Final Report of the First Intersessional Workshop on the *Implementation Review* for Western North Pacific Minke Whales

Report of the First Intersessional Workshop on the *Implementation Review* for Western North Pacific minke whales[1]

1. INTRODUCTORY ITEMS

The Workshop was held In Tokyo, Japan from 25 February-1 March 2019. The list of participants is given as Annex A.

1.1 Opening remarks

Pastene welcomed the participants on behalf of the Japanese delegation to the Workshop. He looked forward to good scientific discussions and a successful workshop.

Donovan (Convenor) welcomed the participants to the 'First' Intersessional Workshop on the *Implementation Review* for common minke whales in the North Pacific and thanked Japan for providing the excellent facilities. The Workshop had been recommended at the last Scientific Committee meeting (IWC, 2019a) and subsequently endorsed by the Commission at its 2018 biennial meeting in Brazil (IWC/67).

The Committee has now started the official *Implementation Review* process in accordance with its Requirements and Guidelines (IWC, 2012b). According to these guidelines, the primary objectives of the 'First Intersessional Workshop' are:

(1) review plausible hypotheses and eliminate any hypotheses that are inconsistent with the data – this will take into account the probable management implications of such hypotheses to try to avoid unnecessary work in the precise specifications of hypotheses for which these are very similar;
(2) examine more detailed information on expected operations, including whether coastal, pelagic, on migration, on feeding, on breeding or combinations of these - when providing such information, users and scientists may provide options or suggest modifications to the pattern of operations;
(3) review the small geographical areas ('sub-areas') that will be used in specifying the stock structure hypotheses and operational pattern; and
(4) specify the data and methods for conditioning the trials that will be carried out before the next Annual Meeting.

Donovan noted that discussions of how to take the work on western North Pacific common minke whales forward after the departure of Japan from the IWC after 30 June 2019 would occur at the Annual Meeting of the Scientific Committee in May 2019 and that that topic was beyond the scope of the present Workshop.

1.2 Election of Chair and appointment of rapporteurs

Donovan was elected Chair. Allison, Butterworth, Hoelzel, Punt and Tiedemann acted as rapporteurs.

1.3 Adoption of Agenda

The adopted agenda is given as Annex B.

1.4 Data available

Data had been made available to the Workshop under Procedure A. Of particular importance were the genetic data held by the ICR (Institute of Cetacean Research).

1.5 Available documents

The list of documents is given as Annex C.

2. SHORT SUMMARY OF THE 2013 *IMPLEMENTATION REVIEW*

2.1 Hypotheses/scenarios considered

The 2013 *Implementation Review* was based on an operating model with 22 sub-areas (Fig. 1) and trials based on stock structure scenarios involving three fundamental stock structure hypotheses (the hypotheses are summarised in Annex D).

(a) Hypothesis A: a single J-stock distributed in the Yellow Sea, Sea of Japan, and Pacific coast of Japan, and a single O-stock in sub-areas 7, 8 and 9. The O-stock migrates in summer mainly to the Okhotsk Sea (sub-areas 12SW and 12NE). Both J- and O-stocks overlap temporally along the Pacific coast (sub-areas 7CS and 7CN) and the southern part of the Okhotsk Sea (sub-areas 11 and 12SW).
(b) Hypothesis B: as for hypothesis A, but a different stock (Y stock) resides in the Yellow Sea and overlaps with J-stock in the southern part of sub-area 6; and
(c) Hypothesis C: five stocks, referred to as Y, JW, JE, OW, and OE, two of which (Y and JW) occur in the Sea of Japan and three of which (JE, OW and OE) are found to the east of Japan.

There was no agreement within the Committee at the time regarding the plausibility category for these hypotheses; in accordance with the RMP guidelines, all were therefore treated as 'medium' plausibility for the purposes of the *Implementation Review*.

The trials also considered various other factors including alternative values for MSYR (1% and 4% on the mature component of the population), and the structure of the mixing matrices.

2.2 Results and conclusions

Application of the results of the Committee's Requirements and Guidelines for *Implementation* under the Revised Management Procedure (IWC, 2012b) led to the following conclusions on the management variants (the management variants are summarised in Annex D):

(1) variants 1, 2, 3, 4, 6 and 8 were 'acceptable without research';
(2) variants 5, 7, 9 and 11 were candidates for 'acceptable with research'; and
(3) variant 10 was 'unacceptable'.

Some members had stated that in reviewing the trials it was apparent that, with only two exceptions, all of the 'unacceptable' trials were under stock structure hypothesis C.

2.3 Recommendations/suggestions made for future work

The Committee had noted the inherent complexity of the western North Pacific common minke whale *Implementation Review* and the lack of data for certain temporal and geographical cells. It had agreed that it was important to

---

[1] Presented to the meeting as SC/68A/Rep04.

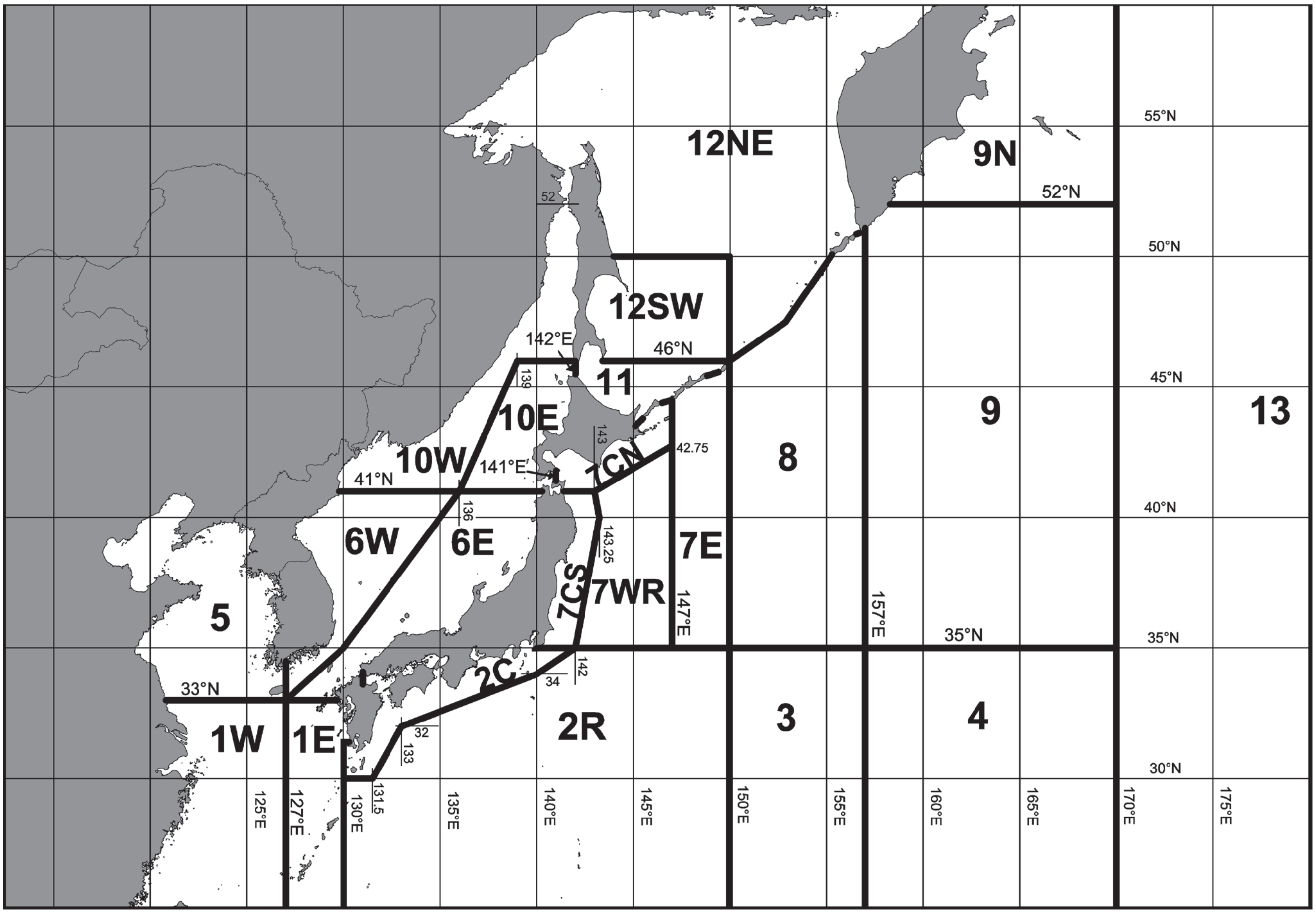


Fig. 1. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales.

begin considering ways to try to improve this data-deficient situation prior to the next *Implementation Review* as early as possible. Stock structure and abundance were identified as of highest priority. A number of suggestions were made for future work including the use of telemetry and the surveying of southern areas to identify breeding grounds to facilitate identification of 'pure' stocks and thus assignment of individuals to putative stocks. It was also noted that in many sub-areas, even the few abundance estimates that are available have large CVs and improved surveys are needed - in coastal areas, aerial surveys should be considered.

3. STOCK STRUCTURE

It has long been recognised that one of the most complex components of implementing the RMP for common minke whales in the western North Pacific has been the question of the stock structure (IWC, 2012a; 2013). As a result, in order to expedite the present *Implementation Review*, a workshop dedicated to consideration of this issue was held in February 2018 with a particular aim of identifying new analyses and techniques that might assist discussions during the review itself (IWC, 2019b). Based upon this work, the Scientific Committee agreed that the following analyses should be performed prior to and reported at the present Workshop (notwithstanding that further analyses would be welcome where feasible and appropriate):

(1) F_{ST}, F_{IS}, heterozygosities, haplotype diversity, and related measures;
(2) PCA (or FCA) analyses (including partitioning based on multiple components) and DAPC;
(3) spatially explicit analyses (BAPS, TESS, GENELAND, spatial pattern of diversity measures);
(4) updated kinship analyses including most recent samples; and
(5) if possible, updated Wahlund analyses similar to those undertaken by Waples (2011).

3.1 Genetic analyses

3.1.1 Introduction to some of the analytical methods

STRUCTURE

Until recently, STRUCTURE[2] was the only hypothesis-free assignment method based on genetics that had been applied to the western North Pacific common minke whales. The program STRUCTURE groups individuals such that departure from Hardy-Weinberg-Expectations (HWE) within groups is minimised. Simulation studies have shown that STRUCTURE has relatively low power (typically finding structure only when F_{ST} is greater than approximately 0.02). While the number of genetic clusters present in the data (k) is an input parameter (as a range of possible values), STRUCTURE provides a likelihood for each given value of k. Applied to the western North Pacific common minke whale microsatellite dataset, STRUCTURE has consistently identified two genetic groups with different spatio-temporal occurrence, the J- and O-stocks. While there is general agreement about that distinction, the debate at the previous *Implementation Review* had focused on whether these stocks should be further subdivided (JW, JE, OW, OE) and whether individuals not assigned with high probability to either J- or O comprise a genetically distinct group (i.e. an additional stock or stocks). Genetic heterogeneity beyond the J/O

---

[2] *https://web.stanford.edu/group/pritchardlab/structure.html.*

classification had been proposed for the east coast of Japan (sub-areas 7CS, 7CN) by some, based on tests performed among spatial strata of pooled individuals. Under scenarios of spatial overlap in the distribution of stocks, these methods have detected heterogeneity, but have not allowed for the identification of individual specimens belonging to putative additional stocks.

