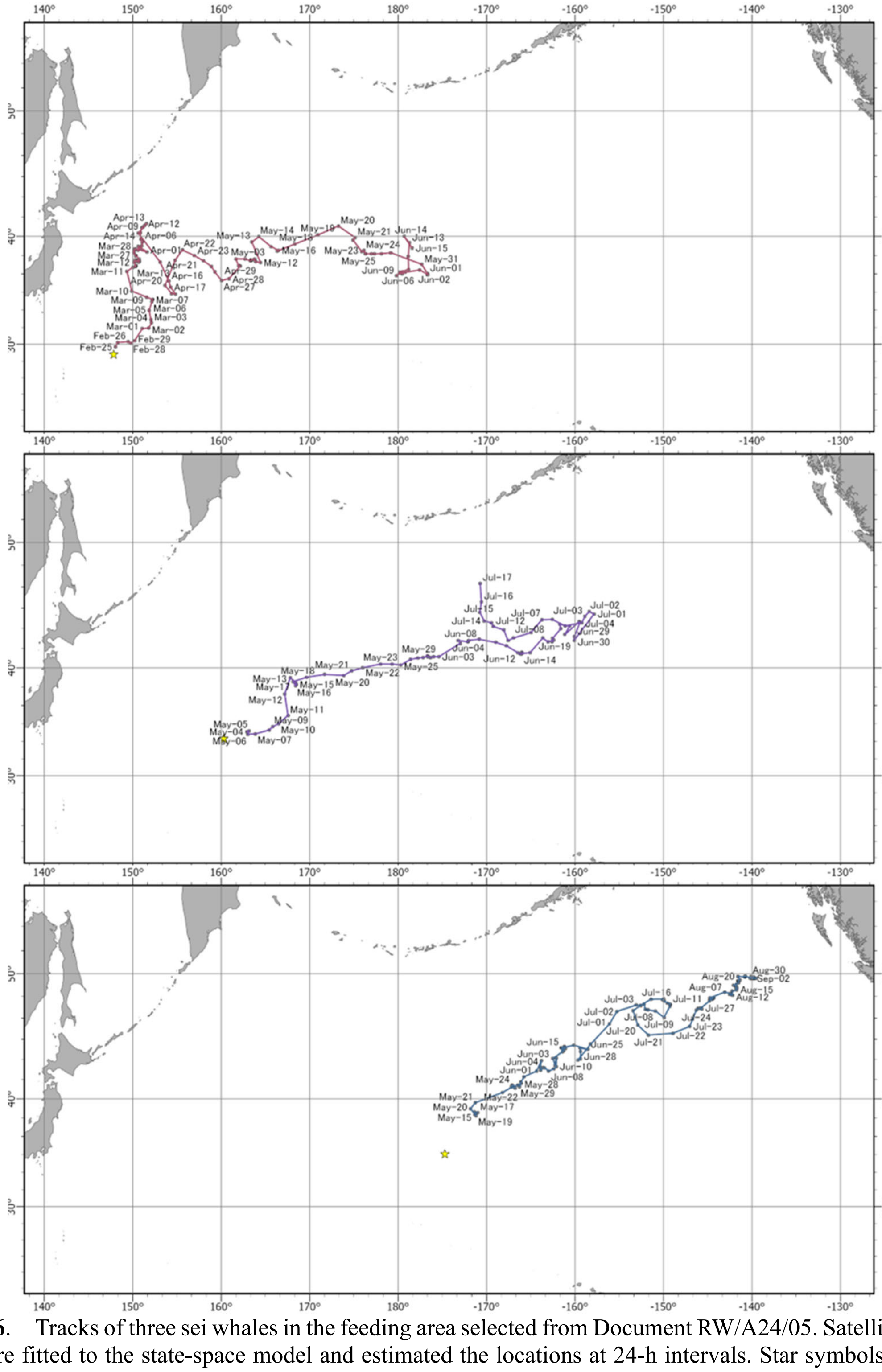

Figure 6. Tracks of three sei whales in the feeding area selected from Document RW/A24/05. Satellite-tracked data were fitted to the state-space model and estimated the locations at 24-h intervals. Star symbols represent the deployment positions. Other tracks are drawn in Document RW/A24/05.

3.1.3 Hypothesis on stock structure

The updated genetic and non-genetic analyses found no evidence of a local coastal stock of sei whales in the western North Pacific. Results of the analyses are consistent with a stock structure hypothesis that assumes two stocks in the North Pacific: (1) W-stock distributed mainly west of 170˚W, and (2) E-stock distributed mainly east of 170˚W. This is the basis for the definition of sub-areas and management areas (*Small Areas*) in the following section.

3.1.4 Definition of sub-areas

Studies on stock structure supported the hypothesis of two stocks in the North Pacific, W-stock and E-stock with a stock boundary around longitude 170˚W. In consideration of uncertainties in stock boundaries, apart from 170˚W, other two boundaries are considered: 180˚ and 170˚E. Therefore, the North Pacific was divided into four sub-areas for management purposes: 1a, 1b, 1c and 2 (Figure 7):

Sub-area 1a: West of 170˚ E and north of 35˚ N in western North Pacific.

Sub-area 1b: Longitudinal sector between 170˚ E and 180˚ , North of 40˚ N and South of Aleutian Islands in the central North Pacific.

Sub-area 1c: Longitudinal sector between 180˚ and 170˚ W, North of 40˚ N and South of Aleutian Islands in the central North Pacific.

Sub-area 2: East of 170˚ W and north of 40˚ N in the eastern North Pacific.

These sub-areas were used for the *ISTs* (see section 3.6 for details).

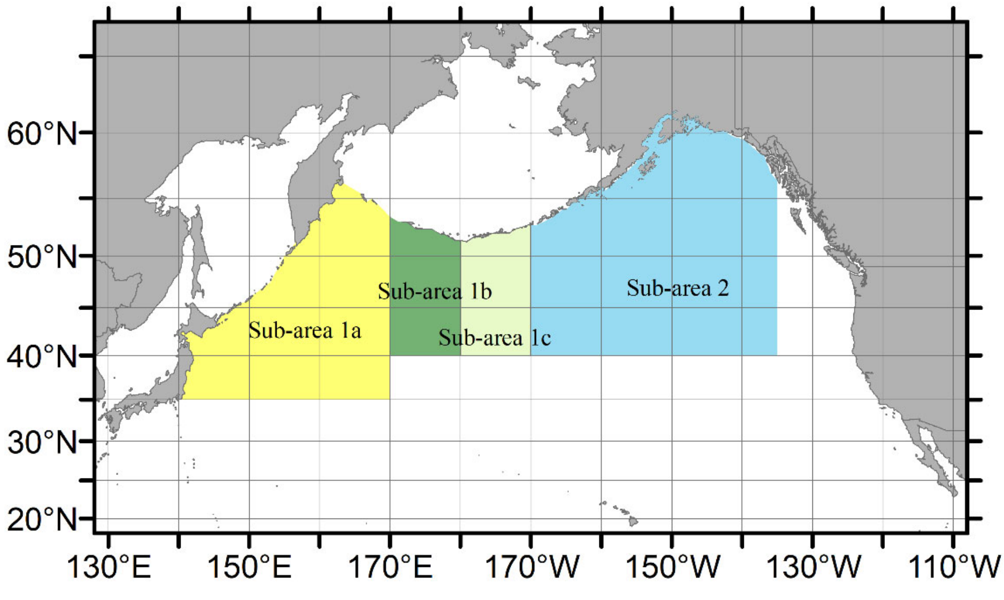

Figure 7. Four sub-areas used for *IST*s of the sei whales.

3.1.5 Definition of *Small Areas*

Three *Small Areas* were defined for management purposes:

i) Sub-areas 1a, 1b and 1c combined are a *Small Area*
ii) Sub-areas 1a and 1b combined are a *Small Area*
iii) Sub-area 1a is a *Small Area*

It is noted that whaling operations will continue to be conducted in Japan's territorial waters and EEZ within sub-area 1a (W-stock).

3.2 Abundance estimates

3.2.1 Previous abundance estimates

Abundance estimates used in the previous catch limit calculation for this species were derived from the sighting data from two sources: JARPNII survey in 2008 and IWC-POWER surveys in 2010, 2011, and 2012 (JRT, 2019). All these surveys were conducted in July-August.

Assuming that $g(0)=1$, the abundance estimate for the western North Pacific was estimated to be 5,086 (CV = 0.378) in 2008; for the central and eastern North Pacific Ocean was estimated as 29,632 (CV = 0.242) in 2011 (JRT, 2019).

3.2.2 Updated abundance estimate in the North Pacific assuming *g*(0)=1

Document RW/A24/07 provided a new series of the abundance estimates of sei whales in the North Pacific based on surveys that covered the whole oceanic basin. A summary of the results is presented in this section.

Data used

Japanese dedicated sighting surveys were conducted during the summer season (July-September) in 2020 and 2021 (Katsumata *et al*., 2021; 2022). The IWC-POWER sighting surveys were conducted in July-September in 2019-2022 (Matsuoka *et al*., 2020; Murase *et al*., 2021; 2022; Morse *et al.*, 2023).

These surveys were all conducted in a systematic manner through the years, and they followed the survey design guidelines of the International Whaling Commision Scientific Committee (IWC SC) (IWC, 2012b). Figure 8 shows the tracklines and sighting positions by survey blocks from recent surveys.

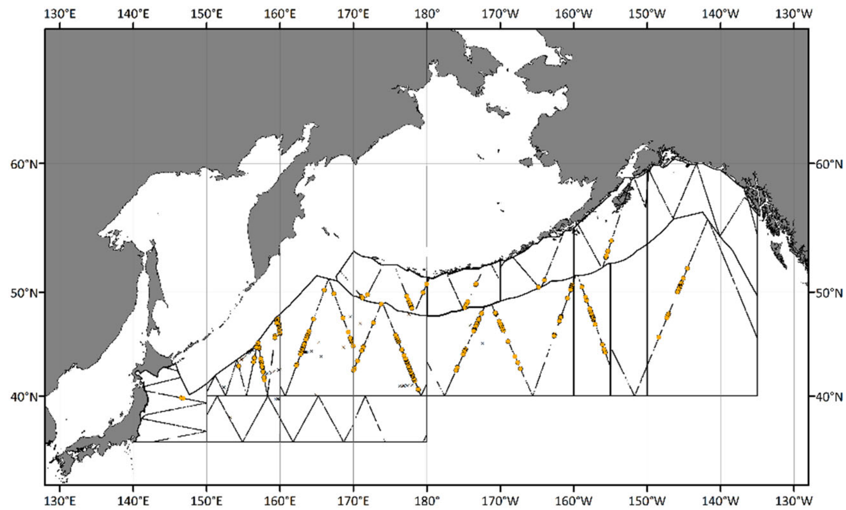

Figure 8. Primary sighting positions of sei whales (yellow circle) and searching effort by survey blocks during sighting surveys conducted in 2019-2022. Black cross marks show secondary sightings during the transit surveys.

Analytical procedures

Analytical procedures followed the IWC SC guidelines (IWC, 2012b). Basically, the distance sampling method was applied to estimate abundance. Abundance estimates and their CVs were estimated based on a Horviz-Thompson-like estimator. Primary sighting positions of sei whales (yellow circle) and searching effort by survey blocks during sighting survey conducted in 2019-2022 are shown in Figure 8. Black cross marks in Figure 8 show secondary sightings during the transit surveys. The computations were conducted truncating the detections at 3.0 n. miles perpendicular distance for this species as is conventional, and the probability of detection on the trackline was assumed to be 1 ($g(0)=1$). Hazard-rate and Half-normal models were considered as candidate models for the detection function.

To consider the effect of factors affecting detectability, school size, Beaufort Sea state and visibility were treated as covariates in the Multiple Covariates Distance Sampling within the DISTANCE program. The best model was selected as the one for which the Akaike's Information Criterion (AIC) value was the smallest.

Additionally, the effect of survey season on the design-based abundance estimate was examined by the Generalized Linear Model (GLM) analysis (Document RW/A24/07). Based on this, adjusted abundance estimates were provided by standardizing the number of the observations per unit effort to high-density season by geographical area: the western North Pacific (WNP: west side of 180˚) or the eastern North Pacific (ENP: east side of 180˚) under the assumptions that their large scale migration occurs in a south-north direction from winter breeding areas in lower latitudes to summer feeding areas in higher latitudes, i.e., at the geographical areas, occur at once a year, that the peak migration period could be different between WNP and ENP, and that the migration does not occur in a west-east direction in the high latitude areas during summer feeding season. This adjustment was also applied to abundance estimates in the 1st period.

Results
Abundance estimates were computed for the WNP and ENP; and those were standardized based on the resultant GLM analysis. Table 2 shows the abundance estimates assuming $g(0)=1$ by periods and geographical areas and its adjusted abundance estimates.

Table 2. Abundance estimates assuming $g(0)=1$ for North Pacific sei whales, by periods and geographical areas (WNP and ENP), based on sightings from Japanese dedicated sighting surveys (western and central North Pacific) and IWC-POWER (western, central and eastern North Pacific) surveys.

Period	Geographical area	Year	Abundance N	CV[N]	Adjusted abundance N_{adj}	CV [N_{adj}]
1st period	WNP	2008	10,975	0.352	17,646	0.362
	ENP	2011	28,129	0.262	40,514	0.310
2nd period	WNP	2020	12,926	0.214	21,319	0.208
	ENP	2020	26,458	0.245	27,111	0.240

3.2.3 Estimates of *g*(0)

Data used
To obtain this estimate, mark-recapture-like data, *i.e.* Independent Observer (IO) data, were collected during IO mode surveys which have been conducted for the Japanese dedicated sighting surveys in 2020 and 2021 and IWC-POWER surveys in 2019-2022.

Analytical procedures
Mark-recapture distance sampling (MRDS) method were used to estimate the probability of detection on the trackline, i.e., $g(0)$, which includes perception bias due to sightings that are missed. The details of the MRDS method are described in Laake and Borchers (2004) and Burt *et al.* (2014). The analyses were conducted using the package "mrds" in R-DISTANCE (Thomas *et al.*, 2010). Details of the application of this method to the present data are given in Document RW/A24/07.

The probability of detection by an observer, given detection by the other observer, was provided by the MR model which was modelled by a logistic regression with the following covariates: platform (TOP or IO barrels), school size, Beaufort Sea state, and visibility. The candidate models were fitted to the four IO data sets, with and without geographical stratification. The best model was selected by using AIC. Furthermore, conditional detection probabilities can be used to estimate the probability of detection on the trackline by at least one observer.

Results
The best models selected by AIC included the MR model with the covariates school size and visibility, and a DS model with the covariate school size. From the best MR model, the probabilities of detection on the trackline

by observers from one platform, given that it was detected by observers from another platform, were 0.666 (CV=0.114) for both Top and IO barrels. The probability of detection on the trackline by at least one observer was 0.866 (CV=0.070). *g*(0) corrected abundance estimates by geographical areas were shown in Table 3.

The *g*(0)-corrected abundance estimates by *Small Areas* are provided in sections 3.5.2 and 3.6.1.

Table 3. Abundance estimates for North Pacific sei whales, by periods and geographical areas, corrected by the *g*(0) estimate.

Period	Geographical area	Year	g(0) corrected abundance $N_{g(0)\text{-corrected}}$	CV [$N_{g(0)\text{-corrected}}$]	95%CI lower limit	95%CI upper limit
1st period	WNP	2008	26,508	0.380	12,907	54,442
	ENP	2011	60,861	0.331	32,371	114,427
2nd period	WNP	2020	24,620	0.219	16,095	37,661
	ENP	2020	31,309	0.250	19,308	50,769

While point estimates of abundance for the 2nd period (24,620 animals in WNP, 31,309 animals in ENP) are lower than those for the 1st period (26,508 animals in WNP, 60,861 animals in ENP), these differences are not statistically significant because the ratios of abundances in 2nd period to 1st period are estimated to be 0.93 with 95% CI [0.41, 2.11] for WNP and 0.51 with 95% CI [0.24, 1.12] for ENP.

3.3 Catch history

Document RW/A24/09 summarized the catch history of sei whales in the North Pacific. Original catch series, which were used for previous catch limit calculation (JRT, 2019), was obtained through the IWC individual and summary database Version 6.1 (Allison, 2017) in the past in-depth assessment by the IWC SC (Cooke, 2019). Using the latest IWC database Version 7.0 (Allison, 2020) and additional information from 2019 to 2023, the catch series for W- and E-stocks were updated in the three alternative stock boundaries: 170˚E, 180˚ and 170˚W longitudinal lines.

In the USSR catch, a total of 351 individuals has no catch position information. They were divided into W- and E-stocks assuming that the proportion was same as that of individuals with known catch position in the best catch series. They were assumed in the W-stock in the high catch series.

3.4 Biological parameters

Biological parameters of sei whales, with a particular focus on age at sexual maturity, were estimated to consider whether new trial scenarios need to be set up, by using new information obtained since the resumption of commercial whaling.

The long-term trend of age at sexual maturity using the transition phase of earplugs in Document RW/A24/11 indicated that younger age at sexual maturity occurred during past commercial whaling, but the age at sexual maturity of individuals taken after the resumed commercial whaling after 2019 was almost the same as during the special permit whaling period, between 8 years old and 9 years old. As for the biological parameters to be used for *ISTs*, the age at sexual maturity for females taken after the resumption of commercial whaling was estimated to be 8.17 (SD=1.47) based on the transition phase, and the age at first parturition is considered reasonable at 9 years old.

As for the natural mortality (M) used for *IST*, Punt's model (A multi-stock model for North Pacific sei whales) used in the in-depth assessment of North Pacific sei whales conducted by the IWC SC adopted a value of 0.05 (Punt, 2020), which is also used in our assessment. On the other hand, no assumptions were made about selectivity in this model, so the selectivity used in the *IST* was assumed to be 5 years old west of 170˚E and 9 years old east of 170˚E (knife-edge type), the same as for Bryde's whales.

3.5 Catch limit

The CLA was applied to *Small Areas* from i) to iii) defined in section 3.1.5. The CLA requires historical catch and abundance data for the corresponding *Small Areas*.

3.5.1 Catch data used in the CLA

Historical catch data in the three *Small Areas* during 1906-2023 are shown in Table 4 based on Document RW/A24/09. The number of catches in 2024 is assumed to be the same as that in 2023.

Table 4. The best series of catches for W- and E-stocks of North Pacific sei whales in different *Small Areas*.