GENELAND, TESS, BAPS, SPCA

GENELAND[3] is a landscape genetics program run in R that groups samples into homogeneous putative populations by assuming approximate Hardy Weinberg and linkage equilibrium, and by incorporating individual-specific spatial data. Although similar in approach to STRUCTURE, the spatially-explicit component generally provides greater power (as long as stocks are not randomly mixed).

TESS[4] incorporates spatial information and conducts Bayesian clustering using tessellations (division of samples into best-fit polygons), and thereby provides a landscape genetics method with a distinct methodology from GENELAND or STRUCTURE. The use of fractals in TESS means that some fine-grained elements of structure might be missed or identified out of place.

BAPS[5] uses Bayesian methods to capture genetic population structure by describing the molecular variation in each subpopulation using a separate joint probability distribution over the observed loci. This method is based on allele frequency distributions rather than equilibrium expectations, and so may not have the power to detect very recently diverged populations.

The sPCA (spatial Principal Component Analysis) approach is based around two key elements – a spatial autocorrelation, implemented using Morin's I, and an assessment of allele frequency variance on global and local scales. Although informed by spatial data (which is incorporated into a network structure), it does not use spatial coordinates directly. The presence of multiple populations sampled in the same designated area could exaggerate local variance, potentially obscuring structure at the global scale. For this reason, spatially-explicit models using equilibrium tests (as implemented in GENELAND) may be better at extracting structure on a local scale from a mixed assemblage of populations.

3.1.2 New analyses conducted for this Workshop

CONVENTIONAL HYPOTHESIS TESTING

SC/F19/WNPM/01 presented a study based on the ICR database of 16 microsatellite DNA loci and mtDNA, including comparisons among individuals from different management sub-areas, and included a distinct subgroup comprised of only bycatch animals from sub-area 7C (designated '7bc'). The authors had found what they believed to be an unusually large number of 'singletons' (animals in which a haplotype was recorded in only one individual) that might be a result of a minor sequencing error and had excluded those from the analyses. Conventional analyses of differentiation (F_{ST}) and modified exact tests showed significant differences between most strata for both microsatellite allele frequencies and mtDNA haplotypes frequencies. In general, the authors considered the results of these initial analyses to be consistent with the predictions of stock structure hypothesis C from the 2013 *Implementation* (see Annex D), providing evidence for JE and JW stocks based on significant differences between sub-areas 6E and 2C, and evidence for OW and OE stocks based on significant differences between sub-area 7bc and other sub-area 7 strata. SC/F19/WNPM/01 focused especially on comparisons with stratum 7bc, on the assumption that this may represent the best proxy (least mixed) representation of a putative OW stock.

SC/F19/WNPM/05 provided a response to this analysis. The authors clarified that the checking and resequencing approach used to produce the mtDNA data set make it unlikely that the singletons in the data set represent sequencing errors. They noted the similarity in the analyses of SC/F19/WNPM/01 to those conducted during the previous *Implementation Review* and that they had not referred to recent discussions and recommendations from the Scientific Committee. The authors commented on the difficulty of interpreting stock structure analyses conducted on strata containing O and J-stock samples in different proportions. They also considered that the analyses and discussion had not taken recent clustering analyses and parent-offspring analyses into account.

The Workshop thanked the authors for their analysis, drawing attention to the fact that unfortunately unforeseen circumstances had meant that none of the authors of SC/F19/WNPM/01 were able to attend[6] - that should be recognised in considering the discussion below. The Workshop noted that the paper was conceptually based on the 2013 Hypothesis C in its original form (Annex D), i.e. with clearly defined stock boundaries and without spatial mixing among some stocks. The Committee had agreed last year that a non-spatial overlap scenario for putative stocks occurring east of Japan (*cf* Hypothesis C) had been invalidated by analysis of close kin data (IWC, 2019a). Consequently, there may be an unknown degree of mixing of J-stock and O-stock in the area-specific sample sets compared in SC/F19/WNPM/01, such that pairwise significant divergence among sub-areas could not discriminate between scenarios of different J/O mixing proportions and of presence of (an) additional stock(s). The limitations of hypothesis testing among strata of pooled individuals to resolve stock structure under scenarios where extensive mixing of stocks may occur was noted.

The Workshop welcomed the definition of bycaught individuals as a separate stratum ('7bc') as a valuable approach to investigate underlying causes of the repeatedly observed genetic heterogeneity in sub-areas 7CS and 7CN. During the Workshop, an evaluation was conducted as to whether consideration of 7bc as a separate stratum had any relation to the genetically inferred Parent Offspring (PO) pairs (SC/F19/WNPM/03; Tiedemann *et al.*, 2017). The observed number of PO pairs among 7bc and any other stratum did not diverge from random expectations (Annex G).

NEW 'SPATIAL' METHODS

SC/F19/WNPM/02 presented analyses in GENELAND using the ICR database and excluding the offspring of inferred parent/offspring pairs. This method assigned individuals with high confidence alternatively to regions understood to be occupied by J- or O-stock (based on earlier analyses using the same microsatellite DNA markers). A subset of individuals from coastal sub-areas 2C, 7C and 11 was also identified by GENELAND using an 'uncorrelated' allele frequency model (and with a correlated model when k was fixed to 4). The group identified within this geographic region overlapped with the distributions of putative J- and

---

[3] *https://i-pri.org/special/Biostatistics/Software/Geneland/.*

[4] *http://membres-timc.imag.fr/Olivier.Francois/tess.html.*

[5] *http://www.helsinki.fi/bsg/software/BAPS/.*

[6] However, the Workshop was grateful to Wade for providing some initial thoughts on stock structure (Annex E) that assisted the overall discussions.

O-stock whales within these areas. Using the correlated allele frequency model, and allowing GENELAND to choose *k*, the distinct cluster identified in sub-areas 2C, 7C and 11 was further divided into two putative populations. These were designated as 'red' and 'blue' (fig. 5 of SC/F19/WNPM/02) and were robust to multiple replicated runs, with assignments being highly similar but not identical among runs. GENELAND uses an assessment of match-to-equilibrium expectations to assign individuals to putative populations, in the context of geographic coordinates. These assignments, if successful, should therefore reflect groups under HWE. Using consensus assignment from three GENELAND runs, all four putative populations met this expectation, while trial mixtures between J- and O-stock whales showed single-locus Wahlund effects not seen in the putative single population sample sets (SC/F19/WNPM/08). Further *post hoc* analyses were undertaken considering the four putative populations, and since essentially the same individuals were represented, this could also be expected to provide inference about the outcome when dividing into three putative populations. A separate analysis employing a distinct approach to assign populations, tessellations (implemented in TESS) found some of the same individuals assigned to the same areas (with *k*=3). This provided a measure of independent confirmation. BAPS did not identify more than *k*=2 clusters. However, this method may have limited power to distinguish multiple, weakly differentiated populations in the same geographic area.

An ordination method (FCA) distinguished J- and O-stock clusters with some overlap, but the two putative coastal populations (designated 'red' and 'blue') overlapped extensively with both J- and O-stock whales (SC/F19/WNPM/02). Neither was strongly assigned more to J- or O-stock clusters, and each showed some independent clustering in the reduced dataset analysis (based on 100 samples from each putative population). Assessments of genetic distance and contemporary gene flow (Wilson and Rannala, 2003) confirmed differentiation between the four putative populations, but also indicated reduced genetic distance between 'red' and J-stock and between 'blue' and O-stock. This was also evident in the mtDNA network analysis presented in SC/F19/WNPM/09. The model showing this relationship was best supported in the ABC analysis (SC/F19/WNPM/02), and the distribution of values within 95% confidence estimates for division times were in each case greater than zero. Taken together, the analyses suggest that there could be up to two additional populations beyond the J- and O-stocks in the coastal waters of sub-areas 2C, 7C and 11. Each could be distinguished from J- and O-stocks by various metrics.

The Workshop thanked the authors of these papers for their extensive work in response to Committee recommendations. In discussion, questions were raised about the MCMC trace plots in SC/F19/WNPM/02 which suggested a possible trend. The author responded that there was no consistent trend, and that multiple chain and burn-in lengths had been trialled, including one 10 times longer than those shown (10 million instead of 1 million iterations). Furthermore, replicate runs always reached essentially the same outcome.

In presenting SC/F19/WNPM/02, Hoelzel commented that illustration of individuals colour-coded to their GENELAND assignments shown on a map and considered by month had suggested possible patterns of movement over time for the 'blue' group. However, the Workshop noted that this was likely explained by seasonal sampling effort and a detailed representation of the catch and effort was provided (Annex F), with catching effort from the coastal components of the special permit programme in sub-area 7CS occurring in April-June, and in sub-area 7CN in September and October, as well as from the offshore component in sub-area 11 in July and August. At the same time, 'blue' group animals were seen in both sub-areas 7CS and 7CN in May and June, and mostly in sub-area 11 in July and August (see Fig.7 in SC/F19/WNPM/02), and it was noted that further analysis may clarify the possibility of migration for this group.

The note provided by Wade (Annex E) proposed consideration of a 'resident' coastal stock in sub-areas 7CS and 7CN, a migratory population that passes the east coast of Japan and Hokkaido on their way to the Sea of Okhotsk, and a population in the Sea of Japan (JW), noting that the GENELAND results in SC/F19/WNPM/02 seemed to agree in part with this hypothesis. In discussion, the Workshop noted that the GENELAND manual stated that 'it is also important to check *post hoc* that the inferred groups are significantly differentiated and at HWLE [Hardy-Weinberg and Linkage Equilibrium].' This was the reason for testing the significance among GENELAND groups using F_{ST} (which would otherwise constitute circular inference for significant division, since the same data already identified these groups). Hoelzel clarified that the FCA analyses were based on the first 100 samples from each list (to allow patterns to be visualised), but that further random selection of individuals in groups of 100 had not yet been tested.

During the presentation of data from SC/F19/WNPM/08, the potential influence of an outlier point on the regression plots was queried. Hoelzel clarified that this data-point had been removed as a test, and two of the mixing trials continued to show a significant regression (equal mixing of 125 O-stock and 125 J-stock – R^2=0.275, *p*=0.045; and 70% J-stock, 30% O-stock, R^2=0.357; *p*=0.0186). The Wahlund analyses were based on consensus 100% assigned individuals from three GENELAND runs, and the author pointed out during the presentation that there was one locus out of HWE (after Bonferoni correction) for the 'red' population, two for the 'blue' population, and none for the 'orange' and 'green' (O-stock and J-stock, respectively), although one in each of orange and green was nearly significant.

SC/F19/WNPM/04 presented the results of Discriminant Analysis of Principal Component (DAPC) and sPCA conducted using microsatellite data (16 loci) to assess the plausibility of the stocks proposed under the 2013 Hypothesis C (see Annex D). The DAPC was performed forcing *k* to different numbers of clusters that simulated putative stocks under Hypothesis C (OW, OE, JW and JE). The spatial distribution of clusters was compared with the geographical distribution of the putative stocks as specified in the Hypothesis C mixing matrices. Consistent with this rationale, the DAPC analyses were performed forcing *k*=2: assuming only O and J-stocks, *k*=3: assuming OW, OE and J-stocks or O, JW and JE stocks, and *k*=4: assuming OW, OE, JW and JE stocks. The DAPC analyses at *k*=2 clearly showed two clusters with distribution corresponding to the known distribution of J- and O-stocks. The analysis at *k*=3 subdivided the O-stock cluster into two sub-clusters, and the analyses at *k*=4 subdivided the O and J-stock clusters into two sub-clusters each. The spatial distribution patterns for clusters under *k*=3 and *k*=4 were not consistent with the hypothesised distribution pattern of the putative stocks under old Hypothesis C. Furthermore, the mtDNA conventional F_{ST} analysis showed no significant differences among the O-stock sub-clusters or among the J-stock sub-clusters, suggesting that the additional clusters were an artefact. In addition, the authors examined the temporal distribution of each sub-cluster based on the idea that different stocks could show seasonally differing proportional occurrence, reflecting independent population dynamics. This analysis suggested temporal differences that were only associated with the known pattern of distribution of the J- and O-stocks. Taking all of the DAPC results into account, the authors concluded that it is unlikely not only that the OW or JE stocks exist, but also that multiple stocks exist with overlapping geographic ranges. The results of the sPCA analyses were consistent with those of the DAPC analyses. In conclusion, the authors summarised that the DAPC and sPCA analyses provided no evidence of the existence of additional stocks other than O and J-stocks, and therefore no evidence for the old Hypothesis C.

In discussion, questions were raised about the unexpected parallel, linear structures generated by DAPC for this dataset, when *k* was set equal to 3 or 4. The clusters only partially reflect the distinction between J- and O and their orientation was diagonal to the first two PCs. While this pattern has been observed repeatedly, the authors noted that no obvious explanation for it was apparent. It also remained unclear how this pattern may have impacted assignment of individuals to clusters. GENELAND and sPCA exhibited some congruent pattern with regard to the affinity of the new groups inferred by GENELAND to the O and J-stocks. The Workshop noted that such a pattern was to be expected, as both methods take individual location information into account in a similar manner. The Workshop recognised that there could be issues with the application of the sPCA method when there are spatially mixed stocks within a local area (since inference in sPCA is based only on spatial autocorrelation and allele frequency variance, rather than equilibrium expectations for an inferred population as is the case for STRUCTURE and GENELAND).

SC/F19/WNPM/09 presented additional analyses of the genetic data to assist the interpretation of the results of the spatially explicit clustering tools used to explore microsatellite data in SC/F19/WNPM/02. The main analyses conducted were: (1) comparison of GENELAND clusters with results of STRUCTURE, DAPC, PCA and sPCA; (2) tests related to HWE and F_{IS} for the GENELAND clusters; and (3) genetic diversity, genetic differentiation and genealogy of the GENELAND clusters based on mtDNA. The authors concluded that their results strongly support the scenario of two differentiated stocks (J- and O-stocks) with complex spatial and temporal mixing near the Pacific coast of Japan (Hypothesis A in the previous *Implementation Review*). The results of some of the analyses were consistent with the scenario of the coastal areas containing genetically admixed specimens, a possibility also mentioned by the authors of SC/F19/WNPM/02. The authors recommended further analyses under the GENELAND as well under the TESS and BAPS approaches (as suggested by the original authors), as well as an examination of the consistency of the resulting clusters with the available biological information.

The Workshop thanked the authors for these analyses. In discussion, Hoelzel clarified that ongoing work with GENELAND included a *post hoc* analysis designed to test the relative fit of non-admixture *vs* admixture models, as well as a full run including inferred offspring instead of parents from parent-offspring pairs (offspring were excluded in the earlier runs). The Workshop suggested that further *post hoc* analyses on outcomes when *k*=3 would be useful for relevant GENELAND runs, especially to compare mtDNA haplotype diversity. TESS included many of the same individuals, but in general this method was less precise for a given run, and therefore further *post hoc* analyses based on TESS would not be a high priority given the limited time available. When comparing the spatial approaches discussed above, the Workshop noted that SC/F19/WNPM/09 found significant differentiation among all four putative GENELAND populations when compared using mtDNA data, although they had been assigned in GENELAND based on microsatellite DNA data discussed above. In addition, the reduced genetic distance between 'red' and J-stocks and between 'blue' and O-stocks found using BayesAss was also evident in the mtDNA network analysis presented in SC/F19/WNPM/09.

PARENT-OFFSPRING PAIRS

SC/F19/WNPM/03 updated the genetic analyses on parent-offspring (P-O) pairs in the region. The analyses were based on a maximum likelihood approach described in the original analyses of Tiedemann *et al.* (2017) that examined 4,554 whales including 53 foetus samples. The update incorporated new samples collected in 2016 during JARPNII and from bycatches (*n*=206), for which complete genotypes at 16 microsatellite loci, mtDNA control region sequences and biological information, were available. The analyses revealed four new P-O pairs in the 2016 data set (table 1 of SC/F19/WNPM/03). In general, results from maximum likelihood estimation using microsatellite data were consistent with the additional genetic and biological information. In all four new cases, at least one specimen in the pairs was an adult whale. The case of a mother-daughter pair was confirmed by identical mtDNA sequences. All four P-O pairs were identified as J-stock whales, reflecting the fact that in 2016, the JARPNII survey was conducted and bycatches occurred exclusively in coastal waters off Japan. The total number of P-O pairs identified so far is 40 for the O-stock and 13 for the J-stock. In the case of the O-stock, several of the P-O pairs were between coastal and offshore sub-areas, while some of the J-stock pairs were between the Sea of Japan and the Pacific side of Japan. As noted earlier, the Committee had already agreed that the results of the kinship analysis are inconsistent with the mixing matrices associated with Hypothesis C as implemented in the 2013 RMP trials among sub-areas 7CS, 7CN, 8 and 9. Results of the update P-O analyses presented here confirm this agreement.

The Workshop thanked the authors of this paper. In discussion, it was decided to incorporate the new data into the comparison of observed and expected P-O pairs within and among sub-areas. As noted earlier, this analysis was performed during the Workshop (Annex G). It revealed a significant overrepresentation of P-O pairs in sub-area 7CS. For these observed seven P-O pairs, parents had been included in the GENELAND analysis. Only one of the parents was from the widely distributed GENELAND cluster mostly representing O-stock individuals, while the remaining six were from the inferred GENELAND clusters with an occurrence mostly restricted to the coastal areas east of Japan.

The analyses of mtDNA differentiation based on mtDNA and F_{ST}/PHI$_{ST}$ presented in table 4 of SC/F19/WNPM/09 were updated by Taguchi during the Workshop (Annex H). The comparison among the blue, green, orange, red and unassigned clusters in GENELAND was conducted considering the STRUCTURE assignment in each cluster. The significant statistical differences among the GENELAND clusters were attributed to the occurrence of STRUCTURE-J and STRUCTURE-O animals.

Table 1

Analytical support for populations suggested by GENELAND. Note that ‘Not supported’ does not imply ‘invalidated’.

	Orange (O-stock)	Green (J-stock)	Blue stock	Red stock
GENELAND using correlated allele frequency model and choosing *k*	Supported (note ongoing additional analyses to test admixture model)	Supported (note ongoing additional analyses to test admixture model)	Supported (note ongoing additional analyses to test admixture model)	Supported (note ongoing additional analyses to test admixture model)
GENELAND using the uncorrelated model or correlated with fixed *k*=4	Supported	Supported	Combines red and blue	Combines red and blue
TESS	Supported	Supported	Combines red and blue	Combines red and blue
BAPS	Supported (but with green mixed in)	Supported	Not supported	Not supported
STRUCTURE	Supported	Supported	Not supported (mostly assigned to orange)	Not supported (combination of orange and green)
DAPC	Supported	Supported	Not supported (mostly matched to orange when compared against Structure assignments)	Not supported (mostly matched to green when compared against Structure assignments)
sPCA	Supported (but with some green mixed in)	Supported	Not supported (mostly matched to orange when compared against Structure assignments)	Not supported (mostly matched to green when compared against Structure assignments)
PCA (Oscar)*	Supported	Supported	Supported but did not distinguish between red and blue	Supported but did not distinguish between red and blue
mtDNA	Supported	Supported	Supported, but mostly matched to orange when compared against Structure assignments	Supported, but mostly matched to green when compared against Structure assignments
Parent-offspring	Compatible	Compatible	Compatible	Compatible
Wahlund	Supported (assessed using consensus of 100% assigned individuals comparing 3 separate GENELAND runs)	Supported (assessed using consensus of 100% assigned individuals comparing 3 separate GENELAND runs)	Supported (assessed using consensus of 100% assigned individuals comparing 3 separate GENELAND runs)	Supported (assessed using consensus of 100% assigned individuals comparing 3 separate GENELAND runs)
Spatial distribution	Supported	Supported	Only if red and blue are combined	Only if red and blue are combined
Age/sex structure	Supported	Supported	Supported	Not supported
Conception date	Supported	No data	Partially different from orange	No data
BayesAss	Supported	Supported	Supported but with admixture from orange and green	Supported but with admixture from orange and green
ABC	Supported (but admixture was not considered)	Supported (but admixture was not considered)	Supported (but admixture was not considered)	Supported (but admixture was not considered)
Morphometrics	Supported*	Supported*	Not evaluated	No data
Flipper colour	Supported*	Supported*	Not evaluated	No data
Fluke colour	Supported*	Supported*	Not evaluated	No data
Contaminant load	No data	No data	Not evaluated	No data
Cookie cutter shark scars	Supported*	Supported*	Not evaluated	No data

*Based on an earlier dataset.