Boundary	Border 170E				Border 180				Border 170W			
Stock	W stock		E stock		W stock		E stock		W stock		E stock	
Sub-area	1a		1b+1c+2		1a+1b		1c+2		1a+1b+1c		2	
Year	M	F	M	F	M	F	M	F	M	F	M	F
1906	8	8	0	0	8	8	0	0	8	8	0	0
1907	21	22	0	0	21	22	0	0	21	22	0	0
1908	49	52	0	0	49	52	0	0	49	52	0	0
1909	28	30	0	0	28	30	0	0	28	30	0	0
1910	51	54	0	0	51	54	0	0	51	54	0	0
1911	106	111	0	0	106	111	0	0	106	111	0	0
1912	76	79	0	0	76	79	0	0	76	79	0	0
1913	115	121	2	1	115	121	2	1	115	121	2	1
1914	89	94	11	8	89	94	11	8	89	94	11	8
1915	272	285	0	0	272	285	0	0	272	285	0	0
1916	144	151	14	11	144	151	14	11	144	151	14	11
1917	195	203	85	62	195	203	85	62	195	203	85	62
1918	289	302	77	57	289	302	77	57	289	302	77	57
1919	441	461	46	35	441	461	46	35	441	461	46	35
1920	147	154	103	78	147	154	103	78	147	154	103	78
1921	188	197	0	0	188	197	0	0	188	197	0	0
1922	91	96	1	1	91	96	1	1	91	96	1	1
1923	204	213	31	23	204	213	31	23	204	213	31	23
1924	261	271	71	31	261	271	71	31	261	271	71	31
1925	183	191	37	36	184	195	36	32	184	195	36	32
1926	213	219	23	29	213	220	23	28	213	220	23	28
1927	211	218	5	2	211	218	5	2	211	218	5	2
1928	112	117	13	13	112	117	13	13	112	117	13	13
1929	152	149	43	33	152	149	43	33	152	149	43	33
1930	171	178	51	37	171	178	51	37	171	178	51	37
1931	140	146	0	0	140	146	0	0	140	146	0	0
1932	130	134	0	0	130	134	0	0	130	134	0	0
1933	131	134	1	0	131	134	1	0	131	134	1	0
1934	108	111	1	2	108	111	1	2	108	111	1	2
1935	145	152	0	0	145	152	0	0	145	152	0	0
1936	130	134	0	0	130	134	0	0	130	134	0	0
1937	158	162	1	1	158	162	1	1	158	162	1	1
1938	192	201	0	0	192	201	0	0	192	201	0	0
1939	237	248	0	0	237	248	0	0	237	248	0	0
1940	159	164	0	0	159	164	0	0	159	164	0	0
1941	245	251	0	0	245	251	0	0	245	251	0	0
1942	115	119	0	1	115	119	0	1	115	119	0	1
1943	162	161	1	1	162	161	1	1	162	161	1	1
1944	338	343	1	1	338	343	1	1	338	343	1	1
1945	30	32	0	0	30	32	0	0	30	32	0	0
1946	186	261	0	0	186	261	0	0	186	261	0	0
1947	180	248	0	3	180	248	0	3	180	248	0	3
1948	270	275	1	1	270	275	1	1	270	275	1	1
1949	388	368	3	1	389	368	2	1	389	368	2	1
1950	144	183	10	14	144	183	10	14	144	183	10	14
1951	235	225	5	0	235	225	5	0	235	225	5	0
1952	376	417	22	8	381	420	17	5	381	420	17	5
1953	398	335	3	12	399	335	2	12	399	335	2	12
1954	438	353	107	84	447	361	98	76	453	365	92	72
1955	284	283	85	56	284	284	85	55	284	284	85	55
1956	541	446	14	26	542	447	13	25	543	447	12	25
1957	297	338	96	108	300	341	93	105	354	385	39	61
1958	364	508	165	211	392	544	137	175	502	680	27	39
1959	656	522	182	153	676	542	162	133	707	573	131	102
1960	296	253	162	121	316	264	142	110	332	286	126	88
1961	338	325	66	42	357	332	47	35	377	339	27	28
1962	459	441	527	394	464	444	522	391	464	444	522	391
1963	608	597	727	508	608	597	727	508	608	597	727	508
1964	416	418	1,615	1,162	418	418	1,613	1,162	697	669	1,334	911
1965	299	211	1,496	1,182	449	354	1,346	1,039	602	503	1,193	890
1966	236	288	1,791	1,384	448	462	1,579	1,210	908	836	1,119	836
1967	867	714	1,965	1,500	1,821	1,435	1,011	779	2,581	2,018	251	196
1968	1,382	1,020	1,431	1,121	2,319	1,784	494	357	2,373	1,821	440	320
1969	944	574	1,699	1,567	1,455	1,065	1,188	1,076	1,739	1,311	904	830
1970	525	522	1,461	1,308	864	839	1,122	991	989	954	997	876
1971	337	299	1,002	1,093	965	1,025	374	367	1,032	1,099	307	293
1972	284	251	868	908	888	885	264	274	916	915	236	244
1973	319	275	665	597	574	502	410	370	619	543	365	329
1974	157	175	458	490	237	256	378	409	238	258	377	407
1975	58	51	202	197	149	136	111	112	183	169	77	79

Table 4. (Continued)

2001	1	0	0	0	1	0	0	0	1	0	0	0
2002	16	24	0	0	16	24	0	0	16	24	0	0
2003	23	27	0	0	23	27	0	0	23	27	0	0
2004	47	53	0	0	47	53	0	0	47	53	0	0
2005	51	49	0	0	51	49	0	0	51	49	0	0
2006	49	52	0	0	49	52	0	0	49	52	0	0
2007	54	46	0	0	54	46	0	0	54	46	0	0
2008	44	56	0	0	44	56	0	0	44	56	0	0
2009	47	54	0	0	47	54	0	0	47	54	0	0
2010	43	57	0	0	43	57	0	0	43	57	0	0
2011	55	41	0	0	55	41	0	0	55	41	0	0
2012	44	56	0	0	44	56	0	0	44	56	0	0
2013	44	56	0	0	44	56	0	0	44	56	0	0
2014	38	52	0	0	38	52	0	0	38	52	0	0
2015	29	62	0	0	29	62	0	0	29	62	0	0
2016	38	52	0	0	38	52	0	0	38	52	0	0
2017	63	71	0	0	63	71	0	0	63	71	0	0
2018	63	71	0	0	63	71	0	0	63	71	0	0
2019	5	20	0	0	5	20	0	0	5	20	0	0
2020	9	16	0	0	9	16	0	0	9	16	0	0
2021	5	20	0	0	5	20	0	0	5	20	0	0
2022	10	15	0	0	10	15	0	0	10	15	0	0
2023	10	15	0	0	10	15	0	0	10	15	0	0
Total	19,307	18,609	17,446	14,714	24,183	23,070	12,570	10,253	26,711	25,249	10,042	8,074

3.5.2 Abundance estimates used in the CLA

Abundance estimates based on sighting surveys were obtained as described in section 3.2. Document RW/A24/07 presented abundance estimates in each survey block (Figure 8). Abundance estimates in the *Small Areas* were calculated by summing over abundance estimates in survey blocks in the *Small Area*. For survey blocks that are only partially contained in the *Small Area*, abundance was assumed to be in proportion to the area size and abundance in the part was calculated.

Abundance estimates in the *Small Areas* were shown in Table 5.

Table 5. Abundance estimates used for CLA for the three *Small Areas*. 95%CI: 95% confidence intervals, LL: lower limit and UL: upper limit.

Small Area	Year	P	CV	95%CILL	95%CIUL
i)	2009	53,084	0.395	25,168	111,965
	2020	33,016	0.175	23,490	46,405
ii)	2008	26,508	0.380	12,905	54,450
	2020	24,620	0.219	16,108	37,629
iii)	2008	19,235	0.500	7,621	48,550
	2020	15,455	0.160	8,661	27,577

While point estimates of abundance for the 2nd period (33,016 animals, 24,620 animals and 15,455 animals) are lower than those for the 1st period (53,084 animals, 26,508 animals and 19,235 animals) in *Small Areas* i), ii) and iii), these differences are not statistically significant because the ratios of abundances in 2nd period to 1st period are estimated to be 0.62 with 95% CI [0.28, 1.40], 0.93 with 95% CI [0.41, 2.11] and 0.80 with 95% CI [0.31, 2.11] in *Small Areas* i), ii) and iii), respectively.

3.5.3 Results of the CLA

The CLA was applied to the three *Small Areas* and results are shown in Table 6. An adjustment for sex ratio was conducted because the actual sex ratio of female during 2019-2023 was 68.8%, as shown in Table 4.

Table 6. Catch limits for the western North Pacific sei whale based on the CLA with a tuning level of 0.6, by *Small Area*

Tuning level		*Small Area*	Stock boundary	Catch Limit
	i)	Sub-area 1a+ 1b + 1c	170˚W	219
0.6	ii)	Sub-area 1a + 1b	180˚	130
	iii)	Sub-area 1a	170˚E	56

3.6 Testing for uncertainties (*ISTs*)

3.6.1 Conditioning

The following explanation is repeated from Allison and de Moor (2020). In the case of *IST* for sei whales, there is no mixing rate to fit the model, different from the case of *IST* for the Bryde's whales. The 'free' parameters for the model above are the initial (pre-exploitation) sizes of each of the stocks. The process used to select the values for these 'free' parameters is known as conditioning. The conditioning process involves first generating 100 sets of 'target' data, detailed in step (a) below, and then fitting the population model to each (in the spirit of a bootstrap). The number of animals in sub-area *k* at the start of year *t* is calculated starting with some initial values for the initial population sizes and then projecting the operating model forward to 2024 to obtain values of abundance by stock for comparison with the generated data.

(a) The 'target' values for the historical abundance by survey-area are generated using the formula:

$$P_t^E = O_t^E \exp\{\mu_t^E - (\sigma_t^E)^2/2\}\;;\; \mu_t^E \sim N[0; (\sigma_t^E)^2\,]$$

where P_t^E is the abundance for survey-area *E* in year *t*;
O_t^E is the actual survey estimate for survey-area *E* in year *t* (Table 7); and
σ_t^E is the CV of O_t^E (Table 7).

Historical abundance estimates used for conditioning
The abundance estimates and their associated CVs are shown in Table 7. To obtain abundance estimates for W-stock used for the *IST*, abundance estimates in Table 5 were divided by areal coverage of the sighting surveys.

Table 7. Abundance estimates for North Pacific sei whales, by W- and E-stocks used for conditioning. AC (%) indicates areal coverage of the sighting surveys. Abundance estimates in Table 5 were divided by areal coverage.

Boundary	W-stock	E-stock

	Year	AC (%)	P	CV	Year	P	CV
170W	2009	82.0%	64,763	0.395	2011	34,286	0.329
	2020	82.7%	39,935	0.175	2020	22,913	0.241
180	2008	78.2%	33,894	0.379	2011	60,862	0.330
	2020	79.1%	31,140	0.220	2020	31,309	0.250
170E	2008	72.3%	26,620	0.500	2011	68,134	0.301
	2020	73.3%	21,072	0.160	2020	40,474	0.202

Historical catches by sub-areas for the IST

Document RW/A24/09 produced 'Best' and 'High' catch series by sex and by sub-areas. The 'Best' series are provided in Table 4 above. Table 8 shows 'High' catch series in 1962, 1963 and 1967, which are different from the 'Best' catch series.

Table 8. The high catch series of North Pacific sei whale in 1962, 1963 and 1967, by W- and E-stocks in three alternative stock boundaries; 170˚E, 180˚ and 170˚W longitudinal lines. In other years, the numbers of the catches are same as Table 4.

Boundary	Border 170E				Border 180				Border 170W			
Stock	W stock		E stock		W stock		E stock		W stock		E stock	
Sub-area	1a		1b+1c+2		1a+1b		1c+2		1a+1b+1c		2	
Year	M	F	M	F	M	F	M	F	M	F	M	F
1962	**614**	**589**	**354**	**264**	**619**	**592**	**349**	**261**	**619**	**592**	**349**	**261**
1963	**632**	**620**	**699**	**489**	**632**	**620**	**699**	**489**	**632**	**620**	**699**	**489**
1967	**868**	**714**	**1,964**	**1,500**	**1,822**	**1,435**	**1,010**	**779**	**2,582**	**2,018**	**250**	**196**

3.6.2 Trials

In the *ISTs,* uncertainty is considered through different trial scenarios with their corresponding operating models.

Trial scenarios

Table 9 lists the factors considered in the trials while Table 10 shows the list of trials in the *ISTs* considered for the North Pacific sei whales. High plausibility was allocated for the SE01-1 and SE01-4 trials in Table 10 because only best values/series were input for all the factors (see Table 9). These two trials are referred to as "base case trials" hereafter.

Table 9. Factors considered in the *ISTs* for North Pacific sei whale. The values in bold are baseline values.

Factor	Values considered
Eastern Boundary of western stock	170˚E, 180˚, **170˚W**
MSYR	**1%(1+), 4%(mature)**
Catch series	**Best**, High
g(0)	1, **Baseline**

Table 10. List of *ISTs* for the western North Pacific sei whale.

Trial numbers	Stock boundary	*MSYR*[*1]	*g*(0)	Catch Series	Trial weight
SE01-1	170°W	1	Baseline	Best	H

SE01-4	170°W	4	Baseline	Best	H
SE02-1	170°E	1	Baseline	Best	M
SE02-4	170°E	4	Baseline	Best	M
SE03-1	180°	1	Baseline	Best	M
SE03-4	180°	4	Baseline	Best	M
SE04-1	170°W	1	Baseline	High	M
SE04-4	170°W	4	Baseline	High	M
SE05-1	170°W	1	1	Best	M
SE05-4	170°W	4	1	Best	M

*1: *MSYR* 1% is related to 1+ component and 4% is related to mature component.

3.6.3 Management variants

There are three management variants. It is noted that in all variants, whaling operations will be conducted in Japan's territorial waters and EEZ within sub-area 1a.

V1: Sub-areas 1a, 1b and 1c is a *Small Area*.
V2: Sub-areas 1a and 1b is a *Small Area*.
V3: Sub-area 1a is a *Small Area*.

The management variant of no commercial catches (V0) is also considered for comparison purposes. Conservation performance among the management variants was compared.

3.6.4 Future survey plans

Future surveys will be conducted in the western and eastern North Pacific. Sub-areas 1a, 1b, 1c and 2 are divided into two, two, two and three blocks respectively, because the whole sub-area cannot be surveyed in a year. Each sub-area will be surveyed once every six years. Within these four sub-areas, there are EEZs of the other coastal states, and the conduct of surveys in these EEZs will be subject to permission being granted by these coastal states. Table 11 shows the tentative future survey plan for 2023-2028. In the trials, this pattern will be repeated every six years. Blank cells in Table 11 indicate that no survey is planned, at least for sei whales. For example, western North Pacific in 2027 is blank because a survey is planned in south of 30˚N for Bryde's whales. Double platform surveys (i.e., using an IO platform) are planned for all the sighting surveys listed in Table 11.

Future abundance estimates in sub-areas are generated in terms of the assumptions mentioned below for use in the CLA. It is assumed that one abundance estimate is obtained with time stamp of the second year during every six years in sub-area 1a. Similarly, it is assumed that one abundance estimate in sub-area is obtained with time stamp of the fifth year of the fourth year and of the third year during every six years in the sub-areas 1b, 1c and 2, respectively. When time stamp for a abundance estimate in multiple sub-areas is needed, the years when sub-areas 1a and 2 are surveyed are doubled in the time stamp calculation given that sub-areas 1a and 2 are much larger than sub-areas 1b and 1c (Figure 7).

Table 11. Tentative future survey plan for North Pacific sei whales assumed for the *ISTs*. It is assumed that the same pattern will be repeated every six years.

Year	Sub-area 1a	Sub-area 1b	Sub-area 1c	Sub-area 2
	West of 170°E	170°E-180°	180°-170°W	East of 170°W

2023	Yes*1		Yes	Yes
2024	Yes			
2025		Yes		
2026				Yes
2027				Yes
2028		Yes	Yes	

*1: The survey in a western part of sub-area 1a was planned to be conducted in 2023 but it was actually conducted in 2022.
NOTE: Future surveys are subject to budget availability and permissions being granted by coastal states.

3.6.5 Result of conditioning

The following results are plotted for the base case trials SE01-1 and SE01-4. Sensitivity trials SE02-1, SE02-4, SE03-1 and SE03-4 are also plotted because the plots are substantially different by the stock boundaries assumed in the trials (Figures 9 and 10). Plots for the trials SE04 and SE05 are similar to those for the SE01, therefore those plots are omitted.

(1) Plot of the 1+population by sub-area

Deterministic (red line), median and 90% confidence intervals for the 1+ population. The abundance estimates are shown (x) together with 90% confidence intervals by sub-area.

(2) Plot of the mature female component of the populations by stock

Deterministic (red line), median and 90% confidence intervals for the mature female abundance by stock and on the same scale.

(3) Plot of the 1+ population by sub-area with the first 10 individual population trajectories

As per (1), but with the first 10 individual trajectories rather than the median and 90% confidence intervals.

Plots of the population trajectories by sub-area indicate that model estimates are quite compatible with the historical abundance data.