The Workshop thanked Taguchi for these additional analyses. In discussion, it was noted that the observed mtDNA divergence is compatible also with a two-stock scenario (i.e. J and O). However, assignment in STRUCTURE is relatively coarse, and thus comparisons based around clustering by STRUCTURE categories should not be expected to easily identify the relatively low F_{ST} values revealed among the GENELAND groupings.

Recent divergence could have provided too little time for the evolution of novel haplotypes in the ‘red’ and ‘blue’ populations, and incomplete lineage sorting could mean that both red and blue still shared proportions of the same haplotypes found in the O-stock (orange) and J-stock (green) populations. This interpretation is consistent with the network presented in fig. 8 of SC/F19/WNPM/09, especially if red evolved from green and blue evolved from orange. The number of *in situ* evolved stock-specific new haplotypes may be small.

A full consolidation of the implications for stock structure of all of the above analyses is given under Item 3.2.

3.2 Evidence in support of alternative stock structure hypotheses

In order to consolidate and integrate the information provided in the extensive new analyses considered under Item 3.1, the Chair appointed a small working group (comprised of Hoelzel, Tiedemann, Pastene, Taguchi and Goto) to:

(1) generate tables considering relative support for the identified GENELAND clusters from work presented here and earlier work using a range of data types and methods (Table 1); and
(2) develop stock structure hypotheses based upon the review in Table 1 and summarise the support for these (Table 2).

As shown in Table 2, four hypotheses were considered, although it was noted that the fourth hypothesis is demographically identical to hypothesis (1) below and thus not necessary to take forward from an RMP trial perspective. The four hypotheses were:

(1) two stocks (J-stock and O-stock);

Table 2

Hypothesis support (but not including the issue of Y-stock due to a lack of data, although see Item 6). The four-stock hypothesis differs from the 2013 Hypothesis C as spatial overlap is not excluded. Note that 'Not supported' does not imply 'invalidated'. Where 'Not evaluated' is shown, it is considered that future evaluation would not be informative.

	Two stocks: O-stock in 2C, 7C, 7WR, 7E, 8, 9, 11, 12; J-stock in 2C, 6E, 6W, 7C, 10E, 11, 12	Three stocks: One additional stock; P-stock (putative) in 2C, 7C, 11	Four stocks: Two additional stocks; (JE and OW) in sub-areas 2C, 7C, 11	Two stocks: J- and O-stocks genetically admix in the range of their overlap
GENELAND using the correlated allele frequency model and choosing *k*	Not supported, but note that GENELAND assigns four distinct assignment groups[1] to 7C, 3 to 2C (blue, red and green), and 2 to 11 (blue and green)	Not supported	Supported[2]	The outcome from GENELAND would be incompatible with recent or ongoing admixture (as in a hybrid zone)
GENELAND using the uncorrelated model or correlated with fixed *k*=4	Not supported, but note that GENELAND assigns three distinct assignment groups[1] to 2C, 7C and 11	Supported	Not supported	The outcome from GENELAND would be incompatible with recent or ongoing admixture (as in a hybrid zone)
TESS	Not supported, but note that GENELAND assigns three distinct assignment groups[1] to 2C, 7C and 11	Supported	Not supported	TESS cannot make this assessment
BAPS	Supported, but O-stock is poorly assigned (many apparent J-stock animals in O-stock areas (e.g. 8 and 9).	Not supported	Not supported	Not informative
STRUCTURE	Supported	Not supported	Not supported	Unassigned individuals would have the potential to reflect admixture
DAPC	Supported	Not supported	Not supported	DAPC cannot assess this
sPCA	Supported	Not supported	Not supported	sPCA cannot assess this
PCA (Oscar)	Supported	Supported, but location not precise	Not supported	Cannot assess from these results
mtDNA	Supported	Not tested yet	Supported, with one stock closer to O-stock and one closer to J stock	Compatible but not the most parsimonious interpretation of the mtDNA network
Kinship[3]	Supported	Supported	Not supported	Not informative[4]
Wahlund[5]	Supported	Supported	Supported	Supported
Spatial distribution	Supported	Supported	Not supported[6]	Opportunity available since ranges overlap
Age/sex structure	Compatible	Compatible with some caveats[7]	Not supported[6]	Compatible
Conception date	Supported	Compatible	No data for one of the putative stocks	Not informative
BayesAss	Not supported	Compatible	Supported with fairly extensive admixture	Not assessed
ABC[8]	Not supported because t1 and t2 were greater than zero	Not tested	Supported because t1 and t2 were greater than zero	Not assessed
Morphometrics	Compatible	Not evaluated	No data	Not evaluated
Flipper colour	Compatible	Not evaluated	No data	Not evaluated
Fluke colour	Compatible	Not evaluated	No data	Not evaluated
Contaminant load	Compatible	Not evaluated	No data	Not evaluated
Contaminant load	Compatible	Not evaluated	No data	Not evaluated

[1] Comparing against equilibrium expectations to identify putative populations. [2] These settings have the potential to overcluster, according to the GENELAND manual. [3] Only parents currently assigned to GENELAND groups. [4] Note that there were no matches found between J-stock and O-stock individuals. [5] Based on an analysis whereby consensus GENELAND assignments are used (only individuals assigned 100% in each of 3 runs). [6] Note however that there could be sampling bias in the current sampleset. [7] Has yet to be tested in the model trials, particularly concerning mature females. [8] Note that admixture not included among the scenarios tested so far.

(2) three stocks (J, P and O), with the P-stock found primarily in sub-areas 2C, 7C and 11;
(3) four stocks i.e. those identified by GENELAND using the correlated allele frequency model; and
(4) as for hypothesis (1), but there is genetic admixture of J-stock and O-stock as a result of geographic overlap of 'breeding regions'.

This work was greatly assisted by mapping the data by clusters, sex, time period and providing summaries of distance from the coast and approximate proportions mature (these were deemed approximate but sufficient to provide inferences as they were based on assuming a knife-edge length at maturity for each sex, recognising that this assumption is unrealistic and that the lengths from bycatches were made by fishermen not scientists). This information is provided in Annex I.

In reviewing Tables 1 and 2, the Workshop **agreed** that spatial and age/sex composition considerations greatly favoured a three-population model (combining the 'red' and 'blue' populations, hereafter referred to as 'purple') over the four-population model.

In particular, the red group is distributed within 3 nautical miles of the coast (due to being almost completely represented by bycatch in set nets) and the blue group (from special permit catches) beyond 3 n.miles, with almost no overlap. Such a hard boundary between two putative coastal stocks was considered unlikely, particularly since a separate red group, as reflected in the bycatch sample, would contain too few mature females to constitute a real stock.

As a result, the Workshop **agreed** to take forward the two-population and three-population hypotheses as defined under Item 3.1, as well as the hypothesis involving the Y stock considered in 2013 (see Item 6).

Table 3a

Past and planned future Japanese sighting surveys of minke whales to the West of Japan.
The survey coverage, where known, is given in parentheses. The same pattern will continue after 2027.

Sub-area:	5	6W	6E	10W	10E
2000	-	Apr-May (14%)	-	-	-
2001	Apr-May (13%)	-	-	-	-
2002	-	Apr-May (14%)	May-Jun (79%)	-	May-Jun (100%)
2003	-	Apr-May (14%)	May-Jun (79%)	-	May-Jun (100%)
2004	Apr-May (13%)	-	May-Jun (79%)	-	-
2005	-	Apr-May (14%)	-	-	May-Jun (64%)
2006	-	Apr-May (14%)	-	May-Jun (60%)	-
2007	-	Apr-May (14%)	-	-	-
2008	Apr-May (13%)	-	-	-	-
2009	-	Apr-May (14%)	-	-	-
2010	-	Apr-May (24%)	-	-	-
2011	Apr-May (13%)	-	-	-	-
2012	-	Apr-May	-	-	-
2013	Apr-May	-	-	-	-
2014	Jun-Jul	-	-	-	Aug-Sep (100%)
2015	-	Apr-May	-	-	-
2016	-	Apr-May	-	-	-
2017	Apr-May	-	-	-	-
2018	May-Jun	-	-	-	May-Jun (100%)
2019	-	-	May-Jun (100%)	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	-	Aug-Sep	Aug-Sep	Aug-Sep
2024	-	-	-	-	-
2025	-	-	-	-	-
2026	-	-	-	-	-
2027	-	-	Aug-Sep	Aug-Sep	Aug-Sep

Table 3b

Past and planned future Japanese surveys to the North and East of Japan. The survey coverage is given in parentheses.
* Estimate=0; [#] surveys covered different parts of sub-area 12NE each year.

Sub-area:	7CS	7CN	7WR	7E	8	9	11	12SW	12NE
1990	-	-	-	-	Aug-Sep (62%)	Aug-Sep (35%)	Aug-Sep (100%)	Aug-Sep (100%)	Aug-Sep (100%)
1991	Aug-Sep*(100%)	Aug-Sep (100%)	Aug-Sep (100%)	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	Aug-Sep (89%)
1999	-	-	-	-	-	-	Aug-Sep (100%)	-	Aug-Sep (64%)
2000	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	Jun-Jul (65%)*	-	-	-	-
2003	-	-	May-Jun (27%)	-	-	Jul-Sep (33%)	Aug-Sep (34%)	Aug-Sep (100%)	Aug-Sep (46%)
2004	May (37%)	-	May-Jun (89%)	May-Jun (57%)	Jun (40%)	-	-	-	-
2005	-	-	-	-	May-Jul (65%)	-	-	-	-
2006	Jun-Jul (100%)	-	-	May-Jun (57%)	May-Jul (65%)	-	-	-	-
2007	-	-	Jun-Jul (89%)	Jun-Jul (65%)*	Jun-Jul (65%)	-	Aug-Sep (20%)	-	-
2008	Jul-Aug*(100%)	Jul-Aug*(75%)	Jul-Aug*(89%)	Jul-Aug*(57%)	Jul-Aug*(65%)	Jul-Aug (87%)	-	-	-
2009	May-Jun (100%)	May-Jun (75%)	May-Jun (89%)	May-Jun (57%)	May-Jun (65%)	May-Jun (87%)	-	-	-
2010	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	May-Jun-(65%)	May-Jun (87%)	-	-	-
2012	May-Jun (100%)	May-Jun (75%) Aug-Sep (75%)	May-Jun (89%)	May-Jun*(57%)	-	-	-	-	-
2013	-	-	May-Jun (89%)	May-Jun (57%)	May-Jun (65%)	-	-	-	-
2014	-	Aug-Sep (73%)	-	-	-	-	Aug-Sep (35%)	-	-
2015	-	-	-	-	-	May-Jun (87%)	-	-	Aug-Sep[#] (17%)
2016	Jul-Aug (100%)	Jul-Aug (75%)	Jul-Aug (89%)	-	-	-	-	-	Aug-Sep[#] (28%)
2017	May-Jun (100%)	May-Jun (75%)	-	-	-	-	-	-	Aug[#] (14%)
2018	May-Jun (100%)	May-Jun (75%)	-	-	-	-	May-Jun (35%)	-	Aug[#] (11%)
2019	-	-	May-Jun (89%)	May-Jun (57%)	-	-	-	-	Aug-Sep[#] (16%)
2020	-	-	-	-	-	-	Aug-Sep	Aug-Sep	Aug-Sep
2021	-	-	Aug-Sep	Aug-Sep	Aug-Sep	Aug-Sep	-	-	-
2022	Aug-Sep	Aug-Sep	-	-	-	-	-	-	-
2023	-	-	-	-	-	-	-	-	-
2024	-	-	-	-	-	-	Aug-Sep	Aug-Sep	Aug-Sep
2025	-	-	Aug-Sep	Aug-Sep	Aug-Sep	Aug-Sep	-	-	-
2026	Aug-Sep	Aug-Sep	-	-	-	-	-	-	-
2027	-	-	-	-	-	-	-	-	-