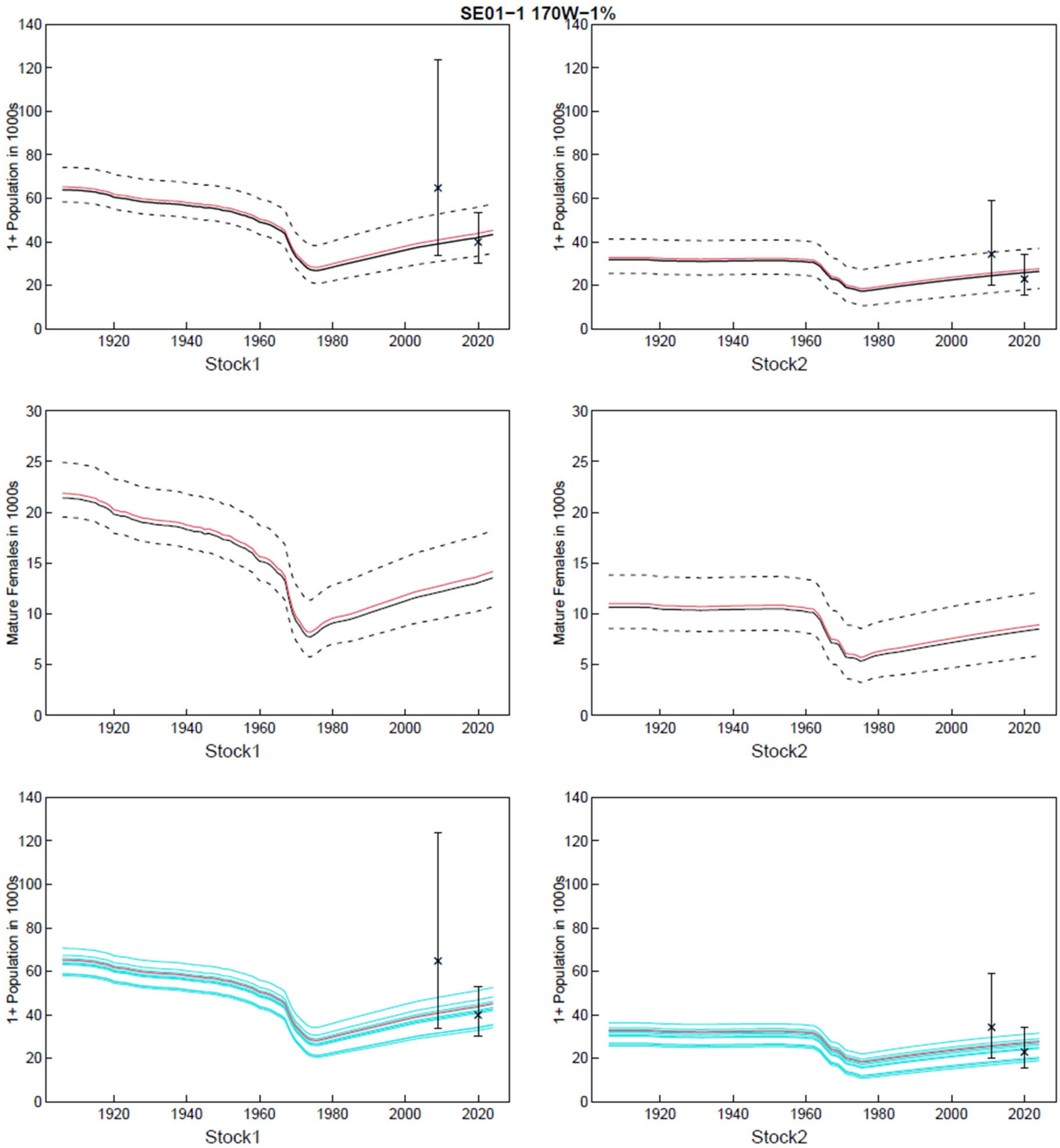

Figure 9. Plots showing results of the conditioning. (1) Plots for the 1+ population by sub-area, (2) Plots of mature female population by stock and (3) Plot of the 1+ population by sub-area with the first 10 trajectories for base case trials SE01-1 and SE01-4. Stock1=Western Stock; Stock 2=Eastern Stock.

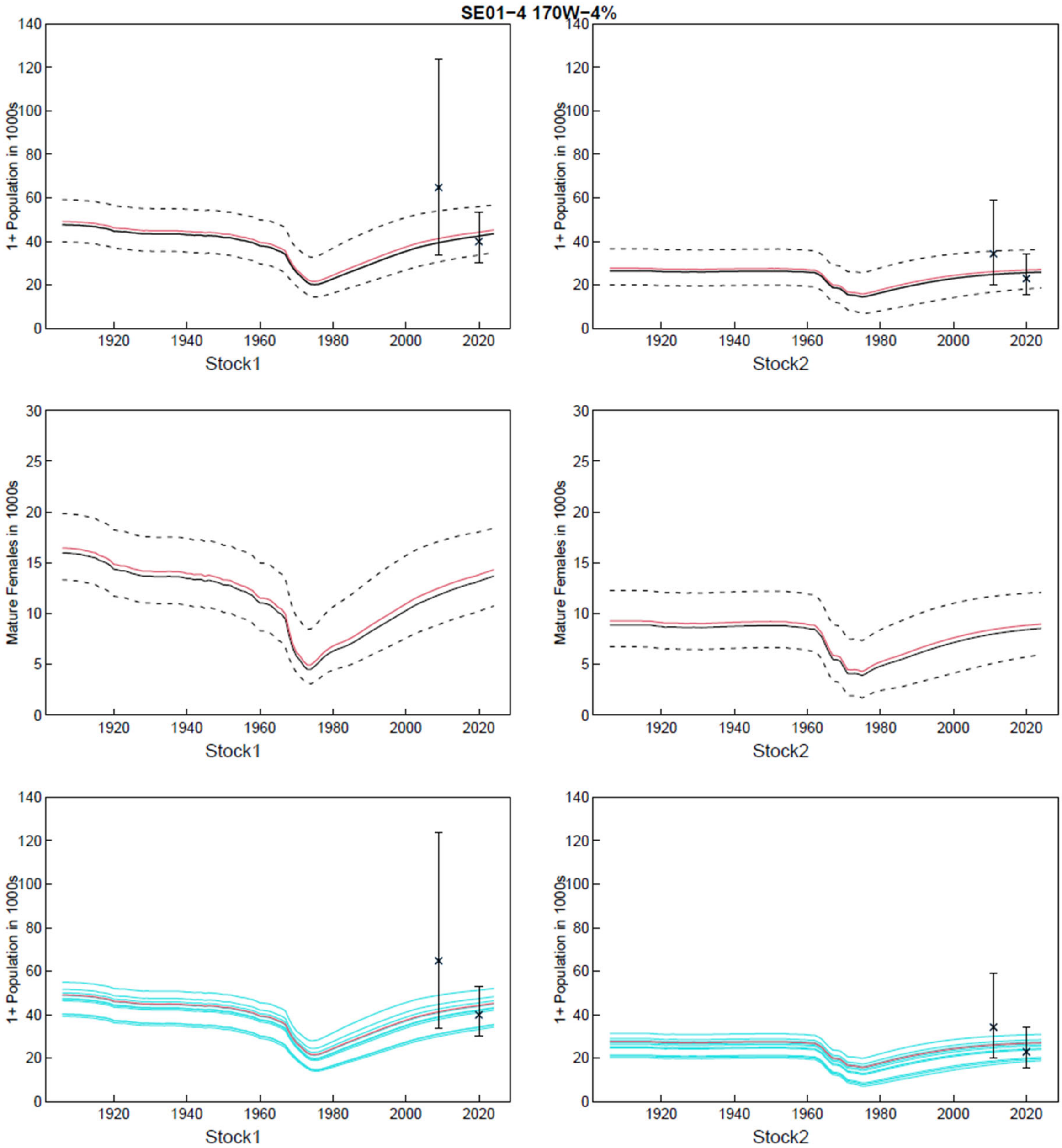

Figure 9. (Continued).

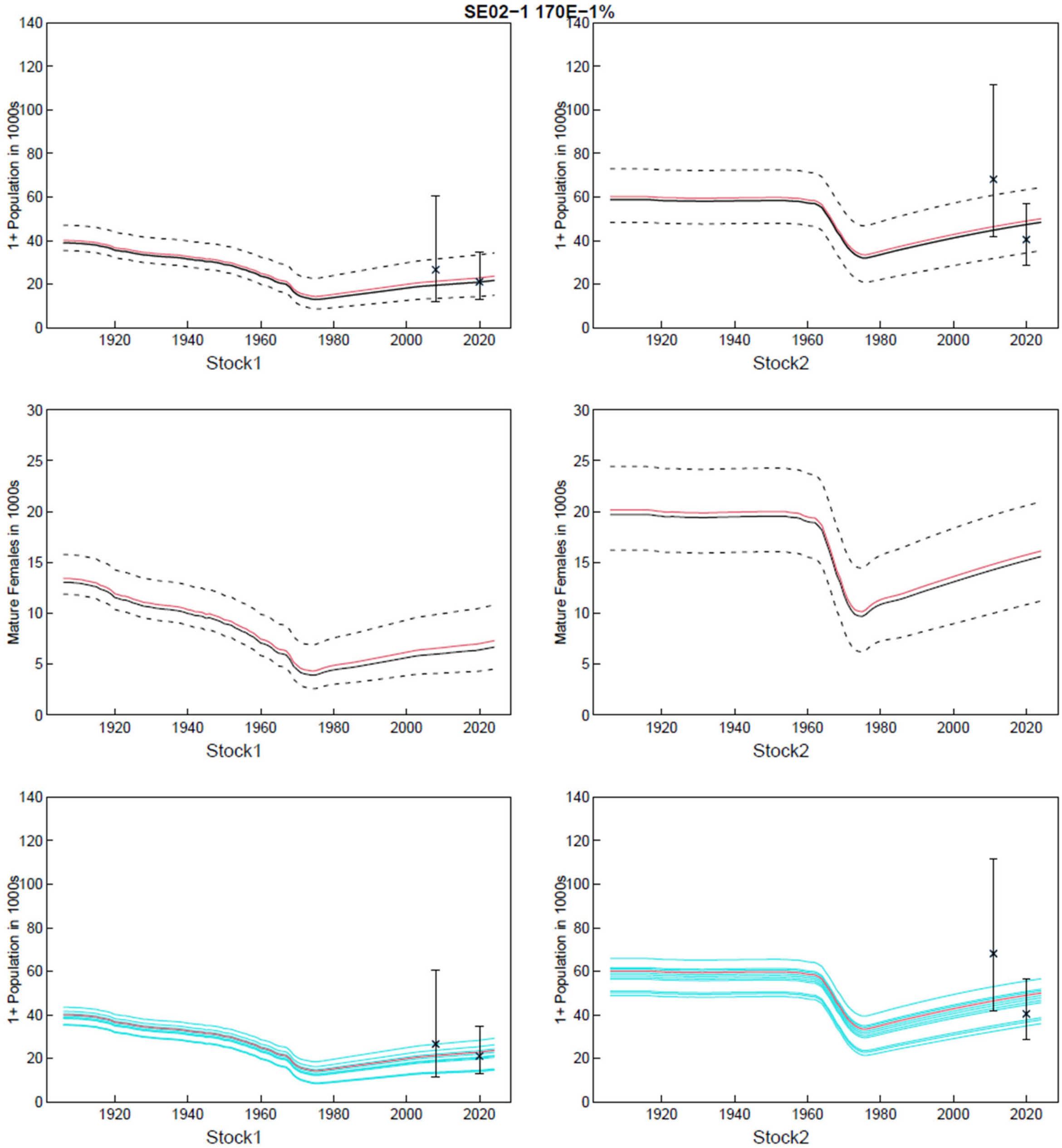

Figure 10. Same as Figure 9 for sensitivity trials SE02-1, SE02-4, SE03-1 and SE03-4. Stock1=Western Stock; Stock 2=Eastern Stock.

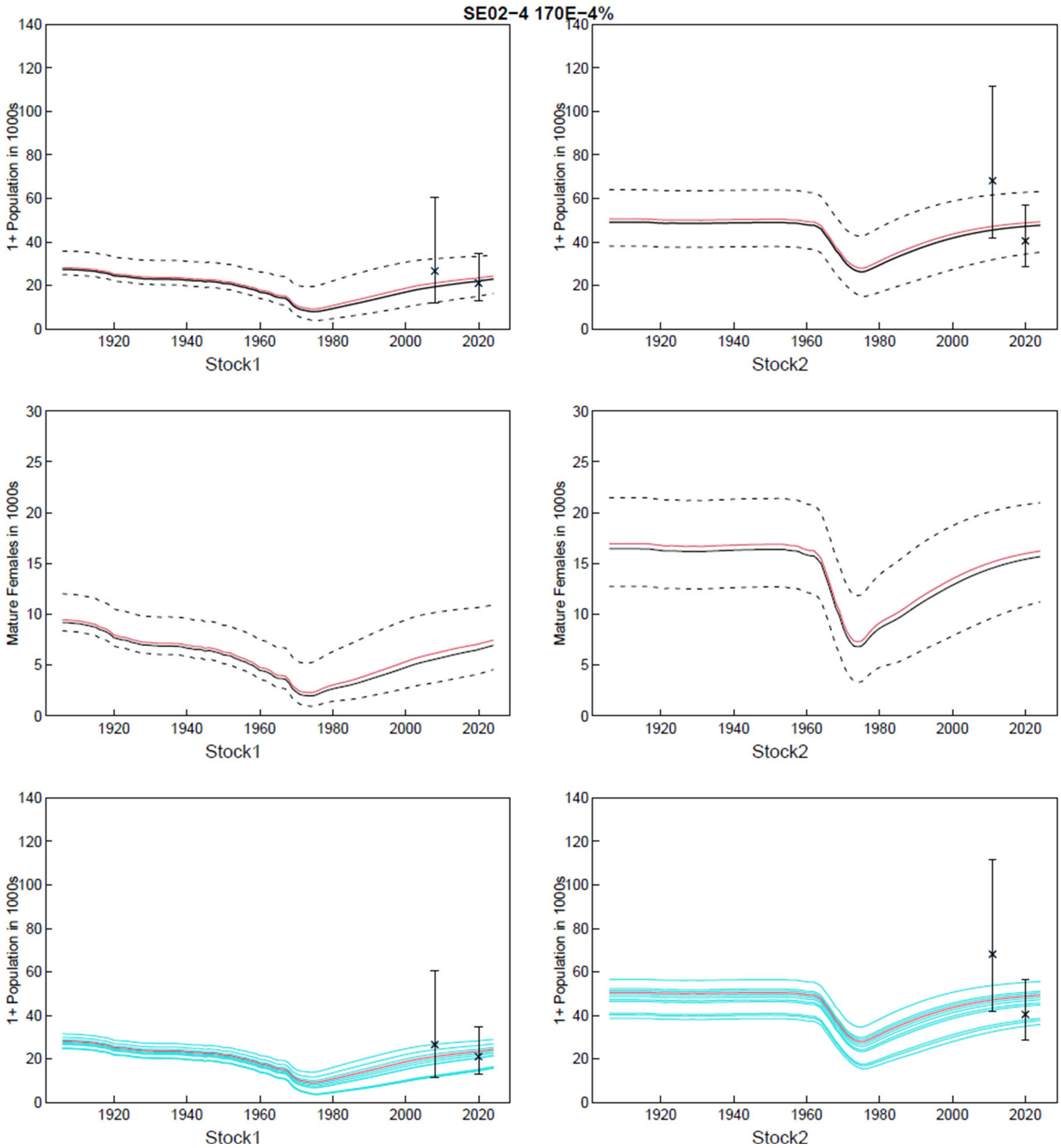

Figure 10. (Continued).

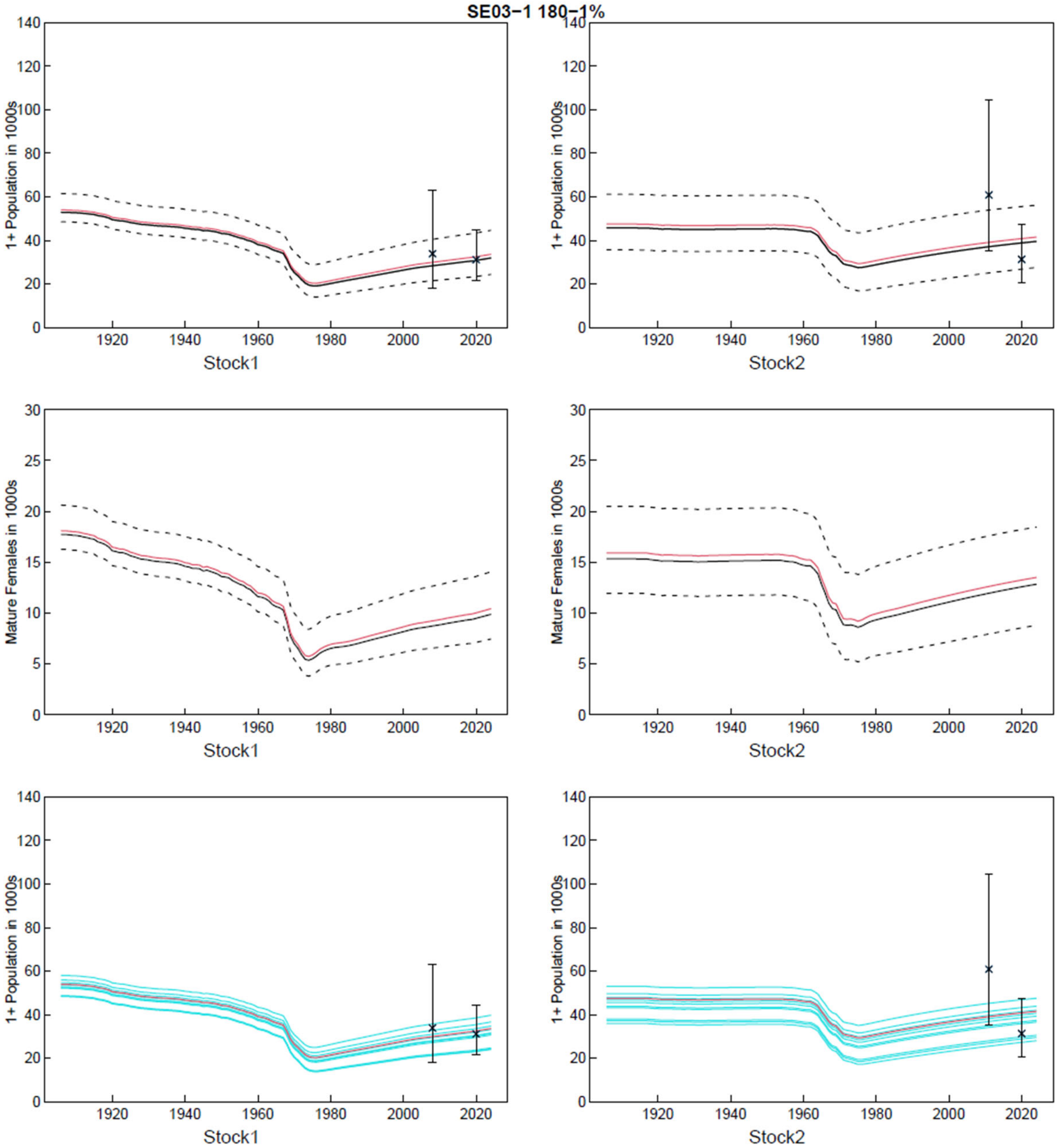

Figure 10. (Continued).