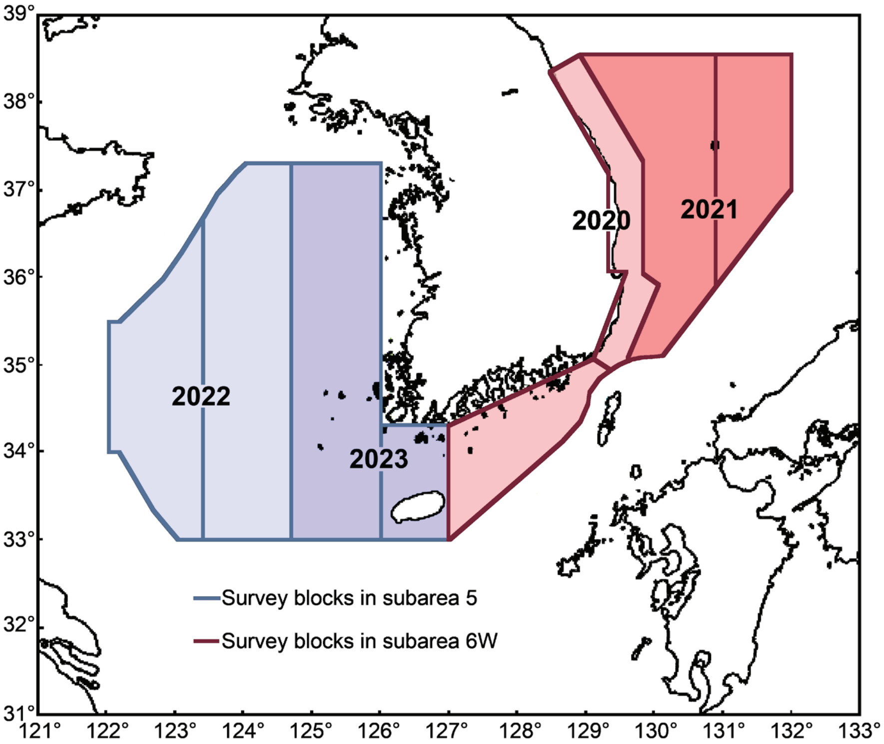


Fig.2. Pattern for future Korean surveys in sub-areas 5 and 6W.

4. ABUNDANCE

4.1 Summary of abundance estimates already agreed by the Scientific Committee, at least for use in conditioning and trials, including *g*(0)

Abundance estimates for use in the trials are listed in Annex J. All the values given correspond to an assumption that *g*(0)=1. Those until 2012 for Japan and until 2011 for Korea are taken from the database prepared and adopted for this purpose by the Scientific Committee (IWC, 2019a).

4.2 New estimates

For sub-areas 7, 8 and 9, Annex J also includes abundance estimates from surveys by Japan for the years 2008, 2009 and 2011-12. These were provisionally accepted by the Workshop for use in conditioning, noting that this will require endorsement at the next Scientific Committee meeting.

Annex J also shows entries, though without values as yet, for the years 2013 to 2019 for Japan. These correspond to surveys conducted under IWC oversight, whose designs were ratified by the IWC Scientific Committee. The Workshop was informed that because of pressure of time on the scientists concerned, Japan has yet to analyse the results from these surveys but that completing this task has recently been accorded a high priority. Annex J also shows similar entries for the years 2012 to 2018 for Korea. Difficulties with the research vessel meant that there will not be any Korean survey in 2019.

The Workshop **strongly recommended** that estimates for all surveys over 2013 to 2018 be prepared for tabling at the 2019 meeting of the Scientific Committee, given their fundamental importance to the *Implementation Review* process. The Workshop **advised** that priority be given to:

(1) providing information on survey coverage to determine whether or not a survey can provide an unbiased estimate, or a minimum estimate only; and

(2) focus first on analysing surveys for the sub-areas which had yielded the largest estimates in the past (*viz*. sub-areas 9 and 12), noting the need to carefully consider covariance, particularly for sub-area 12NE.

Japanese scientists advised that they would do their best to meet this deadline. The Workshop was informed that the cruises in sub-area 12NE were Russian cruises (assisted by Japan), and thus permission will need to be obtained from the Russian scientists to present associated analyses to the Scientific Committee.

An intersessional group consisting of Allison (convenor), Butterworth, Donovan, Hakamada and Palka was appointed to assist Korean scientists to develop abundance estimates from the surveys conducted between 2011 and 2018.

4.3 Generation of future estimates and incorporation of uncertainty

Korea advised that their survey plans are expected to follow the pattern shown in Fig. 2 in the future. A schedule of planned future surveys by Japan is provided in Tables 3a and b. Abundance estimates for these will be generated following the standard procedure set out in the trial specifications (Annex K).

5. REMOVALS DATA

5.1 Catch data

The catch series used in the 2013 *Implementation Review* is given in Allison *et al.* (2014) and included the 'Best' estimates of the catch numbers and an alternative 'High' catch series. The data are listed by sub-area, sex and month. Allison (2011) documents the level of information available on catches, the data sources and how the series were constructed, and where information on the catches is incomplete. Individual data on catches including date, sex, length and position are available for almost 40% of the catches. Directed catches since 2012 are listed in Table 4. The full catch series are provided in the trial specifications (Annex K, Adjunct 1).

5.2 Bycatch data

The Workshop thanked Japan and Korea for providing updates on the numbers of bycatches taken in their waters in recent

Table 4

Directed catches since 2012. In addition, 1 whale was lost in 2017, position unknown.

	5	6W	6E	7CS	7CN	7WR	7E	8	9	11
2012	0	4	0	85	91	5	0	3	0	0
2013	0	12	0	34	58	0	0	0	3	0
2014	3	8	0	30	51	0	0	0	0	0
2015	2	12	0	19	51	0	0	0	0	0
2016	0	0	0	16	21	0	0	0	0	0
2017	1	1	0	3	35	6	11	4	22	47

Table 5

Recent by-catches by Japan (some are updates to those listed in progress reports). It is known that the numbers are incomplete for 2001.

Year	1E	2C	6E	7CN	7CS	10E	11	Total
2001	1	10	25	3	8	4	3	54
2002	7	19	45	13	17	3	5	109
2003	5	17	61	15	18	-	8	124
2004	4	19	66	9	14	-	3	115
2005	4	33	55	10	17	3	6	128
2006	3	28	76	16	21	-	3	147
2007	7	42	69	11	20	-	6	155
2008	9	23	68	11	17	2	3	133
2009	3	17	69	3	25	-	1	118
2010	3	18	74	8	17	-	4	124
2011	6	28	65	9	8	-	1	117
2012	5	25	56	9	15	-	4	114
2013	5	20	54	9	15	2	-	105
2014	3	21	74	16	23	1	2	140
2015	5	28	84	12	26	-	1	156
2016	7	34	86	17	22	3	-	169
Total	77	382	1027	171	283	18	50	2008

years (Tables 5 and 6); data were provided for each individual and included date, position, sex and length. In addition, in regard to information on the numbers of nets in operation, Japan supplied an update that included information from the Japanese Coast Guard for 2014 on the dates that the nets were in operation (Annex F) whilst Korea provided revised data on the number of set nets in operation based on the number of licenses issued between 1994-2017 (also Annex F).

In discussion, it was noted that the set nets are assigned to sub-area based on the position of the centre of the net, although some nets extend beyond a single sub-area.

The Workshop reviewed the bycatches (and the approach used) used in the 2013 *Implementation Review*.

(1) Japan: Numbers of bycatches off Japan from 1945-2001 were extrapolated using the number of nets in operation and the reported catches from 2001 onwards. Since 2001, bycatch data off Japan were considered to be reliable. A sensitivity trial was undertaken that assumed that catches since 2001 were under-reported by 50% and the numbers of nets were double the best-case values from 1946-69 (up to a maximum equal to the number of nets in 1969).

(2) Korea: The same method as used for Japan was applied, except that bycatch numbers since 1945 were extrapolated from reported numbers in sub-areas 5 (Yellow Sea) and 6W (East Sea) since 2000 and 1996 respectively. Catches in sub-area 6W were assumed to be under-reported by 50% (based on DNA profiling and a capture-recapture analysis of market products (Baker *et al.*, 2007). The high effort sensitivity trial assumed that catches in sub-area 5 since 2000 were under-reported by 50%, and the numbers of nets were double the best-case values from 1946-69 (up to a maximum equal to the number of nets in 1969).

(3) China: There were no data on by-catches off China, although they are known to occur. The baseline trials assumed that the bycatch off China was double that off western Korea (Annex K). A sensitivity trial ignored any possible bycatch off China.

In discussion, the lack of information on Chinese bycatches was highlighted. It was noted that there are not many set-nets in operation off China and that the operations are likely to be similar to those off western Korea. In the absence of new information, the approach used for the 2013 *Implementation* will continue to be used.

5.3 Ship strikes data

SC/F19/WNPM/06rev1 provided information on eleven collisions between jet foils and whales in the Korea Strait. The first collision in 2004 was confirmed to be a common minke whale by DNA analysis. The species and fate of the whales in the ten subsequent collisions are unknown. The Workshop thanked Kim for providing this information. The Workshop **agreed** that ship strikes could be assumed to be zero for the purposes of the present *Implementation Review* although the situation should continue to be monitored.

5.4 Finalise the removals data for use in the trials (taking into account uncertainty) including generation of future data (especially bycatch)

The catch series and numbers of nets used in the 2013 *Implementation* will be updated with the new information summarised under Items 5.1 and 5.2 and included in the trial specifications. The new information on the time periods of operation of the set nets will be incorporated into the trials (see Item 6).

Table 6

Recent numbers of bycaught, stranded and found drifting common minke whales in Korea.