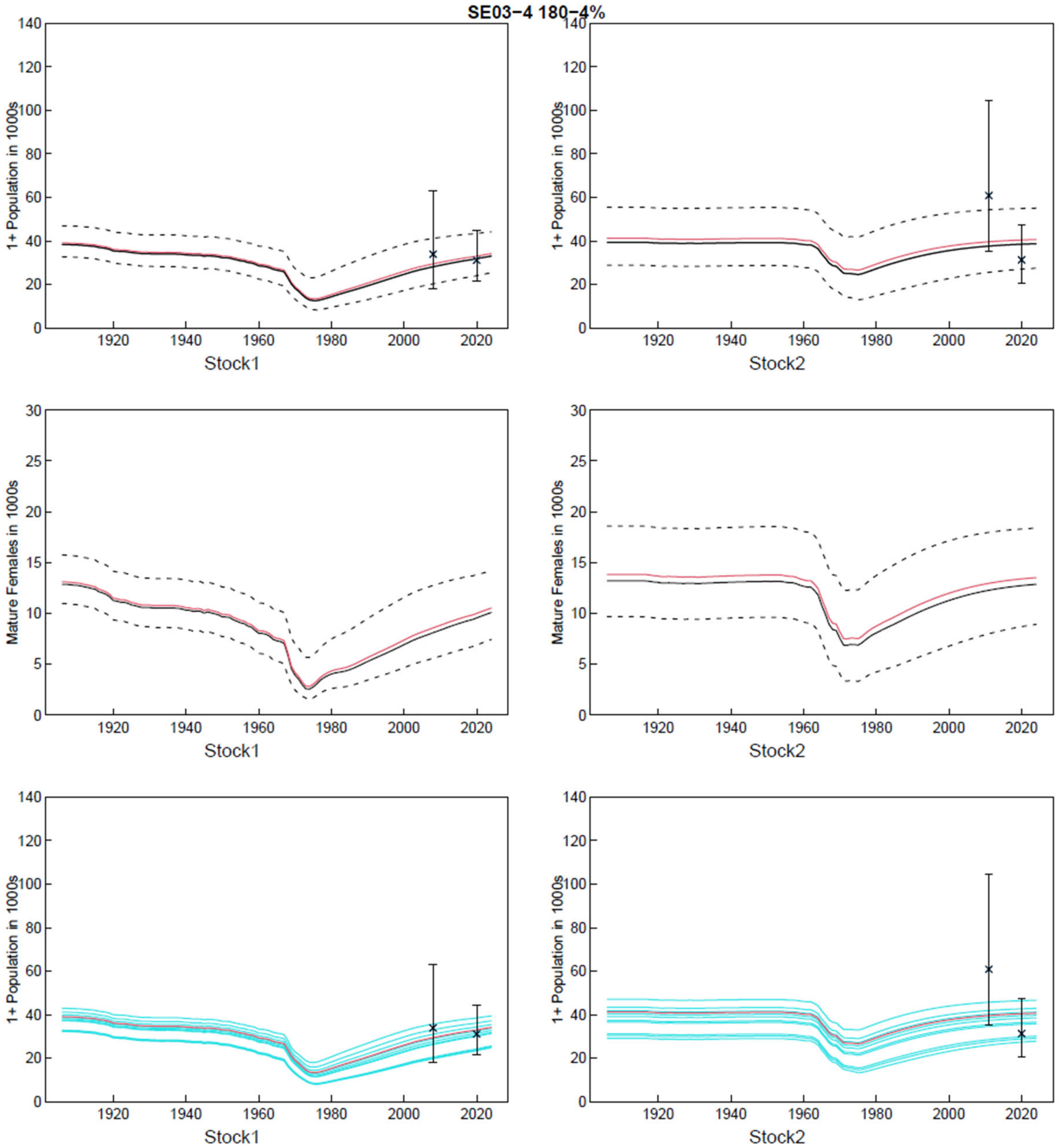

Figure 10. (Continued).

3.6.6 Results of trials

There are two performance measures which pertain to acceptable performance in terms of this IWC RMP-like approach: the final depletion at the end of the 100-year projection period under the MP (P-fin), and the minimum depletion ratio (P-min, which is defined as the minimum over each of these 100-year projections in a trial of the ratio of the population size to that when there are only incidental catches – though such catches are very small in this case). Attainment of 'acceptable performance' is required for the more difficult *MSYR*=1% trials only, as if attained for those, these requirements will also be met for trials with higher *MSYR* values. The lower 5%-ile of P-fin and P-min were calculated for the two stocks in all the combinations of the trials with *MSYR*=1% and three management variants (Figure 11).

IWC (2012c) formally defines "acceptability" of a management variant as follows. The lower 5%-ile of P- fin or P-min must be above the dashed lines shown in Figure 11, where these dashed lines reflect the corresponding results for an "equivalent" single stock trial for an MP with a tuning level of 0.6 (as applies to this MP).

As shown in Figure 11, among Variants 1-3, only V3 satisfies that both of the two performance measures are above the dashed line in terms of stocks S1 (W-stock) and S2 (E-stock) for all the trials with *MSYR*(1+)=1%. Therefore, among Variants 1-3, only V3 is acceptable.

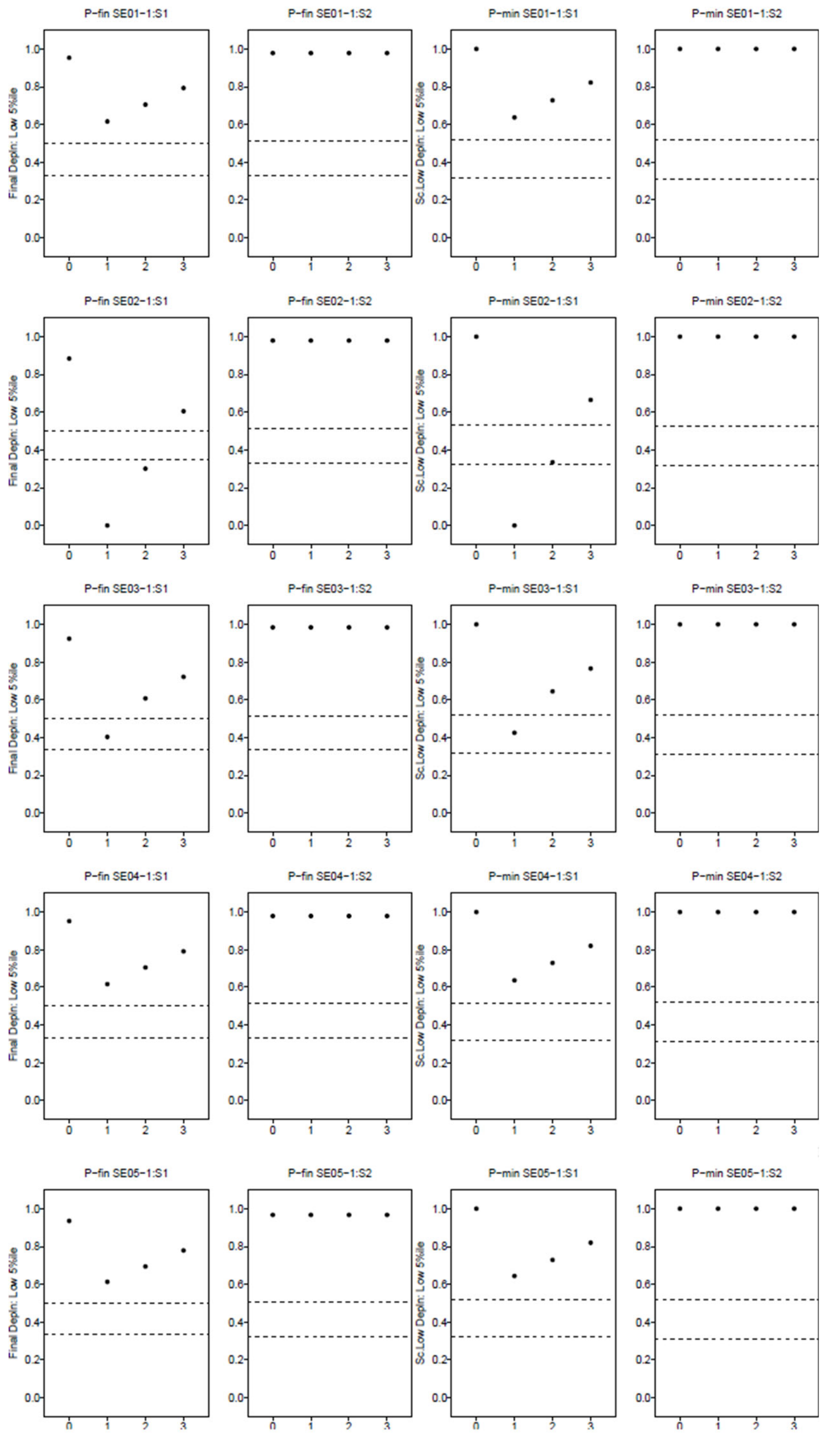

Figure 11. Summary plot of the performance of the three RMP variants V0, V1, V2 and V3 for *MSYR*(1+)=1%. Variants V0-V3 are denoted from 0 to 3 on the horizontal-axis, respectively, with results shown by black dots in the plots. 'Acceptable' performance is indicated by a point above the upper dashed line, 'borderline' performance is a point between the upper and the lower dashed lines, and 'unacceptable' performance in a point below the lower dashed line. S1=W-stock; S2=E-stock. P-fin and P-min are the two performance measures (see text for details).

3.7 Whaling operations and future biological surveys

As mentioned in section 3.6.6, management variant V3 is acceptable, and this variant is recommended.

Future sighting surveys for providing further abundance estimates for use in the CLA will be conducted in line with the options shown in section 3.6.4. A collection of biological data and samples from harvested whales will be conducted for monitoring the exploited stock and improving specification of the scenarios to be considered in future trials.

4. WESTERN NORTH PACIFIC BRYDE'S WHALES

4.1 Stock structure and definition of *Small Areas*

4.1.1 Summary of updated genetic studies

Genetic samples which have been collected since 2019 are now available, which enabled us to examine the plausibility of the stock structure hypotheses adopted in 2019 for defining *Small Areas* for management purposes. Therefore, the North Pacific Bryde's whale's stock structure analysis was updated by adding 759 new genetic samples collected during 2019-2022 into the original sample set (JRT, 2019). In addition, the sPCA(Jombart *et al*., 2008) was used this time. Details of the updated genetic analyses are available in Document RW/A24/04.

Background

Previous stock structure analyses presented in 2019 were based on the area definition of Figure 12 and samples collected between 1979 and 2016. Results suggested weakly differentiated stocks occurring in the sub-areas, with one stock occurring in sub-area 1 and the other in sub-area 2 with possible mixing in sub-area 1E. The stock structure hypotheses were consistent with those adopted by the IWC SC (Hypotheses 2 and 5; Allison and de Moor, 2020).

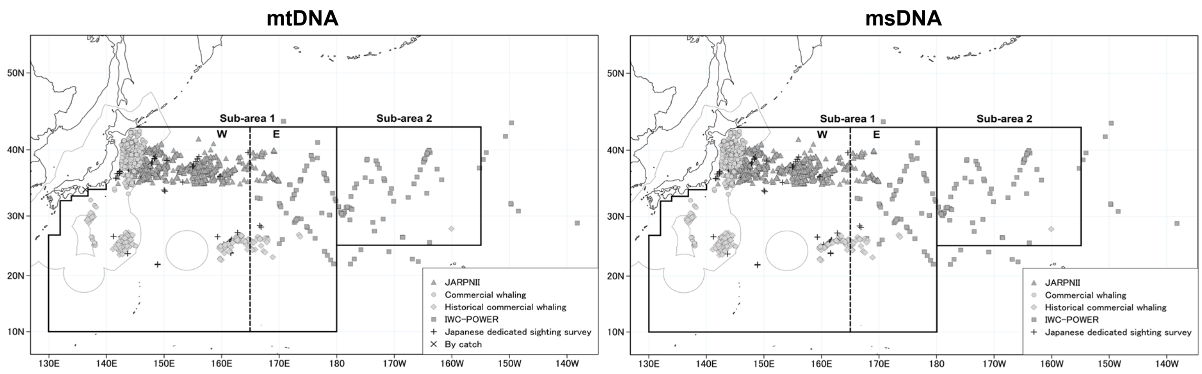

Figure 12. Location of samples used in the mtDNA and msDNA updated analyses. Solid and dash lines illustrate definition of sub-areas used during the RMP *Implementation Review* for the North Pacific Bryde's whale by the IWC SC (Allison and deMoor, 2020).

New genetic samples and dataset for analysis

A total of 759 samples were collected during 2019-2022: samples from commercial whaling within Japan's EEZ (n = 748), biopsy samples from IWC-POWER (n = 5), and biopsy samples from Japanese dedicated sighting survey (n = 6). They were subjected to DNA extraction and genotyped for seventeen msDNA loci, as well as sequenced for a partial mtDNA control region. Samples with successful genotyping and sequencing were then added to the original sample sets used in Appendix 6 of Tamura *et al*. (2019) . After excluding 22 calves sampled together with their mothers and four re-sampling, a total of 1,953 mtDNA sequences and 1,931 msDNA genotypes were prepared as a final dataset. The dataset was divided into the three sub-areas (i.e., sub-areas 1W, 1E, and 2; Table 12 and Figure 12) for the standard stock structure analysis.

Table 12. Sample sizes used in mtDNA/msDNA analyses of North Pacific Bryde's whale, by sub-area and source of samples.

Sub-area	JARPNII (2000-2016)	Commercial whaling (2019-2022)	Historical Commercial whaling (1979-1984)	IWC-POWER (2013-2021)	Dedicated sighting survey (2012-2022)	Bycatch (2010)	Total
1W	743 / 742	748 / 748	186 / 164		59 / 59	1 / 0	1,737 / 1,713
1E	59 / 59		26 / 28	53 / 53	2 / 2		140 / 142
2			1 / 1	75 / 75			76 / 76
Total	802 / 801	748 / 748	213 / 193	128 / 128	61 / 61	1 / 0	1,953 / 1,931

Analytical approaches

<u>Standard stock structure analysis</u>

Calculation of summary statistics and pairwise F_{ST} estimates, and performing heterogeneity test were conducted using both mtDNA and msDNA data.

<u>Spatially explicit analysis</u>

The sPCA analysis was performed to investigate the spatial patterns in genetic variability. Possible change in genetic variation was also examined along a longitudinal cline using genetic statistics (i.e., global scores of the sPCA, expected heterozygosity, inbreeding coefficient, and haplotype diversity).

<u>Mixing proportion</u>

The mixing proportion and its standard error of three postulated mixing areas, (1) 165˚E-180˚, (2) 160˚E-175˚E, and (3) 170˚E-175˚W, were examined based on mtDNA haplotype frequency data, using the Bayesian approach (Punt, 2003).

Results and conclusions of the genetic analyses

The main results are summarized as follows:

- MtDNA control region sequences of 1,953 Bryde's whales resulted in 52 haplotypes, and haplotype and nucleotide diversities were comparable among sub-areas.
- Expected and observed heterozygosities across 17 msDNA loci were comparable among sub-areas. No significant deviations from HWE were observed, except for deviations likely due to genotyping errors in EV94.
- Pairwise F_{ST} estimates were generally low, indicating low levels of genetic differentiation across the study area. The largest estimate was observed between 1W and 2, smallest between 1W and 1E, and intermediate between 1E and 2, both in mtDNA and msDNA.
- Heterogeneity test revealed significant differences in all three pairs of sub-areas in mtDNA and two pairs in msDNA (1W-2 and 1E-2), which suggested a distinct genetic differentiation at least between sub-areas 1W and 2, hereto after referred to 'stock 1' and 'stock 2', respectively.
- The sPCA scatter plot showed that individual plots from three sub-areas extensively overlapped and sPCA did not clearly discriminate among three sub-areas (Figure 13), which was not largely different from the discriminate analysis of principal components that was run in the previous work.
- The genetic statistics along the longitudinal cline showed that genetic variability changes gradually within the area between 165˚E and 180˚, implying that geographical mixing of stocks 1 and 2 occurs around sub-area 1E.

- At all three postulated mixing areas, estimated proportions of stock 1 were consistently larger at target mixing proportions, indicating that stock 1 has a greater influence on the mixing area even when the mixing area shifts slightly westward (160˚E-175˚E) and eastward (170˚E-175˚W).

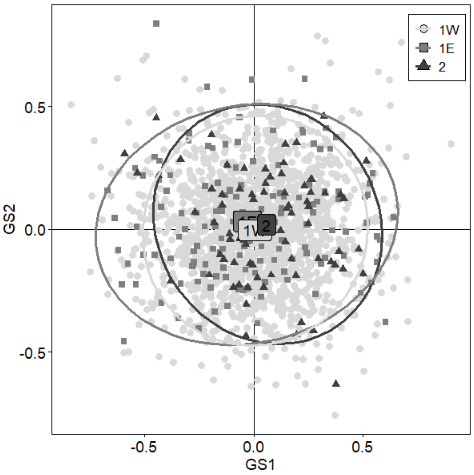

Figure 13. Scatter plot of first and second global scores in sPCA on 1,931 samples of North Pacific Bryde's whale from three sub-areas.

All the results found in this study supported the Hypothesis 5 while the Hypothesis 2 was also plausible considering insignificant msDNA differentiation between 1W and 1E and the low levels of genetic differentiation between the two sub-areas for both markers. This conclusion was the same as the previous one.

4.1.2 Summary of updated non-genetic studies

In 2020 and 2022, satellite-monitored tags were used to track three Bryde's whales, but the number of data is still limited for full analysis and interpretation. One Bryde's whale showed rapid longitudinal movement through Japan's EEZ boundary.

4.1.3 Hypothesis on stock structure

The updated genetic analysis suggested that the two stock structure hypotheses shown in Figure 14, which were the same ones used previously, should be considered in the present assessment and definition of sub-areas and *Small Areas* for management purposes. This conclusion does not contradict the results of the non-genetic analyses.

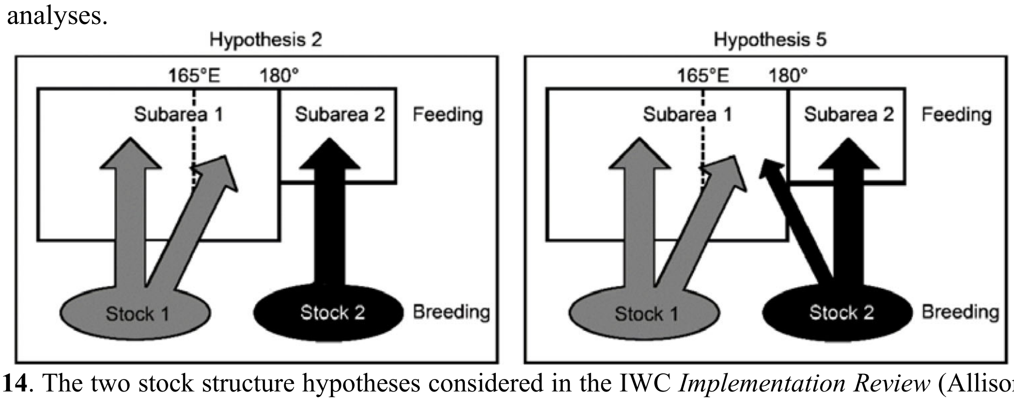

Figure 14. The two stock structure hypotheses considered in the IWC *Implementation Review* (Allison and de Moor, 2020). Hypothesis 2: one stock (stock 1) distributes in sub-area 1 and the other stock (stock 2) distributes in sub-area 2 with no spatial mixing; Hypothesis 5: as in Hypothesis 2 but both stocks mix in sub-area 1E, where

there is a preponderance of the stock 1. These stock structure hypotheses were supported by updated genetic analyses conducted after 2019.

4.1.4 Definition of sub-areas

The IWC SC conducted RMP *Implementation Reviews* of the western North Pacific Bryde's whale which concluded in 2007 and 2019. Figure 15 shows the sub-areas used during these *Implementations*, which are used in our assessment

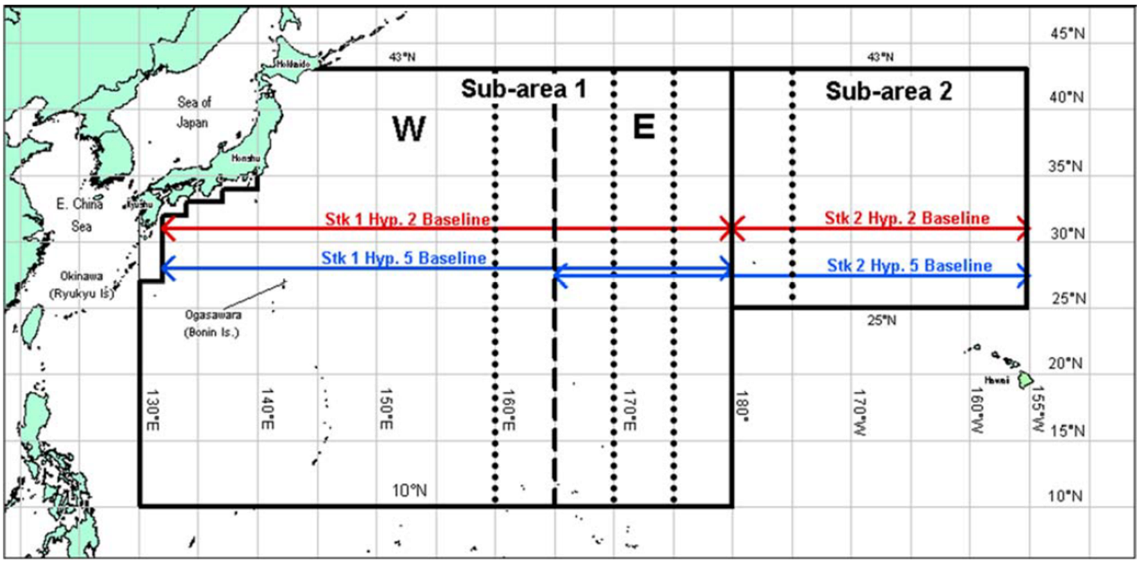

Figure 15. Definition of sub-areas used during the RMP *Implementations* for the North Pacific Bryde's whale by the IWC SC (IWC, 2008; Allison and de Moor 2020), which are used in the present assessment

4.1.5 Definition of *Small Areas*

Based on the two stock structure hypotheses above, the following management areas were defined: i) sub-area 1 (Figure 15) is a *Small Area*, and ii) sub-area 1 is a *Combination Area* with 1W and 1E each *Small Areas* and Catch Cascading applying. Abundance estimates and catch history were computed according to these definitions for *Small Areas*.

It should be noted that both inshore and offshore forms of Bryde's whales occur in the western North Pacific. However, the distribution of the inshore form is restricted to coastal waters inside the Kuroshio Current, and this region is not included in the *Small Areas* defined above. The inshore form of this species is not subject to commercial whaling. The *Small Areas* so defined relate to the larger, offshore form of Bryde's whales, which is distributed outside the Kuroshio Current (see Figure 15).

4.2 Abundance estimates

4.2.1 Previous abundance estimates

Previous abundance estimates and their sampling CVs for North Pacific Bryde's whale from previous studies are shown in Table 13, by three periods (see also Allison and de Moor, 2020). The 1st , the 2nd and the 3rd periods were during 1988-1996 (time stamp 1995), 1998-2002 (time stamp 2000) and 2008-2015 (time stamp 2011).

Table 13. Abundance estimates and survey-specific $g(0)$ for North Pacific Bryde's whale from previous studies (Allison and de Moor, 2020).

Year	Sub-area	g(0)=1		g(0)		g(0) corrected	
		Estimate	Sampling CV	Estimate	CV	Estimate	Sampling CV
1995	1W	8,152	0.329	0.671	0.250	12,149	0.413
	1E	10,814	0.342	0.689	0.250	15,695	0.424
2000	1W	4,957	0.398	0.719	0.250	6,894	0.47
	1E	11,213	0.498	0.584	0.250	19,200	0.557
2011	1W	15,422	0.289	0.613	0.250	25,158	0.382
	1E	6,716	0.216	0.721	0.250	9,315	0.330

4.2.2 Updated abundance estimate in the North Pacific assuming *g*(0)=1

Document RW/A24/08 presented updated abundance estimates. Sighting data from the '3rd period' (2008-2015) and '4th period' (2020-2023) were considered.

Data used

Japanese dedicated sighting surveys were conducted in 2020, 2021 and 2023 (Katsumata *et al.*, 2021; 2022; Kim *et al.*, 2024). The IWC-POWER surveys were conducted in 2020 (Murase *et al.*, 2021). All these surveys were conducted in July-September.

These surveys were all conducted in a systematic manner during through the years, and they followed the survey design guidelines of the IWC SC (IWC, 2012b). Figure 16 shows the tracklines and primary sighting positions from those surveys. Although several whales have been observed north of the north boundary of the management area (43˚N), these data were used to only fit the detection function.

Additionally, sightings from JARPNII surveys in 2008, 2012, and 2014 (Tamura *et al.*, 2009; Matsuoka *et al.*, 2013; 2015) were also combined with the latest series of the data for the purpose of improving precisions of the detection probability estimates. These surveys have also been conducted in the same manner as the latest series of sighting surveys, except that sighting surveys in IO mode were not conducted.

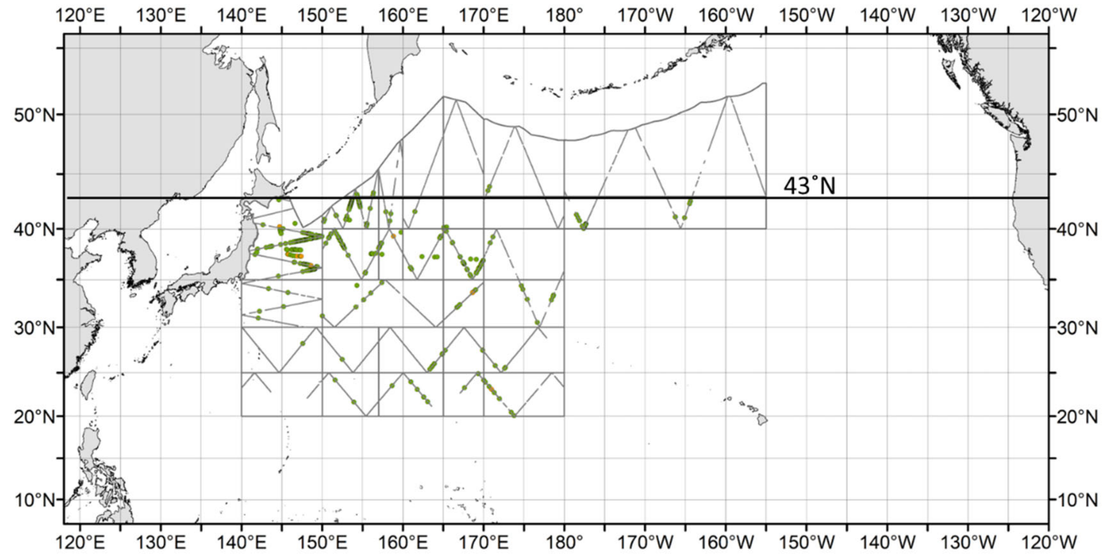

Figure 16. Sighting position of Bryde's whales (green circle: primary sighting; orange circle: secondary sighting), actual surveyed trackline (black lines) for 2020, 2021, and 2023 sighting surveys (August to September). Orange circles are secondary sightings, which were not used in abundance estimation and were included for information here.

Analytical procedure

Analytical procedures followed the IWC SC guidelines (IWC, 2012b). Basically, the distance sampling method is applied to estimate abundance. Abundance estimates and their CVs were estimated based on a Horviz-Thompson-like estimator. The computations were conducted truncating the detections at 3.0 n. miles perpendicular distance for this species as is conventional, and the probability of detection on the trackline was assumed to be 1 (i.e. $g(0)=1$). Hazard-rate and Half-normal models were considered as candidate models for the detection function.

To consider the effect of factors affecting detectability, school size, Beaufort Sea state and visibility, were treated as covariates in the Multiple Covariates Distance Sampling within the DISTANCE program. The best model was selected as the one for which the AIC value was the smallest.

Results

Abundance estimates were computed for each sub-area (for the 3rd period, sub-area 1W and the western part of sub-area 1E, covered by the JARPNII survey). The abundance estimate for the 3rd period in sub-area 1E was provided by summing the updated abundance estimate in the western part of sub-area 1E (Document RW/A24/08) to the abundance estimate in the eastern part of sub-area 1E (covered by IWC-POWER survey) (Hakamada *et al*., 2017). Table 14 shows the abundance estimates assuming $g(0)=1$ by sub-area.

Table 14. Abundance estimates of Bryde's whales by sub-area, based on sightings from JARPNII, Japanese dedicated sighting surveys and IWC-POWER surveys assuming $g(0)=1$.

Period	Sub-area		Abundance N	CV[N]
3rd period (2008-2015)	1W		13,065	0.234
	1E	western part (JARPNII)	3,936	0.305
		eastern part (IWC-POWER)	4,057	0.195
		Total	7,993	0.180
4th period (2020-2023)	1W		10,782	0.187
	1E		4,699	0.221

4.2.3 Estimate of *g*(0)

Data used

For *g*(0) estimates, mark-recapture-like data, *i.e.*, IO data, were collected during IO mode surveys conducted for the Japanese dedicated sighting surveys in 2020-2023 and IWC-POWER survey in 2020.

Analytical procedures

MRDS method were used to estimate the probability of detection on the trackline, *i.e.*, *g*(0), which include perception bias due to sightings that are missed. The details of the MRDS method are described in Laake and Borchers (2004) and Burt *et al*. (2014). The analyses were conducted using the package "mrds" in R-DISTANCE (Thomas *et al*., 2010). Details of the application of this method to the present data are given in Document RW/A24/08.

The probability of detection by an observer, given detection by the other observer, was provided by the MR model which was modelled by a logistic regression with the following covariates: platform (TOP or IO barrels), school size, Beaufort Sea state, and visibility. The candidate models were fitted to the four IO data sets, with and without geographical stratification as for that in the recent abundance estimation in the North Pacific. The best model was selected by using AIC. Furthermore, conditional detection probabilities can be used to estimate the probability of detection on the trackline by at least one observer.

Additionally, the *g*(0) estimate for the 3rd period was based on less IO data from the IO mode survey and was more uncertain than the estimate based on the new IO data during the recent (4th) period. Therefore, to improve the precisions of the *g*(0) for correction of abundance in previous series, an inverse-variance weighted average of the *g*(0) estimates for the 3rd (Hakamada *et al.,* 2018) and 4th periods (Document RW/A24/08) was used to correct the abundance estimates by sub-area for both periods.

Results

The best models selected by AIC include the MR model with the covariates Beaufort sea state, and a DS model with the covariate school size. From the best MR model, the probabilities of detection on the trackline by observers from one platform, given that it was detected by observers from another platform, were 0.76 (CV=0.067) for both Top and IO barrels. The probability of detection on the trackline by at least one observer was 0.940 (CV=0.027).

The inverse-variance weighted average of the probability of detection on the trackline *g*(0) by sub-area and series were shown in Table 15. Abundance estimates by sub-area corrected by the particular *g*(0) estimates are also shown in Table 15.

The *g*(0) corrected abundance estimates by *Small Areas* from the 1st to the 4th periods considering *g*(0) and additional variance estimates, are provided in sections 4.5.2 and 4.6.1.

Table 15. Abundance estimates for North Pacific Bryde's whales, by sub-area, corrected by the inverse-variance weighted averaged $g(0)$ values. Estimates of $g(0)$ and $g_{TOP}(0)$ indicate the probability of the detection on the trackline by at least one observer and that for TOP barrel, respectively.

Period	Sub-area	Weighted average g.(0)	CV [Weighted average g.(0)]	Weighted average $g_{Top}(0)$	CV [Weighted average $g_{Top}(0)$]	g(0) corrected abundance $N_{g(0)\text{-corrected}}$	CV [$N_{g(0)\text{-corrected}}$]	CV [$N_{g(0)\text{-corrected}}$] with process error*	95%CI lower limit	95%CI upper limit
3rd period (2008-2015)	1W	-	-	0.755	0.058	17,307	0.241	0.421	7,848	38,170
	1E	-	-	0.758	0.057	10,551	0.189	0.390	5,050	22,046
4th period (2020-2023)	1W	0.937	0.025	-	-	11,504	0.189	0.390	5,507	24,035
	1E			-	-	5,014	0.223	0.409	2,319	10,839

*: Additional CV of 0.335 (Hakamada *et al*., 2017) is considered.

While point estimates of abundance for the 4th period (11,504 animals in sub-area 1W, 5,014 animals in sub-area 1E) are lower than those for the 3rd period (17,307 animals in sub-area 1W, 10,551 animals in sub-area 1E), these differences are not statistically significant because the ratios of abundances in the 4th period to the 3rd period are estimated to be 0.66 with 95% CI [0.23, 1.89] in sub-area 1W and 0.48 with 95% CI [0.17, 1.33] in sub-area 1E.

4.3 Catch history

Total catch series for Bryde's whales in the North Pacific were made from the latest IWC individual and summary catch database Version 7.0 (Allison, 2020), following the procedure used to make the series for western North Pacific Bryde's whales' *implementation* by IWC SC (Allison and de Moor, 2020). Then, catch series by sex in each area were made. For data after 2020, which is not included in the IWC database version 7.0, catch series through 2023 were prepared by referring to the Progress Report for large cetaceans and other reliable sources (Document RW/A24/10).

4.4 Biological parameters

Biological parameters of Bryde's whales, with a particular focus on age at sexual maturity were estimated to consider whether new trial scenarios need to be set up, by using new information obtained since the resumption of commercial whaling. Estimates of age at sexual maturity were made only for the mean age at first ovulation at this time.

The number of individuals of first ovulation has been five with readable earplugs, and the average age at first ovulation was 8.6 years old. It was similar to the value used in the current *IST*s, and therefore it is not necessary to change the age at sexual maturity at the current *ISTs*. Table 16 shows biological and technological parameters used for the *IST*.

Table 16. The values for the biological and technological parameters that are fixed for the latest IWC SC *IST* in 2019（Allison and de Moor, 2020）

Plus group age, x	15 years
Natural mortality, M	0.08 yr^{-1}
Age at first parturition, α_m	9 years （calculated as 8.6）
Selectivity (historical)	
Sub-area 1W:	Knife-edged at age 5
Sub-area 1E&2:	Knife-edged at age 9
Selectivity (future)	Knife-edged at age 5
MSYL（1+ component）	0.6

4.5 Catch limit

4.5.1 Catch data used in the CLA

Catch series used for the CLA calculations correspond to the 'best' series used in the IWC SC *Implementation Review* for the western North Pacific Bryde's whale (Allison and de Moor, 2020) (Table 17).

Table 17. The best catch series by sub-areas for the western North Pacific Bryde's whales used in the CLA.