Year	Set net	Pots	Gill net	Stow net	Trawl	Other	Unid.	Stranded	Drifted	Total in sub-area 5	Total in 6W	Total	Other
1996	32	50	45	-	1	0	-	-	-	0	128	128	-
1997	36	24	14	-	1	1	2	1	2	0	150	81	-
1998	27	7	12	-	-	0	1	-	-	0	47	47	-
1999	16	16	17	-	4	1	-	4	1	0	59	59	-
2000	37	23	23	5	-	3	1	2	1	14	81	95	-
2001	58	22	58	3	3	1	5	6	6	12	150	162	-
2002	28	17	28	7	1	2	-	2	4	8	81	89	-
2003	12	33	29	1	2	3	7	2	3	10	80	92	2 in 1W
2004	15	21	15	2	2	2	4	1	7	13	56	69	-
2005	41	36	22	3	2	0	1	-	2	7	100	107	-
2006	20	26	16	1	4	2	11	-	2	11	69	82	-
2007	16	20	22	3	1	0	10	1	7	13	66	80	-
2008	25	27	8	3	4	0	8	-	6	12	67	81	-
2009	38	23	15	1	-	2	3	1	4	12	72	87	-
2010	26	13	16	3	1	7	5	-	5	8	67	76	-
2011	24	27	16	4	1	1	13	3	2	16	74	91	-
2012	25	16	22	6	4	1	-	2	3	9	70	79	-
2013	27	6	12	4	1	1	-	1	5	11	46	57	-
2014	22	17	3	6	2	-	-	1	3	10	44	54	-
2015	47	20	15	4	-	-	1	4	6	7	88	97	1 in 1W
2016	44	23	20	6	1	-	-	-	5	10	89	99	-
2017	26	24	7	10	2	-	-	-	3	13	59	72	-
2018	23	39	15	3	-	-	-	-	2	8	74	82	-

6. DEVELOPMENT OF *IMPLEMENTATION SIMULATION TRIAL* STRUCTURE

The trials structure (see Annex K) is based on representing the stock structure hypotheses in the form of mixing matrices in which some of the parameters of these matrices are estimated by fitting the operating model to data on absolute abundance and mixing proportions, subject to constraints on the predictions of the operating model for sub-areas with sparse data.

The trials reflect combinations of factors (see Table 7), each of which captures one or more sources of uncertainty. The trials are based on the same set of sub-areas as the previous trials (Fig. 1) and are based on time-steps of (1) January-March; (2) April; (3) May; (4) June; (5) July; (6) August; (7) September; and (8) October-December, as before. As noted by IWC (IWC, 2012a)Annex D1), the primary function of sub-areas is to allow stock structure hypotheses to be adequately specified in space and time.

There are three 'baseline' trials and a set of sensitivity trials. The set of factors, including stock structure hypotheses and MSYR values, are based on *a priori* considerations. The final set of factors (and trials) will be selected taking into account whether it is possible to condition the resulting trials and the assignment of plausibility, which will occur during the 'First Annual Meeting'. As in the past, it may be necessary later to modify which entries in the mixing matrices (the 'gammas') are estimated in the conditioning process. Allison will identify the need for additional gamma parameters based on initial attempts at conditioning and inform the Steering Group for their approval.

6.1 Factors to be considered in the trials (including incorporation of uncertainty)

The factors in Table 7 match those used in the previous *Implementation* less factors (such as the variants of the previous stock structure hypothesis C, which has been replaced by hypothesis E as explained under Item 3) and the trials that vary dispersal rates, given there are no JW/JE and OW/OE stocks in the current trials. The list of factors includes a new factor related to the threshold for defining when an assignment of an individual to a putative stock[7] can be made. The baseline value of this is a probability of 0.9, with sensitivity to be explored to a probability of 0.7 (trials A05-1, etc).

6.1.1 Stock structure hypotheses

Based upon the discussions under Item 3, the Workshop **agrees** that the trials for the Western North Pacific common minke whales will be based on three fundamental stock structure hypotheses (see Item 3 and Table 2):

(1) there is a single J-stock distributed in the Yellow Sea, Sea of Japan, and Pacific coast of Japan, and a single O-stock in sub-areas 7, 8, and 9 (referred to as Hypothesis A as it was in 2013);

(2) as for hypothesis A, but there is a third stock (Y) that resides in the Yellow Sea and overlaps with J-stock in the southern part of sub-area 6W (referred to as Hypothesis B in 2013 as it was in 2013); and

(3) there are four stocks, referred to Y, J, P, and O, two of which (Y and J) occur in the Sea of Japan, and three of which (J, P, and O) are found to the east of Japan (a new hypothesis referred to as Hypothesis E). Stock P (earlier termed 'purple') is a coastal stock.

Variants of these fundamental structure stock-structure hypotheses reflect a lower threshold for defining when an individual can be assigned to a stock and the presence of the J/G stock in sub-area 12SE in June (Table 7).

6.1.2 Mixing matrices

Adjunct 2 of the trial specifications (Annex K) specify the mixing matrices. The mixing matrices are established by first creating presence-absence matrices based on the assignment of individuals to sub-areas. The multipliers were then chosen so that the qualitative patterns of movement inferred from changes over the year in age/sex structure spatially (see Annex I for the plots of the distribution of the samples

---

[7] For ease of presentation, 'putative stocks' will be referred to as stocks in the remainder of this section.

Table 7

The factors to be considered in the *Implementation Simulation Trials.*

Factor
Stock structure hypothesis
Stock structure hypotheses A, B and E.
MSYR
$1\%_{1+}$; $4\%_{\text{mat.}}$
***g*(0)**
0.798; 1.00 (Trial 3).
Other stock structure issues
With a C-stock (Trial 2).
Alternative basis for mixing rates (Trial 5).
10% J-stock in sub-area 12SW in June (Trial 10).
30% J-stock in sub-area 12SW in June (Trial 11).
No C animals (i.e. from a putative 'Central' North Pacific population) in sub-area 12NE (Trial 23).
10% J-stock in sub-area 12NE in May-July (Trial 21).
Catches and bycatches
High direct catches + alternative Korean + Japanese bycatch level (Trial 4).
More Korean catches in sub-area 5 (and fewer in 6W) (Trial 8).
More Korean catches in sub-area 6W (and fewer in 5) (Trial 9).
Chinese incidental catch=0 (Trial 12) (Baseline value=2* Korean bycatch in sub-area 5).
Number of bycaught animals is proportional to square root of abundance (Trial 17).
Mixing and dispersion
Mixing proportion in sub-areas 7CS and 7CN calculated using 2/60 weight for bycatch (Trial 6).
Mixing proportion in sub-areas 7CS and 7CN calculated using 10/60 weight for bycatch (Trial 7).
A substantially larger fraction of whales aged 1-4 from O-stock found in sub-areas 2R, 3 and 4 year round (Trial 18).
Set the proportion of O-stock animals of ages 1-4 in sub-areas 9 and 9N to zero (Trial 19).
Time-varying mixing matrix for the bycatch (Trial 22).
Abundance estimates
Alternative abundance estimate for sub-area 6E (Trial 13).
Alternative abundance estimate for sub-area 10E in 2007 (Trial 14).
Abundance estimate in sub-area 5='maximum' (Trial 15).
Abundance estimate in sub-area 6W='maximum' (Trial 16).
The number of 1+ whales in 2009 in sub-area 2C in any month <200 (Trial 20).

assigned to-stock by month/month grouping). A baseline set of mixing matrices was constructed which applied to most of the trials (see Annex K, Adjunct 2), with alternative mixing matrices reflecting the alternative assumptions regarding the threshold for defining when an assignment of an individual to a putative stock can be made.

6.1.3 MSYR

Two values for MSYR are considered in the trials: 1% defined in terms of the total (1+) component of the population, and 4% defined in terms of the mature female component of the population. These choices for MSYR are based on the outcomes of the MSYR review (IWC, 2014a; 2014b). Last year (IWC, 2019a), the Committee noted that information on bycatch rates by stock may provide information about MSYR, and that papers on this topic should be presented to the First Annual Meeting. The Workshop noted that care should be taken to account for the changes in the proportion of the genetic samples 'close to' the coast of Japan, particularly for males.

6.1.4 Biological parameters

The biological parameters are taken to be those used in the 2013 *Implementation* (see Section F of the trial specifications in Annex K) in the absence of new information regarding natural mortality and maturation.

6.1.5 Catches and bycatches

As discussed under Item 5, the trials are based on the best estimates of the (commercial and special permit/directed) catches and the bycatches off Korea and Japan, with bycatches off China assumed as for the 2013 *Implementation*. Sensitivity is explored to alternative catch series for Korea and Japan, lower catches off China, and to the relationship between population size and expected bycatch.

Different mixing matrices apply to bycatches and catches. The removal of bycatches is based on a mixing proportion determined from the bycatch samples. The catches occur throughout the sub-areas, so that calculating mixing proportions for a sub-area based on pooling all of the data for the sub-area would tend to overweight the information from the bycatch data. To overcome this problem, the 2013 *Implementation Review* weighted the mixing proportions from the bycatch and the special permit catches by the proportion of the sub-area to which each applied (5/60 for bycatch and 55/60 for special permit catches). Sensitivity will be explored to modifying 5/60 to 2/60 and 10/60.

6.1.6 Other

The baseline value for *g*(0) is set to 0.798, with sensitivity explored to a conservative value of 1. The trials also involve changes to some of the abundance estimates used for conditioning.

6.2 Information to be used in conditioning

Conditioning is the process of specifying the values for the parameters of the operating model for a given simulation trial such that the conditioned model is consistent with the available data given the set of hypotheses which define the trial. Determining the success or not of conditioning is the responsibility of the First Annual Meeting.

6.2.1 Abundance

The abundance estimates to use for conditioning are listed in Annex J, based on the discussions under Item 4. Some of the abundance estimates are minima while in addition upper bounds are placed on the number of animals in sub-area 2C.

Table 8

The list of Trials (MSYR 1% is defined in terms of the total (1+) component and 4% on the mature female component of the population).