Year	Sub-area 1W			Sub-area 1E			Sub-area 1		
	M	F	Total	M	F	Total	M	F	Total
1906	6	7	13	0	0	0	6	7	13
1907	17	18	35	0	0	0	17	18	35
1908	39	42	81	0	0	0	39	42	81
1909	23	24	47	0	0	0	23	24	47
1910	26	29	55	0	0	0	26	29	55
1911	75	81	156	0	0	0	75	81	156
1912	38	43	81	0	0	0	38	43	81
1913	58	66	124	0	0	0	58	66	124
1914	24	32	56	0	0	0	24	32	56
1915	72	97	169	0	0	0	72	97	169
1916	45	60	105	0	0	0	45	60	105
1917	88	93	181	0	0	0	88	93	181
1918	69	79	148	0	0	0	69	79	148
1919	77	84	161	0	0	0	77	84	161
1920	41	51	92	0	0	0	41	51	92
1921	40	49	89	0	0	0	40	49	89
1922	37	44	81	0	0	0	37	44	81
1923	32	43	75	0	0	0	32	43	75
1924	48	63	111	0	0	0	48	63	111
1925	55	63	118	0	0	0	55	63	118
1926	60	74	134	0	0	0	60	74	134
1927	53	65	118	0	0	0	53	65	118
1928	36	44	80	0	0	0	36	44	80
1929	29	34	63	0	0	0	29	34	63
1930	27	35	62	0	0	0	27	35	62
1931	64	71	135	0	0	0	64	71	135
1932	51	53	104	0	0	0	51	53	104
1933	39	49	88	0	0	0	39	49	88
1934	48	51	99	0	0	0	48	51	99
1935	48	48	96	0	0	0	48	48	96
1936	40	48	88	0	0	0	40	48	88
1937	60	66	126	0	0	0	60	66	126
1938	76	83	159	0	0	0	76	83	159
1939	88	105	193	0	0	0	88	105	193
1940	48	57	105	0	0	0	48	57	105
1941	64	81	145	0	0	0	64	81	145
1942	9	12	21	0	0	0	9	12	21
1943	17	13	30	0	0	0	17	13	30
1944	37	37	74	0	0	0	37	37	74
1945	5	7	12	0	0	0	5	7	12
1946	52	74	126	0	0	0	52	74	126
1947	51	60	111	0	0	0	51	60	111
1948	57	76	133	0	0	0	57	76	133
1949	101	97	198	0	0	0	101	97	198
1950	117	156	273	0	0	0	117	156	273

Table 17. (Continued)

1951	166	141	307	0	0	0	166	141	307
1952	303	188	491	0	0	0	303	188	491
1953	25	36	61	0	0	0	25	36	61
1954	31	44	75	0	0	0	31	44	75
1955	34	60	94	0	0	0	34	60	94
1956	12	12	24	0	0	0	12	12	24
1957	12	27	39	0	0	0	12	27	39
1958	113	141	254	0	0	0	113	141	254
1959	153	110	263	0	0	0	153	110	263
1960	188	216	404	0	0	0	188	216	404
1961	83	84	167	0	0	0	83	84	167
1962	209	295	504	0	0	0	209	295	504
1963	100	110	210	0	0	0	100	110	210
1964	25	43	68	0	0	0	25	43	68
1965	1	7	8	1	1	2	2	8	10
1966	19	36	55	1	2	3	20	38	58
1967	17	28	45	0	0	0	17	28	45
1968	70	101	171	1	2	3	71	103	174
1969	34	55	89	6	10	16	40	65	105
1970	36	37	73	4	7	11	40	44	84
1971	96	121	217	118	166	284	214	287	501
1972	38	46	84	22	41	63	60	87	147
1973	190	402	592	20	31	51	210	433	643
1974	287	422	709	120	186	306	407	608	1015
1975	358	343	701	129	167	296	487	510	997
1976	390	461	851	370	207	577	760	668	1428
1977	416	371	787	78	72	150	494	443	937
1978	274	216	490	167	126	293	441	342	783
1979	670	570	1240	23	16	39	693	586	1279
1980	401	354	755	0	0	0	401	354	755
1981	249	236	485	0	0	0	249	236	485
1982	275	207	482	0	0	0	275	207	482
1983	403	142	545	0	0	0	403	142	545
1984	353	175	528	0	0	0	353	175	528
1985	249	108	357	0	0	0	249	108	357
1986	217	100	317	0	0	0	217	100	317
1987	256	61	317	0	0	0	256	61	317
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0
1998	0	1	1	0	0	0	0	1	1
1999	0	0	0	0	0	0	0	0	0
2000	20	23	43	0	0	0	20	23	43
2001	17	33	50	0	0	0	17	33	50
2002	25	25	50	0	0	0	25	25	50
2003	19	31	50	0	0	0	19	31	50
2004	19	25	44	1	6	7	20	31	51
2005	21	29	50	0	0	0	21	29	50
2006	18	20	38	3	10	13	21	30	51
2007	23	25	48	0	2	2	23	27	50
2008	30	20	50	0	0	0	30	20	50
2009	16	19	35	2	13	15	18	32	50
2010	20	16	36	5	9	14	25	25	50
2011	18	28	46	2	2	4	20	30	50
2012	11	20	31	0	3	3	11	23	34
2013	13	15	28	0	0	0	13	15	28
2014	6	19	25	0	0	0	6	19	25
2015	14	11	25	0	0	0	14	11	25
2016	11	15	26	0	0	0	11	15	26
2017	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0
2019	82	105	187	0	0	0	82	105	187
2020	85	102	187	0	0	0	85	102	187
2021	69	118	187	0	0	0	69	118	187
2022	80	107	187	0	0	0	80	107	187
2023	74	113	187	0	0	0	74	113	187

4.5.2 Abundance estimates used in the CLA

Abundance estimates in the 1st and the 2nd periods were derived from the estimates assuming $g(0)=1$ in Table 13 . The $g(0)$ estimates to correct these abundance estimates were the inverse-variance weighted average of $g(0)$ estimates by periods and sub-areas in Hakamada *et al*. (2018) (see also Document RW/A24/08). Abundance estimates in the 3rd and 4th periods were provided in Document RW/A24/08.

Additional CV of 0.335 (Hakamada *et al*., 2017) was considered to estimate the precision of the abundance estimate used in the CLA. Thus, abundance estimates by sub-areas in the four-time stamps were obtained and provided in Table 18.

Table 18. Abundance estimates by sub-areas used for the application of the CLA on North Pacific Bryde's whale. 95%CL: 95% confidence intervals, LL: lower limit and UL: upper limit.

Year	Sub-area	g(0)=1		g(0)		g(0) corrected			
		Estimate	Sampling CV	Estimate	CV	Estimate	CV*	95%CI LL	95%CI UL
1995	1W	8,152	0.329	0.751	0.056	10,857	0.486	4,404	26,766
	1E	10,814	0.342	0.753	0.056	14,369	0.496	5,733	36,015
	1W+1E	18,966	0.241	-	-	25,226	0.351	12,924	49,238
2000	1W	4,957	0.398	0.755	0.055	6,563	0.540	2,434	17,693
	1E	11,213	0.498	0.745	0.057	15,047	0.626	4,876	46,433
	1W+1E	16,170	0.366	-	-	21,610	0.466	9,069	51,492
2011	1W	13,065	0.234	0.755	0.058	17,307	0.421	7,848	38,170
	1E	7,993	0.180	0.758	0.057	10,551	0.390	5,050	22,046
	1W+1E	21,058	0.160	-	-	27,859	0.300	15,669	49,533
2021	1W	10,782	0.187	0.937	0.025	11,504	0.390	5,507	24,035
2022	1E	4,699	0.221	0.937	0.025	5,014	0.409	2,319	10,839
2021	1W+1E	15,481	0.146	-	-	16,518	0.298	9,319	29,279

*: Additional CV of 0.335 (Hakamada *et al*., 2017) is considered.
While point estimates of abundance for the 4th period (16,518 animals, 11,504 animals and 5,014 animals in sub-areas 1, 1W and 1E, respectively) are lower than those for the 3rd period (27,859 animals, 17,307 animals and 10,551 animals in sub-areas 1, 1W and 1E, respectively), these differences are not statistically significant because the ratios of abundances in 4th period to 3rd period are estimated to be 0.59 with 95% CI [0.27, 1.31], 0.66 with 95% CI [0.23, 1.89] and 0.48 with 95% CI [0.17, 1.33] in sub-areas 1, 1W and 1E, respectively.

4.5.3 Results of the CLA

Table 19 shows the results of the CLA applied to the management areas defined above, Option i): sub-areas 1 is a *Small Area*; and Option ii): sub-area 1 is a *Combination Area* with 1W and 1E each being *Small Areas* and Catch Cascading applying.

An adjustment for sex ratio was required because the actual sex ratio in the recent catch of Bryde's whales for the last five years (2019-2023) is 0.583.

As explained above, this catch limit applies to the larger, pelagic Bryde's whales, which are distributed outside the Kuroshio Current where whaling operation will be conducted.

Table 19. Catch limits for the western North Pacific Bryde's whales.

Tuning level	*Small Area*		
	Option i)	Option ii)	
	SA1	SA1W	SA1E
0.6	154	53	101

4.6 Testing for uncertainties (*ISTs*)

4.6.1 Conditioning

The explanation about the conditioning was provided under item 3.6.1. The difference of the conditioning process in the case of the Bryde's whales is that mixing proportion estimates of stock 1 in sub-area 1E were used in addition to historical abundance estimate data.

Abundance estimate used for the conditioning

Abundance estimates for the entire area for the entire historical time series are required for the conditioning based on the method in Palka (2020) to consider extrapolation for unsurvey area. Survey coverage in sub-area 2 in 2021 is about one over six, therefore abundance estimate in sub-area 2 in 2021 was multiplied by six used for conditioning (Table 20).

Table 20. Abundance estimates by sub-areas used for the conditioning of North Pacific Bryde's whale.

Sub-area	Year	$g(0)$		$g(0)$=1		$g(0)$ corrected	
		Estimate	CV	Estimate	CV	Estimate	CV
1W	1995	0.751	0.056	8,152	0.329	10,857	0.334
	2000	0.755	0.055	4,957	0.398	6,563	0.402
	2011	0.755	0.058	20,786	0.288	27,535	0.293
	2021	0.937	0.025	17,154	0.269	18,303	0.270
1E	1995	0.753	0.056	10,814	0.342	14,369	0.347
	2000	0.745	0.057	11,213	0.498	15,047	0.501
	2011	0.758	0.057	8,228	0.176	10,862	0.185
	2022	0.937	0.025	4,837	0.216	5,161	0.217
2	1995	0.752	0.057	2,860	0.372	3,805	0.376
	2000	0.756	0.056	4,331	0.553	5,726	0.556
	2014	0.756	0.058	4,161	0.264	5,506	0.270
	2021	0.937	0.025	21,936	0.520	23,405	0.521

Mixing proportions used for the conditioning

In stock structure hypothesis 5, mixing of stocks 1 and 2 is occurring in sub-area 1E. Historical mixing proportions used in the *ISTs* were provided in Table 21. The 'targets' for the mixing proportion in the mixing area trials based on stock structure hypothesis 5 are generated from normal distributions (mean and SD given in Table 21), truncated at 0 and 1.

Table 21. Estimates of mixing proportions of stock 1 in sub-area 1E and their standard errors (Document RW/A24/04).

Area	Average proportion of stock 1 during 2002-2020	SE	Proportion of stock 1 in 1979	SE
Baseline: 165°E-180°	0.759	0.085	0.836	0.109
Trial Br6: 160°E-175°E	0.855	0.060	0.928	0.052
Trial Br7: 170°E-175°W	0.635	0.099	0.652	0.240

Catch series used for the IST

Document RW/A24/10 produced 'Best' and 'High' catch series by sex and by sub-areas based on IWC catch data base ver 7.0 (Allison, 2020). The 'High' catch series is same as those provided in the *IST* for this species completed in 2019 (Allison and de Moor, 2020). The 'Best' series are provided in Table 22 and the 'high' series are provided in Table 23.

Table 22. Best catch series for Bryde's whales in the North Pacific based on IWC (2020).

	1Wa	1Wa	1Wb	1Wb	1Ea	1Ea	1Eb	1Eb	1Ec	1Ec	2a	2a	2b	2b
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1906	6	7	0	0	0	0	0	0	0	0	0	0	0	0
1907	17	18	0	0	0	0	0	0	0	0	0	0	0	0
1908	39	42	0	0	0	0	0	0	0	0	0	0	0	0
1909	23	24	0	0	0	0	0	0	0	0	0	0	0	0
1910	26	29	0	0	0	0	0	0	0	0	0	0	0	0
1911	75	81	0	0	0	0	0	0	0	0	0	0	0	0
1912	38	43	0	0	0	0	0	0	0	0	0	0	0	0
1913	58	66	0	0	0	0	0	0	0	0	0	0	0	0
1914	24	32	0	0	0	0	0	0	0	0	0	0	0	0
1915	72	97	0	0	0	0	0	0	0	0	0	0	0	0
1916	45	60	0	0	0	0	0	0	0	0	0	0	0	0
1917	88	93	0	0	0	0	0	0	0	0	0	0	0	0
1918	69	79	0	0	0	0	0	0	0	0	0	0	0	0
1919	77	84	0	0	0	0	0	0	0	0	0	0	0	0
1920	41	51	0	0	0	0	0	0	0	0	0	0	0	0
1921	40	49	0	0	0	0	0	0	0	0	0	0	0	0
1922	37	44	0	0	0	0	0	0	0	0	0	0	0	0
1923	32	43	0	0	0	0	0	0	0	0	0	0	0	0
1924	48	63	0	0	0	0	0	0	0	0	0	0	0	0
1925	55	63	0	0	0	0	0	0	0	0	0	0	0	0
1926	60	74	0	0	0	0	0	0	0	0	0	0	0	0
1927	53	65	0	0	0	0	0	0	0	0	0	0	0	0
1928	36	44	0	0	0	0	0	0	0	0	0	0	0	0
1929	29	34	0	0	0	0	0	0	0	0	0	0	0	0
1930	27	35	0	0	0	0	0	0	0	0	0	0	0	0
1931	64	71	0	0	0	0	0	0	0	0	0	0	0	0
1932	51	53	0	0	0	0	0	0	0	0	0	0	0	0
1933	39	49	0	0	0	0	0	0	0	0	0	0	0	0
1934	48	51	0	0	0	0	0	0	0	0	0	0	0	0
1935	48	48	0	0	0	0	0	0	0	0	0	0	0	0
1936	40	48	0	0	0	0	0	0	0	0	0	0	0	0
1937	60	66	0	0	0	0	0	0	0	0	0	0	0	0
1938	76	83	0	0	0	0	0	0	0	0	0	0	0	0
1939	88	105	0	0	0	0	0	0	0	0	0	0	0	0
1940	48	57	0	0	0	0	0	0	0	0	0	0	0	0
1941	64	81	0	0	0	0	0	0	0	0	0	0	0	0
1942	9	12	0	0	0	0	0	0	0	0	0	0	0	0
1943	17	13	0	0	0	0	0	0	0	0	0	0	0	0
1944	37	37	0	0	0	0	0	0	0	0	0	0	0	0
1945	5	7	0	0	0	0	0	0	0	0	0	0	0	0
1946	52	74	0	0	0	0	0	0	0	0	0	0	0	0
1947	51	60	0	0	0	0	0	0	0	0	0	0	0	0
1948	57	76	0	0	0	0	0	0	0	0	0	0	0	0
1949	101	97	0	0	0	0	0	0	0	0	0	0	0	0
1950	117	156	0	0	0	0	0	0	0	0	0	0	0	0
1951	166	141	0	0	0	0	0	0	0	0	0	0	0	0
1952	303	188	0	0	0	0	0	0	0	0	0	0	0	0
1953	25	36	0	0	0	0	0	0	0	0	0	0	0	0
1954	31	44	0	0	0	0	0	0	0	0	0	0	0	0
1955	34	60	0	0	0	0	0	0	0	0	0	0	0	0
1956	12	12	0	0	0	0	0	0	0	0	0	0	0	0
1957	12	27	0	0	0	0	0	0	0	0	0	0	0	0
1958	113	141	0	0	0	0	0	0	0	0	0	0	0	0
1959	153	110	0	0	0	0	0	0	0	0	0	0	0	0
1960	188	216	0	0	0	0	0	0	0	0	0	0	0	0
1961	83	84	0	0	0	0	0	0	0	0	0	0	0	0
1962	209	295	0	0	0	0	0	0	0	0	0	0	0	0
1963	100	110	0	0	0	0	0	0	0	0	0	0	0	0
1964	25	43	0	0	0	0	0	0	0	0	0	0	0	0
1965	1	7	0	0	0	0	0	0	1	1	2	2	0	0
1966	19	36	0	0	0	0	0	0	1	2	2	3	0	0
1967	17	28	0	0	0	0	0	0	0	0	0	0	0	0
1968	70	101	0	0	0	0	0	0	1	2	4	5	0	0
1969	34	55	0	0	0	0	0	0	6	10	16	22	0	0
1970	36	37	0	0	0	0	0	0	4	7	11	15	0	0
1971	96	121	0	0	37	54	19	19	62	93	48	70	23	29
1972	38	46	0	0	2	4	0	0	20	37	4	6	0	3
1973	185	391	5	11	6	6	7	12	7	13	4	11	16	25
1974	282	418	5	4	13	9	12	30	95	147	67	84	80	76
1975	349	331	9	12	17	37	72	76	40	54	89	119	138	89
1976	379	446	11	15	106	62	183	95	81	50	14	5	11	1

Table 22. (Continued)

	1Wa	1Wa	1Wb	1Wb	1Ea	1Ea	1Eb	1Eb	1Ec	1Ec	2a	2a	2b	2b
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1977	182	192	234	179	66	49	10	14	2	9	0	3	2	4
1978	252	203	22	13	102	48	51	57	14	21	7	4	1	1
1979	589	517	81	53	23	13	0	3	0	0	0	0	0	2
1980	401	354	0	0	0	0	0	0	0	0	0	0	0	0
1981	249	236	0	0	0	0	0	0	0	0	0	0	0	0
1982	275	207	0	0	0	0	0	0	0	0	0	0	0	0
1983	403	142	0	0	0	0	0	0	0	0	0	0	0	0
1984	353	175	0	0	0	0	0	0	0	0	0	0	0	0
1985	249	108	0	0	0	0	0	0	0	0	0	0	0	0
1986	217	100	0	0	0	0	0	0	0	0	0	0	0	0
1987	256	61	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	20	23	0	0	0	0	0	0	0	0	0	0	0	0
2001	17	33	0	0	0	0	0	0	0	0	0	0	0	0
2002	25	25	0	0	0	0	0	0	0	0	0	0	0	0
2003	18	28	1	3	0	0	0	0	0	0	0	0	0	0
2004	14	23	5	2	1	6	0	0	0	0	0	0	0	0
2005	21	26	0	3	0	0	0	0	0	0	0	0	0	0
2006	12	7	6	13	3	10	0	0	0	0	0	0	0	0
2007	23	25	0	0	0	2	0	0	0	0	0	0	0	0
2008	30	20	0	0	0	0	0	0	0	0	0	0	0	0
2009	15	18	1	1	2	13	0	0	0	0	0	0	0	0
2010	3	5	17	11	5	9	0	0	0	0	0	0	0	0
2011	17	24	1	4	2	2	0	0	0	0	0	0	0	0
2012	10	17	1	3	0	3	0	0	0	0	0	0	0	0
2013	12	13	1	2	0	0	0	0	0	0	0	0	0	0
2014	6	19	0	0	0	0	0	0	0	0	0	0	0	0
2015	14	11	0	0	0	0	0	0	0	0	0	0	0	0
2016	7	14	4	1	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	82	105	0	0	0	0	0	0	0	0	0	0	0	0
2020	85	102	0	0	0	0	0	0	0	0	0	0	0	0
2021	69	118	0	0	0	0	0	0	0	0	0	0	0	0
2022	80	107	0	0	0	0	0	0	0	0	0	0	0	0
2023	74	113	0	0	0	0	0	0	0	0	0	0	0	0

Table 23. High catch series for Bryde's whales in the North Pacific based on IWC (2020).

	1Wa	1Wa	1Wb	1Wb	1Ea	1Ea	1Eb	1Eb	1Ec	1Ec	2a	2a	2b	2b
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1906	9	11	0	0	0	0	0	0	0	0	0	0	0	0
1907	24	28	0	0	0	0	0	0	0	0	0	0	0	0
1908	57	67	0	0	0	0	0	0	0	0	0	0	0	0
1909	33	39	0	0	0	0	0	0	0	0	0	0	0	0
1910	35	41	0	0	0	0	0	0	0	0	0	0	0	0
1911	109	128	0	0	0	0	0	0	0	0	0	0	0	0
1912	61	75	0	0	0	0	0	0	0	0	0	0	0	0
1913	94	115	0	0	0	0	0	0	0	0	0	0	0	0
1914	51	68	0	0	0	0	0	0	0	0	0	0	0	0
1915	154	208	0	0	0	0	0	0	0	0	0	0	0	0
1916	94	126	0	0	0	0	0	0	0	0	0	0	0	0
1917	124	142	0	0	0	0	0	0	0	0	0	0	0	0
1918	112	138	0	0	0	0	0	0	0	0	0	0	0	0
1919	113	132	0	0	0	0	0	0	0	0	0	0	0	0
1920	78	101	0	0	0	0	0	0	0	0	0	0	0	0
1921	72	93	0	0	0	0	0	0	0	0	0	0	0	0
1922	66	84	0	0	0	0	0	0	0	0	0	0	0	0
1923	68	92	0	0	0	0	0	0	0	0	0	0	0	0
1924	100	134	0	0	0	0	0	0	0	0	0	0	0	0
1925	93	115	0	0	0	0	0	0	0	0	0	0	0	0
1926	114	143	0	0	0	0	0	0	0	0	0	0	0	0
1927	97	122	0	0	0	0	0	0	0	0	0	0	0	0
1928	65	83	0	0	0	0	0	0	0	0	0	0	0	0
1929	49	61	0	0	0	0	0	0	0	0	0	0	0	0
1930	59	75	0	0	0	0	0	0	0	0	0	0	0	0
1931	97	115	0	0	0	0	0	0	0	0	0	0	0	0
1932	69	78	0	0	0	0	0	0	0	0	0	0	0	0
1933	79	97	0	0	0	0	0	0	0	0	0	0	0	0
1934	65	73	0	0	0	0	0	0	0	0	0	0	0	0
1935	64	64	0	0	0	0	0	0	0	0	0	0	0	0
1936	86	100	0	0	0	0	0	0	0	0	0	0	0	0
1937	122	123	0	0	0	0	0	0	0	0	0	0	0	0
1938	127	143	0	0	0	0	0	0	0	0	0	0	0	0
1939	177	211	0	0	0	0	0	0	0	0	0	0	0	0
1940	104	120	0	0	0	0	0	0	0	0	0	0	0	0
1941	145	178	0	0	0	0	0	0	0	0	0	0	0	0
1942	25	26	0	0	0	0	0	0	0	0	0	0	0	0
1943	57	38	0	0	0	0	0	0	0	0	0	0	0	0
1944	139	111	0	0	0	0	0	0	0	0	0	0	0	0
1945	11	15	0	0	0	0	0	0	0	0	0	0	0	0
1946	110	154	0	0	0	0	0	0	0	0	0	0	0	0
1947	80	99	0	0	0	0	0	0	0	0	0	0	0	0
1948	111	148	0	0	0	0	0	0	0	0	0	0	0	0
1949	152	169	0	0	0	0	0	0	0	0	0	0	0	0
1950	146	175	0	0	0	0	0	0	0	0	0	0	0	0
1951	178	157	0	0	0	0	0	0	0	0	0	0	0	0
1952	341	239	0	0	0	0	0	0	0	0	0	0	0	0
1953	54	75	0	0	0	0	0	0	0	0	0	0	0	0
1954	66	91	0	0	0	0	0	0	0	0	0	0	0	0
1955	34	60	0	0	0	0	0	0	0	0	0	0	0	0
1956	12	12	0	0	0	0	0	0	0	0	0	0	0	0
1957	12	27	0	0	0	0	0	0	0	0	0	0	0	0
1958	113	141	0	0	0	0	0	0	0	0	0	0	0	0
1959	153	110	0	0	0	0	0	0	0	0	0	0	0	0
1960	188	216	0	0	0	0	0	0	0	0	0	0	0	0
1961	83	84	0	0	0	0	0	0	0	0	0	0	0	0
1962	209	295	0	0	0	0	0	0	0	0	0	0	0	0
1963	100	110	0	0	0	0	0	0	0	0	0	0	0	0
1964	25	43	0	0	0	0	0	0	0	0	0	0	0	0
1965	1	7	0	0	0	0	0	0	1	1	2	2	0	0
1966	19	36	0	0	0	0	0	0	1	2	2	3	0	0
1967	17	28	0	0	0	0	0	0	0	0	0	0	0	0
1968	70	101	0	0	0	0	0	0	1	2	4	5	0	0
1969	34	55	0	0	0	0	0	0	6	10	16	22	0	0
1970	36	37	0	0	0	0	0	0	4	7	11	15	0	0
1971	96	121	0	0	37	54	19	19	62	93	48	70	23	29
1972	38	46	0	0	2	4	0	0	20	37	4	6	0	3
1973	185	391	5	11	6	6	7	12	7	13	4	11	16	25
1974	282	418	5	4	13	9	12	30	95	147	67	84	80	76
1975	349	331	9	12	17	37	72	76	40	54	89	119	138	89
1976	379	446	11	15	106	62	183	95	81	50	14	5	11	1

Table 23. (Continued)

	1Wa	1Wa	1Wb	1Wb	1Ea	1Ea	1Eb	1Eb	1Ec	1Ec	2a	2a	2b	2b
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1977	182	192	234	179	66	49	10	14	2	9	0	3	2	4
1978	315	263	27	17	102	48	51	57	14	21	7	4	1	1
1979	619	546	85	56	23	13	0	3	0	0	0	0	0	2
1980	401	354	0	0	0	0	0	0	0	0	0	0	0	0
1981	324	298	0	0	0	0	0	0	0	0	0	0	0	0
1982	409	300	0	0	0	0	0	0	0	0	0	0	0	0
1983	462	161	0	0	0	0	0	0	0	0	0	0	0	0
1984	542	262	0	0	0	0	0	0	0	0	0	0	0	0
1985	428	178	0	0	0	0	0	0	0	0	0	0	0	0
1986	426	196	0	0	0	0	0	0	0	0	0	0	0	0
1987	444	104	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	20	23	0	0	0	0	0	0	0	0	0	0	0	0
2001	17	33	0	0	0	0	0	0	0	0	0	0	0	0
2002	25	25	0	0	0	0	0	0	0	0	0	0	0	0
2003	18	28	1	3	0	0	0	0	0	0	0	0	0	0
2004	14	23	5	2	1	6	0	0	0	0	0	0	0	0
2005	21	26	0	3	0	0	0	0	0	0	0	0	0	0
2006	12	7	6	13	3	10	0	0	0	0	0	0	0	0
2007	23	25	0	0	0	2	0	0	0	0	0	0	0	0
2008	30	20	0	0	0	0	0	0	0	0	0	0	0	0
2009	15	18	1	1	2	13	0	0	0	0	0	0	0	0
2010	3	5	17	11	5	9	0	0	0	0	0	0	0	0
2011	17	24	1	4	2	2	0	0	0	0	0	0	0	0
2012	10	17	1	3	0	3	0	0	0	0	0	0	0	0
2013	12	13	1	2	0	0	0	0	0	0	0	0	0	0
2014	6	19	0	0	0	0	0	0	0	0	0	0	0	0
2015	14	11	0	0	0	0	0	0	0	0	0	0	0	0
2016	7	14	4	1	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	82	105	0	0	0	0	0	0	0	0	0	0	0	0
2020	85	102	0	0	0	0	0	0	0	0	0	0	0	0
2021	69	118	0	0	0	0	0	0	0	0	0	0	0	0
2022	80	107	0	0	0	0	0	0	0	0	0	0	0	0
2023	74	113	0	0	0	0	0	0	0	0	0	0	0	0

4.6.2 Trials

In the *ISTs,* uncertainty is considered through different trial scenarios with their corresponding operating models. The same trial structure used in 2019 is used this time.

Trial scenarios

Table 24 lists the factors considered in the trials while Table 25 shows the list of trials in the *ISTs* considered for the North Pacific Bryde's whales. High plausibility was allocated for the BR01-1, BR01-4, BR02-1 and BR02-4 trials in Table 25 because only best values/series were input for all the factors (see Table 24). These four trials are referred to as "base case trials" hereafter.

Table 24. Factors considered in the *ISTs* for western North Pacific Bryde's whale. The values in bold are baseline values, which were same as adopted in IWC SC *Implementation Review* for this species (Allison and de Moor, 2020).

Factors	Values considered
Stock structure hypotheses	**2, 5**
MSYR	**1%(1+), 4%(mature)**
Catch series	Low, **Best**, High
Additional CV	**Baseline=0.335**, Upper 5%ile=0.737
Western boundary of stock 2 under hypothesis 5	160˚E, **165˚E**, 170˚E
Western boundary of stock 2 under hypothesis 2	175˚E, **180˚**
Eastern boundary of stock 1	175˚E, **180˚**, 175˚W

Table 25. List of candidate *ISTs* considered for domestic *ISTs* for the western North Pacific Bryde's whale, selected from the list of trials in the associated IWC SC *Implementation Review* (Allison and de Moor, 2020).

Trial numbers	Stock hypothesis	*MSYR*[*1]	Additional Variance	Catch Series	Western Boundary of stock 2	Eastern Boundary of stock 1	Trial weight
BR01-1	2	1	Baseline	Baseline	180°	180°	H
BR01-4	2	4	Baseline	Baseline	180°	180°	H
BR02-1	5	1	Baseline	Baseline	165° E	180°	H
BR02-4	5	4	Baseline	Baseline	165° E	180°	H
BR03-1	5	1	Baseline	High	165° E	180°	M
BR03-4	5	4	Baseline	High	165° E	180°	M
BR04-1	5	1	Upper CI	Baseline	165° E	180°	M
BR04-4	5	4	Upper CI	Baseline	165° E	180°	M
BR05-1	2	1	Baseline	Baseline	175° E	175° E	M
BR05-4	2	4	Baseline	Baseline	175° E	175° E	M
BR06-1	5	1	Baseline	Baseline	160° E	175° E	M
BR06-4	5	4	Baseline	Baseline	160° E	175° E	M
BR07-1	5	1	Baseline	Baseline	170° E	175° W	M
BR07-4	5	4	Baseline	Baseline	170° E	175° W	M

*1: *MSYR* 1% is related to 1+ component and 4% is related to mature component.

4.6.3 Management variants

Whaling is to be conducted in Japan's territorial sea and EEZ within sub-area 1W during all months of the year. There are two management variants, V1 and V2, which correspond to Options i) and ii) of the CLA implementations considered, respectively (section 4.5).

V1: Sub-area 1 is a *Small Area*. Catches are taken from sub-area 1W.
V2: Sub-area 1 is a *Combination Area*. Sub-areas 1W and 1E are *Small Areas* with Catch Cascading applying. Catches are not taken from sub-area 1E.

The management variant of no commercial catches (V0) is also considered for comparison purposes. Conservation performances among the management variants were compared.

4.6.4 Future survey plans

Future surveys will be conducted in the western and eastern North Pacific. Sub-areas 1W and 1E are divided into four and three blocks, respectively because whole sub-area cannot be surveyed in a year. Sub-areas will be surveyed once every six years. Within the sub-area 1W, there are EEZs of other coastal states, and the conduct of surveys in these EEZs will be subject to permission being granted by these coastal states. Table 26 shows the tentative future survey plan for 2023-2028. In the trials, this pattern will be repeated every six years. Blank cells in Table 26 indicate that no survey is planned, at least for the Bryde's whales. Double platform surveys (i.e., using an IO platform) are planned for all the sighting surveys listed in Table 26.

Future abundance estimates in sub-areas are generated in terms of the assumptions mentioned below for use in the CLA. It is assumed that one abundance estimate is obtained with time stamp of the third year during every six years in the sub-area 1W. Similarly, it is assumed that one abundance estimate in sub-area is obtained with time stamp of the fourth year and of the third year during every six years in the sub-areas 1E and 1, respectively.

Table 26. Tentative future survey plan for North Pacific Bryde's whales assumed for the *ISTs*. It is assumed that the same pattern will be repeated every six years.

Year	Sub-area 1W	Sub-area 1E	Sub-area 2
	West of 165° E	165° E-180°	East of 180°
2023	Yes*1		Yes
2024	Yes	Yes	
2025	Yes	Yes	
2026			
2027	Yes		
2028		Yes	

*1: The survey in a western part of sub-area 1W was planned to be conducted in 2023 but it was actually conducted in 2022.

NOTE: Future surveys are subject to budget availability and permissions being granted by coastal states.

4.6.5 Result of conditioning

The following results are plotted for the base case trials of the stock hypotheses BR01-1, BR01-4, BR02-1 and BR02-4 because the plots are not substantially different amongst the trials (Figures 17 and 18).

(1) Plot of the 1+population by sub-area

Deterministic (red line), median and 90% confidence intervals for the 1+ population. The abundance estimates are shown (x) together with 90% confidence intervals by sub-area. The extended blue dashed line indicates the additional variance about the abundance estimates; these are not used during conditioning but are taken into account when generating future abundance estimates for each sub-area.

(2) Plot of the mixing proportion of the stock 1 in sub-area 1E (this plot is produced for the trials assuming stock structure hypothesis 5)

Deterministic (red line), median and 90% confidence intervals for the proportion of stock 1 in the sub-area. The proportions estimated from commercial and survey samples are shown (x) together with 90% confidence intervals based on the sampling standard error.

(3) Plot of the mature female component of the populations by stock

Deterministic (red line), median and 90% confidence intervals for the mature female abundance by stock.

(4) Plot of the 1+ population by sub-area with the first 10 individual population trajectories

As per (1), but with the first 10 individual trajectories rather than the median and 90% confidence intervals.

Plots of the population trajectories and the proportion of the stock 1 in sub-area 1E indicate that model estimates are quite compatible with the historical abundance and the proportion data.

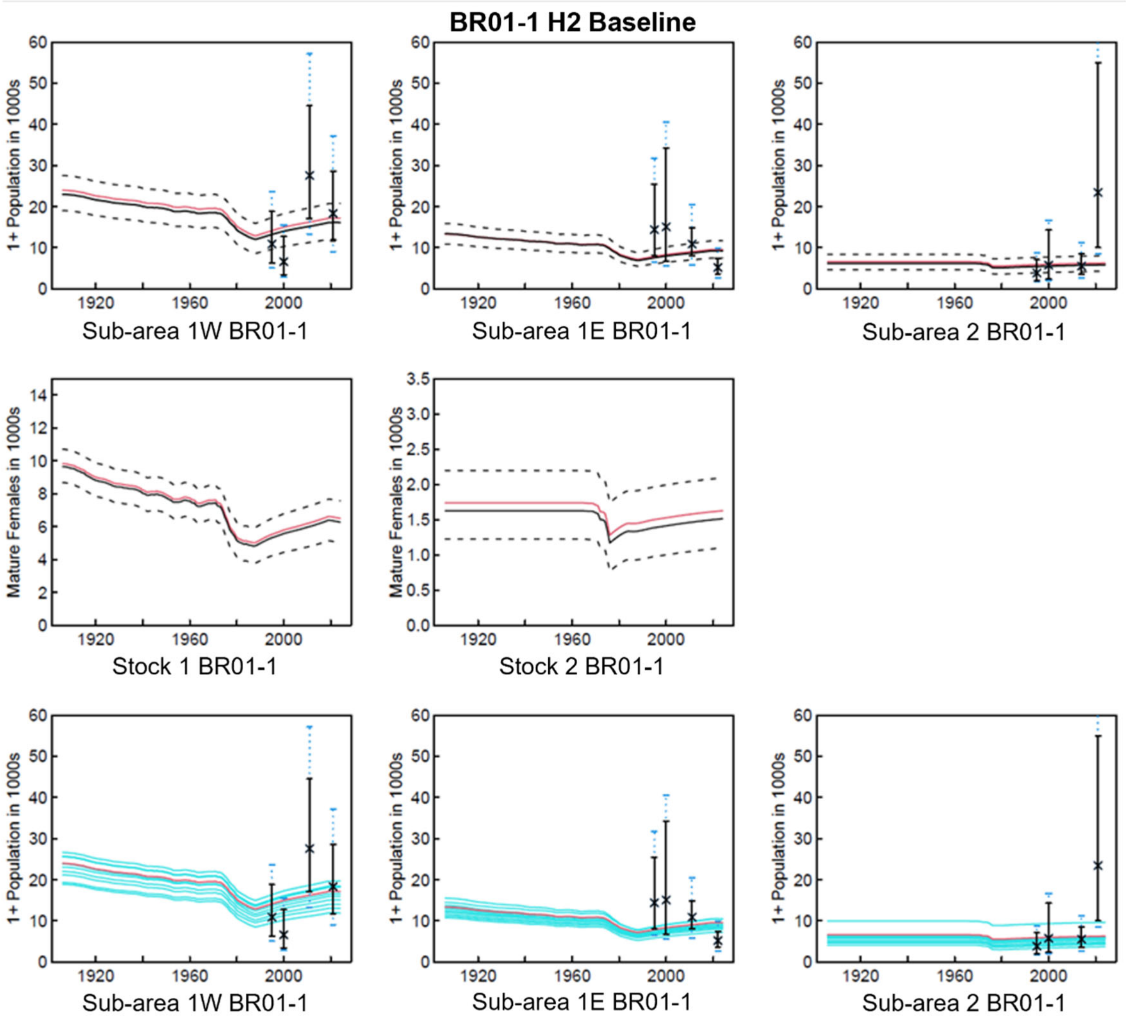

Figure 17. Plots showing results of the conditioning. (1) Plots for the 1+ population by sub-area, (2) Plots of mature female population by stock (Only trials assuming stock structure hypothesis 5) and (3) Plot of the 1+ population by sub-area with the first 10 trajectories for trials BR01-1 and BR01-4.