Stock hypothesis	Trial no.	MSYR	Description
A	A01-1 and A01-4	1% 4%	Baseline A: 2 stocks (J and O); *g*(0)=0.798; including Chinese bycatch.
B	B01-1 and B01-4	1% 4%	Baseline B: 3 stocks (J, O, and Y); *g*(0)=0.798; including Chinese bycatch.
E	E01-1 and E01-4	1% 4%	Baseline E: 4 stocks (J, P, O, and Y); *g*(0)=0.798; including Chinese bycatch.
AE	A02-1 etc.	1% 4%	With a C ('Central' North Pacific) stock.
ABE	A03-1 etc.	1% 4%	Assume *g*(0)=1.
ABE	A04-1 etc.	1% 4%	High direct catches + alternative Korean and Japanese bycatch level.
ABE	A05-1 etc.	1% 4%	Alternative thresholds (70% probability) for assignments of stock proportions.
ABE	A06-1 etc.	1% 4%	Mixing proportion in sub-areas 7CS and 7CN calculated using 2/60 weight for bycatch.
ABE	A07-1 etc.	1% 4%	Mixing proportion in sub-areas 7CS and 7CN calculated using 10/60 weight for bycatch.
ABE	A08-1 etc.	1% 4%	More Korean catches in sub-area 5 (and fewer in 6W). Rationale: the baseline uses the best split. Trials 8 and 9 test alternatives in both directions.
ABE	A09-1 etc.	1% 4%	More Korean catches in sub-area 6W (and fewer in 5).
ABE	A10-1 etc.	1% 4%	10% J-stock in sub-area 12SW in June (base case value=20%). See Annex K, section F(c).
ABE	A11-1 etc.	1% 4%	30% J-stock in sub-area 12SW in June (base case value=20%). See Annex K, section F(c).
ABE	A12-1 etc.	1% 4%	Chinese incidental catch=0 (the base case value=twice that of Korea in sub-area 5).
ABE	A13-1 etc.	1% 4%	Alternative abundance estimates for sub-area 6E (see Annex K, table 6a).
ABE	A14-1 etc.	1% 4%	Additional abundance estimate for sub-area 10E in 2007 (see Annex K, table 6a).
ABE	A15-1 etc.	1% 4%	Abundance estimate in sub-area 5='maximum' value (=5 * baseline value), with CV=0.1. (The baseline fits to a low variance pseudo-estimate of abundance drawn from U[minimum:maximum] where the 'minimum' and 'maximum' values are those listed in Table 6b of Annex K).
ABE	A16-1 etc.	1% 4%	Abundance estimate in sub-area 6W='maximum' value (=5 * baseline value), with CV=0.1.
AE	A17-1 etc.	1% 4%	The number of bycaught animals is proportional to the square-root of abundance rather than to abundance (in order to examine the impact of possible saturation effects).
AB	A18-1 etc.	1% 4%	A substantially larger fraction of whales aged 1-4 from O-stock are found in sub-areas 2R, 3 and 4 year-round (so the proportion of 1-4 whales in sub-area 9 is closer to expectations given the length-frequencies of catches from sub-area 9). The mixing matrices are adjusted such that the numbers of age 1-4 O-stock animals in sub-areas 9 and 9N are no more than half the base case numbers; juveniles will be allowed into sub-areas 2R, 3 and 4 in the corresponding months.
ABE	A19-1 etc.	1% 4%	Set the proportion of O-stock animals of ages 1-4 in sub-areas 9 and 9N to zero and allow the abundance in sub-areas 7CS and 7CN to exceed the abundance estimates for these sub-areas. Projections for these sub-areas will need to account for the implied survey bias.
ABE	A20-1 etc.	1% 4%	The number of 1+ whales in 2009 in sub-area 2C in any month <200 (if large numbers of whales were found in 2C, the historical catch would be expected to be much greater).
ABE	A21-1 etc.	1% 4%	10% J-stock in sub-area 12NE in May-July. See Annex K, section F(c).
ABE	A22-1 etc.	1% 4%	Time-varying mixing matrix for the bycatch.
E	E23-1 and 4	1% 4%	No C (putative Central North Pacific stock) animals in sub-area 12NE.

6.2.2 Mixing proportions

'Mixing' refers to the temporary overlap of two (or more) stocks in a sub-area during a given time-step. Genetic data will be used for calculating mixing rates (as was the case for the 2013 *Implementation Review*). The advance this time is that the new analyses allow mixing proportions to be based on the assignment of individuals to stock rather than the previous 'mixed stock genetic analysis'. This in turn depends on the stock hypothesis and the threshold for defining when an assignment of an individual to a stock can be made.

Some of the data from commercial whaling operations in sub-area 11 were used to calculate mixing proportions for the 2013 *Implementation*. However, the associated samples are no longer available due to loss in the tsunami and microsatellite data are also not available, precluding the use of these data in STRUCTURE and GENELAND, and hence as the basis for mixing proportions.

The likelihood function for the mixing proportions will be assumed to be binomial (when there are two stocks in a sub-area) or multinomial (when there are three or more stocks in a sub-area). It will be necessary to check whether the fits are overdispersed during conditioning, in which case a decision will be made whether it will be necessary to estimate an overdispersion rate – this decision will be made by the Steering Group (see Item 8).

6.2.3 Other

The conditioning process includes some constraints to: (i) reflect sub-areas for which mixing information is not available; (ii) the need to ensure that all of the catches can be taken; and (iii) a penalty to allow the exploitation rate resulting in bycatch to be estimated.

The operating model does not fit the data on age/sex structure. However, the Workshop **agreed** that consistency with age-/sex-structure should be considered qualitatively when assigning plausibility to stock structure hypotheses. It also **agreed** that the standard set of diagnostic plots and tables should be extended to include plots that summarise the distribution of each stock in an unfished state and in recent years. Finally, it **agreed** that the effort data for the Japanese bycatches should be explored to confirm that they are consistent with the bycatch data (e.g. months in which there are no bycatches are when there are no nets in operation).

6.3 Review draft trial specifications

Table 8 lists the trials. It was not possible to complete the trials specifications during the meeting given the need, for example, to compute mixing proportions using the genetics data. The specifications in Annex K will be updated by the Secretariat and provided for final comment by the Steering Group.

7. FUTURE LIKELY WHALING OPERATIONS

Pastene informed the meeting that future whaling operations preliminarily being considered would be limited to outside a certain distance from the coast to minimise catch of J-stock whales and without any seasonal restrictions. Catches would be taken from parts of *Small Areas* which might include sub-areas 7, 8, 9, 11 and 12.

Table 9

Summary of the work plan.

Item	Responsible person(s)	Timeline
Completion of ongoing GENELAND analyses (testing the *post hoc* assessment of the admixture model, and identifying offspring to GENELAND groups).	Hoelzel	By SC/68A
Update database with stock assignments (J *vs* O based on STRUCTURE and J *vs* P *vs* [Z] based on GENELAND) for a threshold of 0.7.	Taguchi (Japan)	15 March
Examine the genetics data to determine how use those data to determine mixing proportions for each stock structure hypothesis. It will be necessary to establish a minimum sample size and then combine sexes and/or months to achieve at least the minimum sample size.	Small group: Allison (Chair), de Moor, Punt, Goto, Hoelzel, Pastene, Tiedemann, Taguchi	15 April
Calculate abundance estimates for the Korean surveys.	Kim (Korea) with the help of the advisory group (Allison (Convenor), Butterworth, Donovan, Hakamada, Palka and Wade	By SC/68A
Determination as to whether or not a survey can provide an unbiased estimate, or a minimum estimate only, based upon the information on coverage provided.	Advisory group as noted above	End March
Provide abundance estimates for the Japanese surveys since 2013, giving initial priority to the sub-areas which had yielded the largest estimates in the past (*viz* sub-areas 9 and 12), noting the need to carefully consider covariance, particularly for sub-area 12NE.	Hakamada, Miyashita (Japan)	By SC/68A
Korean individual bycatch data.	Kim (Korea)	End March
Age /length data for use in evaluating conditioning.	Goto (Japan)	By SC/68A
Undertake the necessary computing work including updating the control program and input files to allow preliminary testing of the model conditioning, particularly for Baseline E.	Allison and de Moor	By SC/68A

8. WORK PLAN

8.1 Genetic and related work

The Workshop welcomed the great progress made over the last two years in the genetic analyses, as discussed under Item 3. It encouraged additional studies that will assist discussions of plausibility at SC/68a and assist in refining mixing matrices. Japan indicated that it would work with Hoelzel and colleagues, who will perform analyses recommended or encouraged by the Workshop, to extend the data availability agreement until SC/68a.

In particular, the Workshop **recommends** that the ongoing GENELAND analyses (testing the *post hoc* assessment of the admixture model and identifying offspring to GENELAND groups) be completed and presented at SC/68a.

The Workshop also **encourages** an analysis using the isolation with migration method implemented in Ima2p (Sethuraman and Hey, 2016) to better resolve and understand the genetic system. This is a Bayesian coalescent method that can test posterior support and identify confidence intervals for the timing of division points between putative populations (including a lack of support for a given division point). It also estimates directional patterns of migration and effective population size. The analysis can include multiple putative populations at the same time, together with an unsampled ‘ghost’ population that may be exchanging genes with the other populations. It needs to be based on an initial tree, and this could be the best supported tree in the ABC analysis (scenario 1 in fig. 11 in SC/F19/WNPM/02 when considering a 4-population model), or a simple tree based on mtDNA genetic distances for the 3-population model. To provide sufficient power, this analysis depends on a large number of loci (doubling for each new population added), and less so on the number of samples. The convergence parameters will permit an assessment of whether or not there has been sufficient mixing for strong inference. In future it would be desirable to then apply further ABC modelling that includes scenarios that incorporate admixture and an appropriate number of populations, as indicated from the Ima2 analyses.

8.2 Trial specifications

The Workshop established a Steering Group (Punt [Convenor], Allison, Butterworth, de Moor, Donovan, Kim, Pastene, Tiedemann and Wilberg) to finalise the trial specifications, and to review any proposed modifications to those that may arise from initial attempts to condition the operating models. The possibility of a trial in which there is time-varying mixing in the region in which bycatch occurs was raised to address a comment in IWC (2019a). However, this trial has yet to fully specified. The Steering Group will also oversee the additional data-related intersessional work.

8.3 Overall work plan

A summary of the future work identified during the Workshop is given in Table 9.

9. ADOPTION OF REPORT

The Chair thanked the participants for the excellent collaborative work undertaken during the Workshop and especially the rapporteurs. All participants wished Wade a speedy recovery and thanked him for the comments sent. Thanks were also given to the Government of Japan for the facilities, the staff of ICR for their assistance with the logistics and the ever-patient interpreters. The Workshop thanked the Chair for his customary fairness and good humour in steering the workshop to a successful conclusion. Most of the report was agreed during the meeting and items for modification/clarification identified. It was agreed that the updated version should be circulated to the participants for final editorial comments.

REFERENCES

Allison, C. 2011. Direct catch data for western North Pacific minke whale simulation trials. Paper SC/D11/NPM3 presented to the First Intersessional Workshop for the *Implementation Review* of western North Pacific common minke whales, 12-16 December 2011, Tokyo, Japan (unpublished). [Paper available from the Office of this Journal].

Allison, C., de Moor, C.L. and Punt, A.E. 2014. Report of the Scientific Committee. Annex D1. Report of the Working Group on the *Implementation Review* for Western North Pacific Common Minke Whales. Appendix 2. North Pacific minke whale *Implementation Simulation Trial* specifications. *J. Cetacean Res. Manage. (Suppl.)* 15: 133-80.