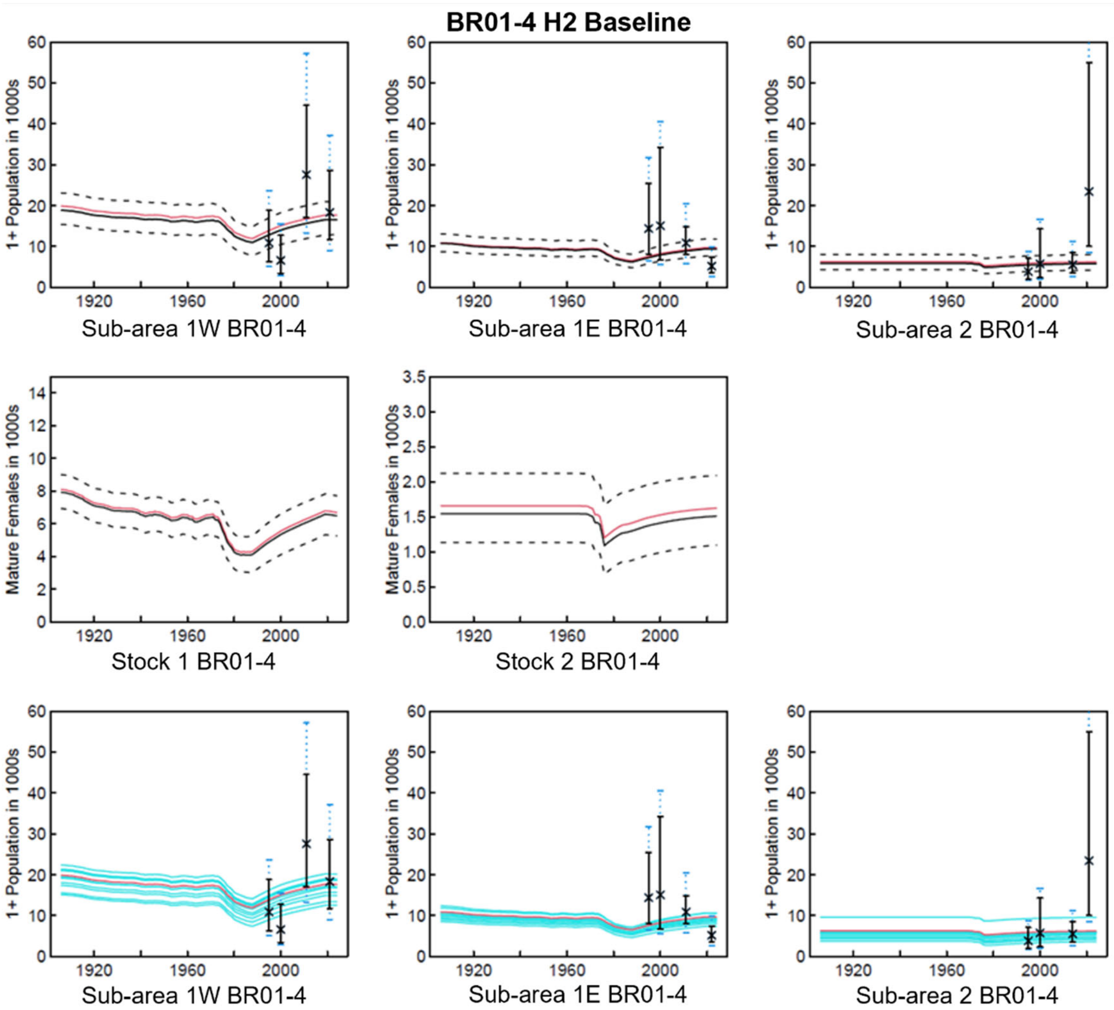

Figure 17. (Continued).

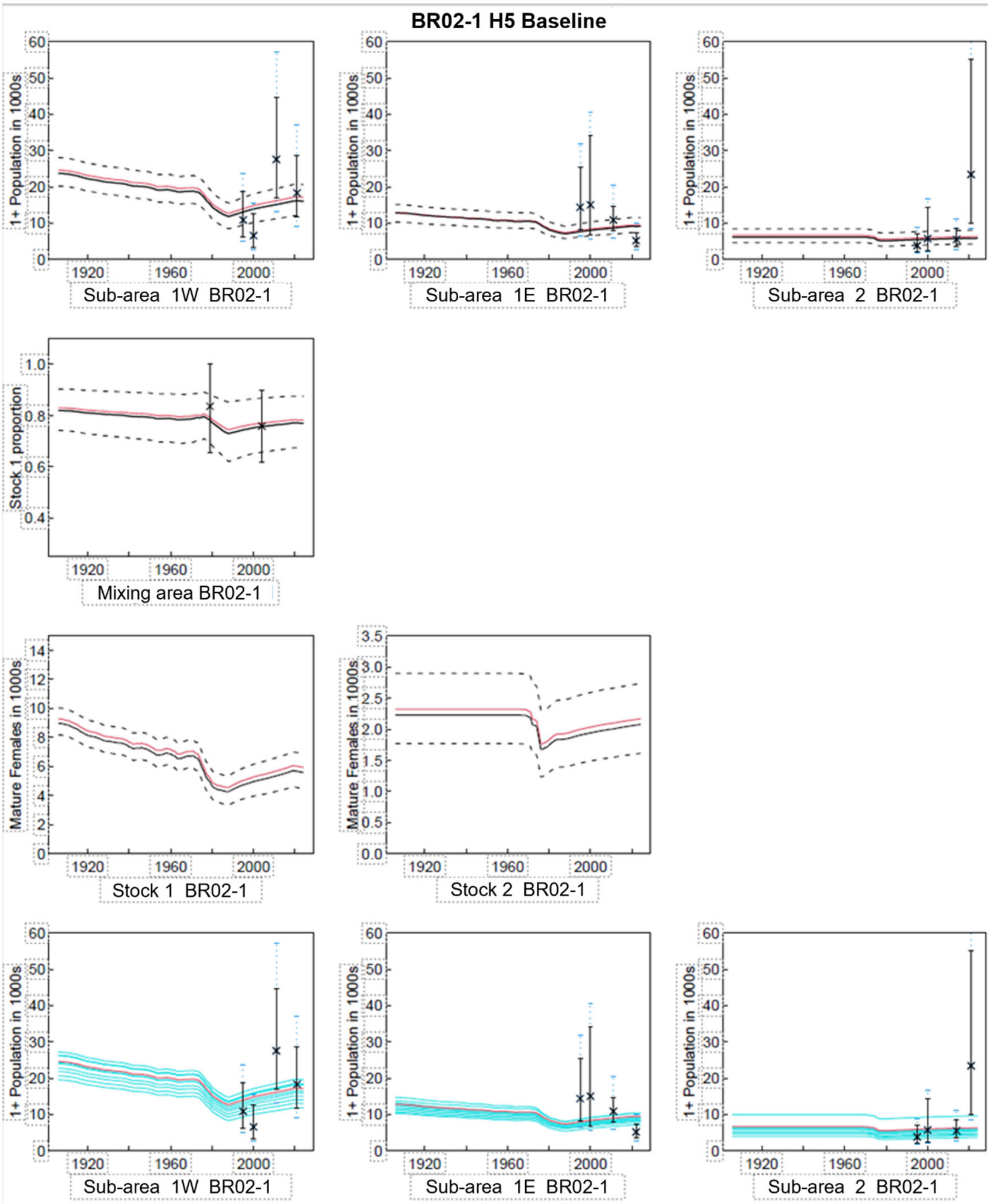

Figure 18. Same as Figure 17 for trials BR02-1 and BR02-4.

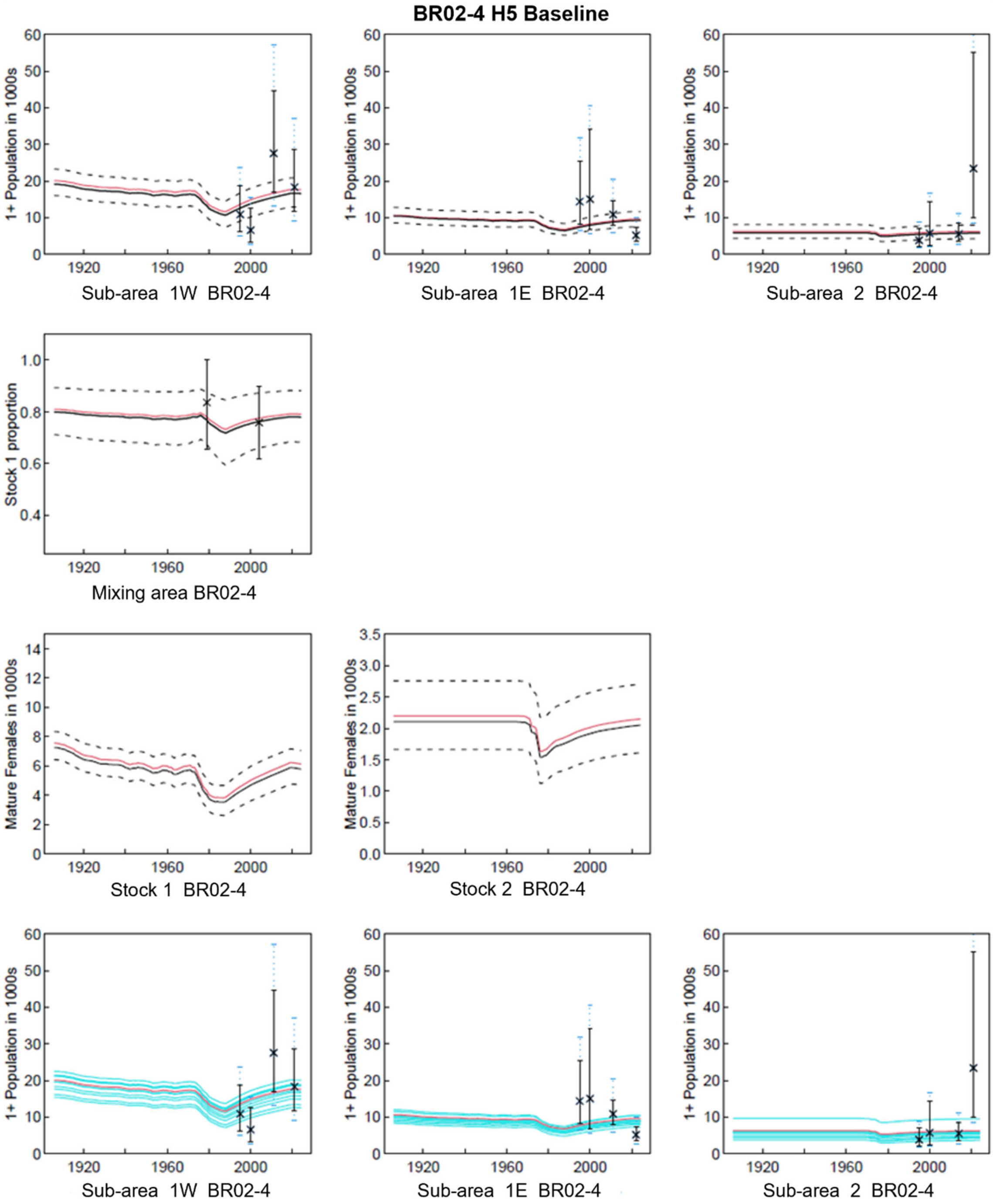

Figure 18. (Continued)

4.6.6 Results of trials

There are two performance measures which pertain to acceptable performance in terms of this IWC RMP-like approach: the final depletion at the end of the 100-year projection period under the MP (P-fin), and the minimum depletion ratio (P-min, which is defined as the minimum over each of these 100-year projections in a trial of the ratio of the population size to that when there are only incidental catches – though such catches are very small in this case). Attainment of 'acceptable performance' is required for the more difficult *MSYR*=1% trials only, as if attained for those, these requirements will also be met for trials with higher

MSYR values. The lower 5%-ile of P-fin and P-min were calculated for the two stocks in all the combinations of the trials with *MSYR*=1% and three management variants (Figure 19).

IWC (2012c) formally defines "acceptability" of a management variant as follows. The lower 5%-ile of P-fin or P-min must be above the upper dashed lines shown in the Figure 19, where these dashed lines reflect the corresponding results for an "equivalent" single stock trial for an MP with a tuning level of 0.60 (as applies to this MP).

As shown in Figure 19, both of the two performance measures are above the dashed lines for stocks S1 (stock 1) and S2 (stock 2) for all the trials with *MSYR*(1+)=1%. Therefore, both management variants examined (V1 and V2) are acceptable.

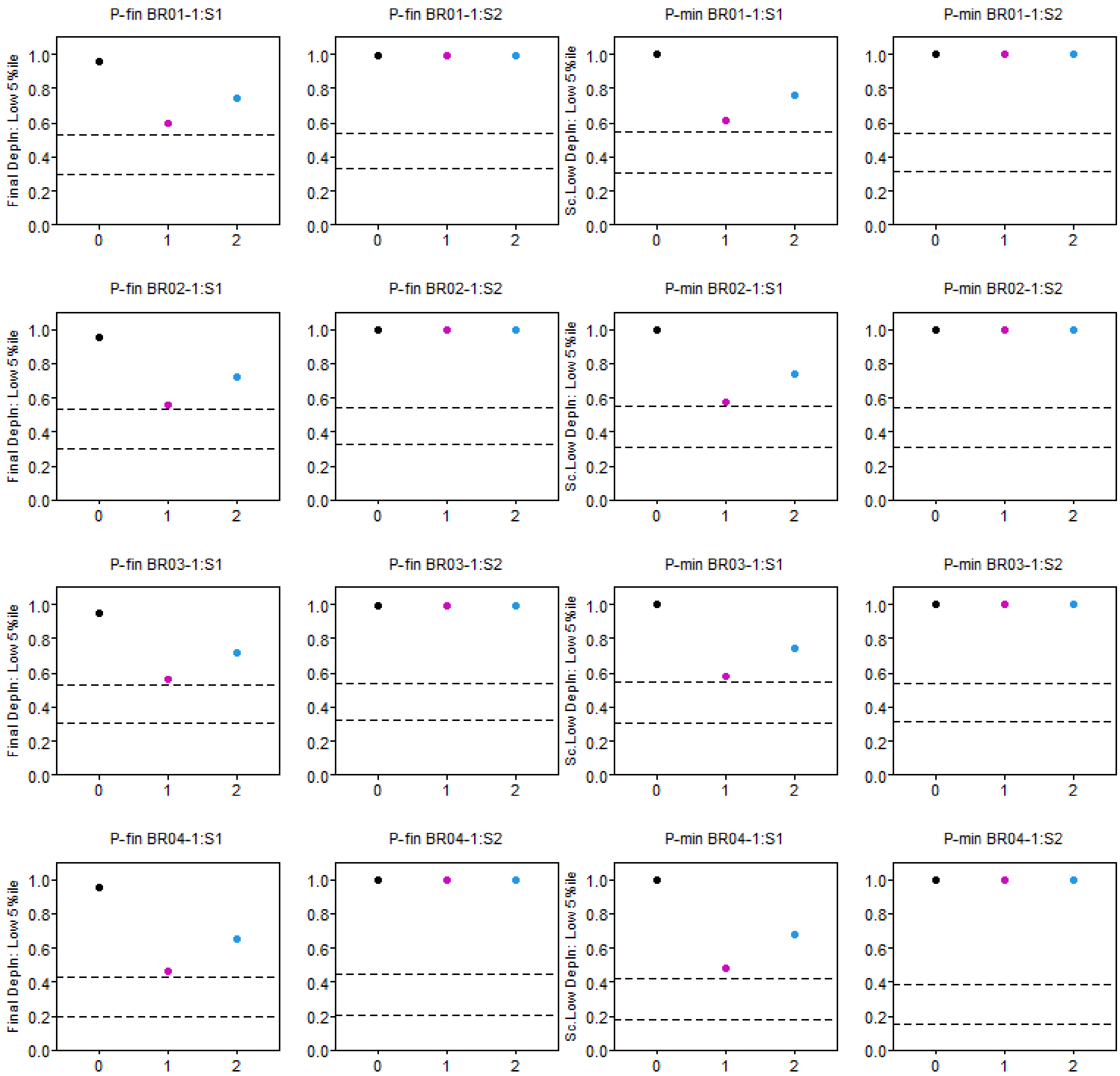

Figure 19. Summary plot of the performance of the three RMP variants, V0, V1 and V2 for *MSYR*(1+)=1%. Variants V0, V1 and V2 are denoted 0, 1, and 2 on the horizontal-axis, respectively, with results shown by black, pink and blue dots in the plots. 'Acceptable' performance is indicated by a point above the dashed lines. S1 for the stock 1, and S2 for the stock 2. P-fin and P-min are the two performance measures (See main text for more details).

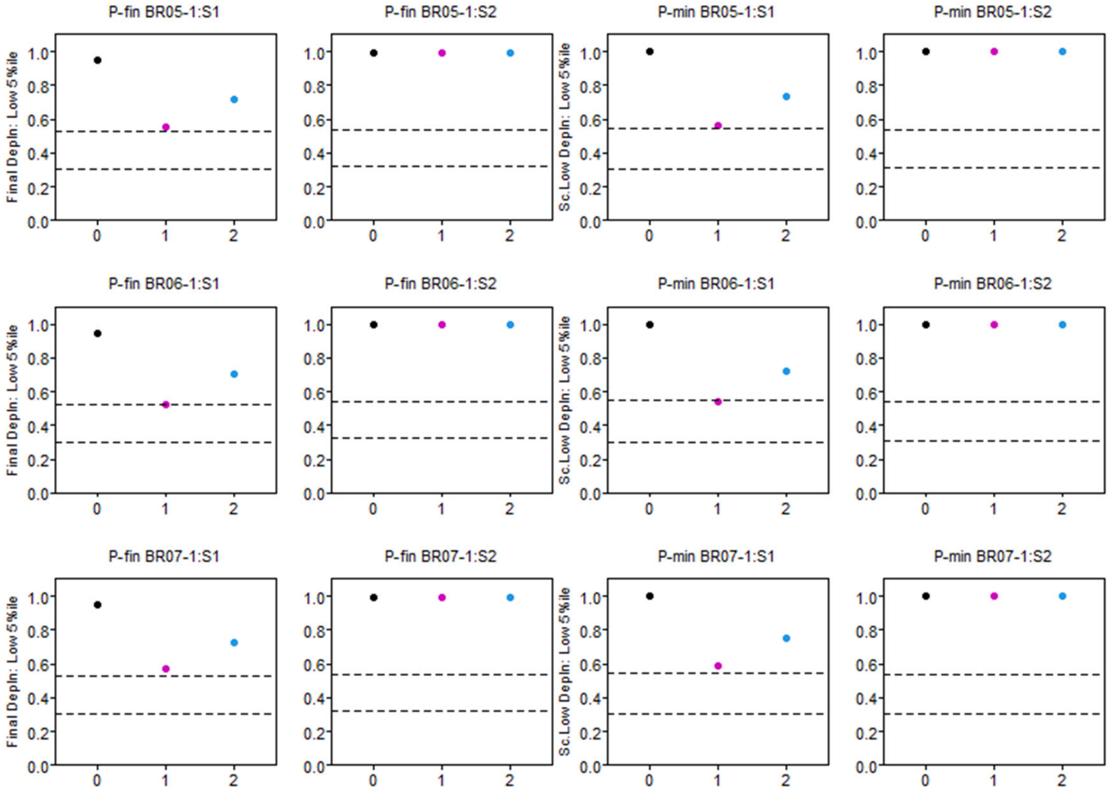

Figure 19 (Continued).

4.7 Whaling operations and future biological surveys

As mentioned in section 4.6.6, both management variants are acceptable. Management variant V1 is recommended because of the better catch performance of this variant.

Future sighting surveys for providing further abundance estimates for use in the CLA will be conducted in line with the options shown in section 4.6.4. A collection of biological data and samples from harvested whales will be conducted for monitoring the exploited stock and improving specification of the scenarios to be considered in future trials.

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