Baker, C.S., Cooke, J.G., Lavery, S., Dalebout, M.L., Ma, Y.U., Funahashi, N., Carraher, C. and Brownell, J., R.L. 2007. Estimating the number of whales entering trade using DNA profiling and capture-recapture analysis of market produce. *Mol. Ecol.* 16(13): 2617-26.

International Whaling Commission. 2012a. Report of the first RMP intersessional workshop for western North Pacific common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 13:411-60.

International Whaling Commission. 2012b. Requirements and Guidelines for *Implementations* under the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 13:495-506.

International Whaling Commission. 2013. Report of the Second 'First Intersessional Workshop' for the *Implementation Review* of Western North Pacific Common Minke Whales. *J. Cetacean Res. Manage. (Suppl.)* 14:357-70.

International Whaling Commission. 2014a. Report of the Fourth Intersessional Workshop on the Review of Maximum Sustainable Yield Rates (MSYR) in Baleen Whales, 26-28 March 2013, La Jolla, California, USA. *J. Cetacean Res. Manage. (Suppl.)* 15:507-18.

International Whaling Commission. 2014b. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 15:1-75.

International Whaling Commission. 2019a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)*.

International Whaling Commission. 2019b. Report of the Workshop on Western North Pacific Common Minke Whale Stock Structure in Preparation for the Start of the *Implementation Review* in April 2018, 12-13 February 2018, Tokyo, Japan. *J. Cetacean Res. Manage. (Suppl.)* 20: 549-555.

Sethuraman, A. and Hey, J. 2016. IMa2p – parallel MCMC and inference of ancient demography under the isolation with migration (IM) model. *Mol. Ecol. Res.* 16(1): 206-15.

Tiedemann, R., Tiedemann, M.R., Goto, M., Taguchi, M. and Pastene, L.A. 2017. Finding parent-offspring pairs among western North Pacific common minke whales. Paper SC/67a/SDDNA01 presented to the IWC Scientific Committee, May 2017, Bled, Slovenia (unpublished). 18pp. [Paper available from the Office of this Journal].

Waples, R.S. 2011. Can evidence for spatial and/or temporal genetic heterogeneity of North Pacific minke whales be explained by different mixture fractions of the same two core stocks, or is it necessary to postulate an additional stock(s)? Paper SC/63/RMP7 presented to the IWC Scientific Committee, June 2011, Tromsø, Norway (unpublished). 7pp. [Paper available from the Office of this Journal].

Wilson, G.A. and Rannala, B. 2003. Bayesian inference of recent migration rates using multilocus genotypes. *Genetics* 163(3): 1177-91.

Annex A

Participants

Japan
Kazuhumi Aoki
Mutsuo Goto
Takashi Hakamada
Satoko Inoue
Yu Kanaji
Toshiya Kishiro
Hiroshi Kubo
Yuki Morita
Hideki Moronuki
Luis A. Pastene
Mioko Taguchi
Megumi Takahashi
Ryota Terai
Hideyoshi Yoshida
Saemi Baba (I)
Hiroko Yasokawa (I)

Korea, Republic of
Hyun Woo Kim
Eun-Mi Kim

USA
Wade (limited remote participation)

Invited Participants
Doug Butterworth
Rus Hoelzel
André Punt
Ralph Tiedemann
Lars Walløe
Mike Wilberg

IWC Secretariat
Cherry Allison
Greg Donovan

Annex B

Agenda

1. Introductory items
    - 1.1 Opening remarks
    - 1.2 Election of Chair and appointment of rapporteurs
    - 1.3 Adoption of Agenda
    - 1.4 Data available
    - 1.5 Available documents
2. Short summary of the 2013 *Implementation Review*
    - 2.1 Hypotheses/scenarios considered
    - 2.2 Results and conclusions
    - 2.3 Recommendations/suggestions made for future work
3. Stock structure
    - 3.1 Genetic analysis
        - 3.1.1 Introduction to some of the analytical methods
        - 3.1.2 New analyses conducted for this Workshop
    - 3.2 Evidence in support of alternative stock structure hypotheses
4. Abundance
    - 4.1 Summary of abundance estimates already agreed by the Scientific Committee, at least for use in conditioning and trials, including $g(0)$
    - 4.2 New estimates
    - 4.3 Generation of future estimates and incorporation of uncertainty
5. Removals data
    - 5.1 Catch data
    - 5.2 Bycatch data
    - 5.3 Ship strikes data
    - 5.4 Finalise the removals data for use in the trials (taking into account uncertainty) include generation of future data (especially bycatch)
6. Development of *Implementation Simulation Trial* structure
    - 6.1 Factors to be considered in the trials (including incorporation of uncertainty)
        - 6.1.1 Stock structure hypotheses
        - 6.1.2 Mixing matrices
        - 6.1.3 MSYR
        - 6.1.4 Biological parameters
        - 6.1.5 Catches and bycatches
        - 6.1.6 Other
    - 6.2 Information to be used in conditioning
        - 6.2.1 Abundance
        - 6.2.2 Mixing proportions
        - 6.2.3 Other
    - 6.3 Review draft trial specifications
7. Future likely whaling operations
8. Work plan
    - 8.1 Genetic and related work
9. Adoption of Report

Annex C

Documents

SC/F19/WNPM/

1. Baker, C.S., Brownell, R.L., Jr, and Wade, P.R. Preliminary analyses of population structure of North Pacific minke whales based on Japanese bycatch and scientific whaling.
2. de Jong, M. and Hoelzel, A.R. Collaborative analysis of WNP minke whale stock structure using the Japanese microsatellite DNA database and spatially explicit population structure analyses.
3. Goto, M., Taguchi, M. and Pastene, L.A. A note with an update of the parent-offspring genetic analyses in the western North Pacific common minke whales.
4. Taguchi, M., Goto, M. and Pastene, L.A. Results of Discriminant Analysis of Principal Component (DAPC) and Spatial Analysis of Principal Component (sPCA) and implications for the stock structure of western North Pacific common minke whale.
5. Taguchi, M., Goto, M. and Pastene, L.A. Response to SC/F19/WNPM/01 'Preliminary analyses of population structure of North Pacific minke whales based on Japanese bycatch and scientific whaling' by Baker *et al.*
6. Kim, H.W. A brief information of collisions between jetfoil vessels and whales on the Korea Strait.
7. Kim, H.W. Statistics of the bycaught, stranded and drifted common minke whales in Korea.
8. Hoelzel, A.R. and de Jong, M. North Pacific Minke whale putative populations as assigned by Geneland; testing for single-locus Wahlund effects.
9. Goto, M., Taguchi, M. and Pastene, L.A. Additional analyses to assist the interpretation of the results of the spatially explicit clustering tools used to explore microsatellite data of western North Pacific common minke whale (see SC/F19/WNPM/02).

Annex D

Summary of Hypotheses and Variants for the *Implementation Review* Completed in 2013

STOCK STRUCTURE HYPOTHESES

Three fundamental hypotheses were considered to account for patterns observed in the results from the genetic analyses:

(a) there is a single J-stock distributed in the Yellow Sea, Sea of Japan, and Pacific coast of Japan, and a single O-stock in sub-areas 7, 8, and 9 (referred to as hypothesis A);
(b) as for hypothesis (A), but there is a third stock (Y-stock) which resides in the Yellow Sea and overlaps with J-stock in the southern part of sub-area 6W (referred to as hypothesis B); and
(c) there are five stocks, referred to Y, JW, JE, OW, and OE, two of which (Y and JW) occur in the Sea of Japan, and three of which (JE, OW, and OE) are found to the east of Japan (referred to as hypothesis C).

Sensitivity tests in which there was a C-stock were also conducted based on stock structure hypotheses A and C. The C-stock stock is found in sub-areas 9 and 9N for the sensitivity test based on stock structure hypothesis A and in these sub-areas as well as sub-area 12NE for the sensitivity test based on stock structure hypothesis C. There is uncertainty regarding whether C-stock is found in sub-area 12NE because of the lack of genetics data for this sub-area.

MANAGEMENT VARIANTS

(1) *Small Areas* equal sub-areas. for this option, the *Small Areas* for which catch limits are set are 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9*, and 11.
(2) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CN, 9, and 11.
(3) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 9, and 11.
(4) Sub-areas 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 7CN, 7WR, 9 and 11.
(5) Sub-areas 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. sub-areas 7+8+9*+11+12 form a combination area and catches are cascaded to the sub-areas within the combination area. the catch limits for sub-areas 12SW and 12NE are not taken.
(6) sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* except that the catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading to allocate the catch across the two sub-areas.
(7) sub-areas 5+6W+6E+10W+10E and 7+8+9*+11 are *Small Areas*; catches from the 5+6W+6E+10W+10E *Small Area* are taken from sub-areas 5 and 6W using the same method as for catch cascading to allocate the catch across those five sub-areas, and catches from the 7+8+9+11 *Small Area* are taken in sub-area 7CN.
(8) sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading to allocate the catch across the two sub-areas.
(9) sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas.
(10) sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using the same method as for catch cascading to allocate the catch across these sub-areas. catches from sub-area 11 occur in May and June only.
(11) sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas, except the catches from sub-areas 7CS, 7CN, 7WR and 7E are reduced by 50% after first subtracting the bycatches in these sub-areas.

*refers to sub-area 9 alone (i.e. excluding 9N) in the definitions of the variants given above.

Annex E

Some Thoughts on Stock Structure Hypotheses

Paul Wade

OBSERVATIONS TO RECONCILE

(1) The genetic heterogeneity in 7CN and 7CS is not explained simply by J-O dichotomy.
(2) The genetic difference between Sea of Japan and 7CN and 7CS, (coastal Pacific) not explained just by the presence of the Sea of Japan stock.
(3) The parent-offspring matches from coastal to sub-areas 8/9.
(4) The lack of females in 8/9 (needs checking) make it not look like there is not an isolated stock there.

Point (1) argues against a single J- and single O-stock complete hypotheses. If so what fits with these observations?

POSSIBLE HYPOTHESIS

The main hypothesis to explain this could be that:

(a) there is a coastal stock in 7CS and 7CN that is mainly resident year round (like US minke whales), or moves a little bit north-south seasonally;
(b) there is a migratory stock that uses the east side of Japan as a migratory corridor on its way to the Sea of Okhotsk and North Pacific. Some of these whales pass Hokkaido on way to Sea of Okhotsk, some migrate along Japan coast and then move offshore to SA 8/9 and areas further north[8]; and

(c) there is a Sea of Japan stock. Not clear if it spills into Pacific much or not.

This hypothesis seems to fit with available observations and explains why there can be genetic heterogeneity along the coast, but there is also movement of parent-offspring between coastal and offshore water.

I note that the GENELAND results seem to agree in part with this hypothesis.

---

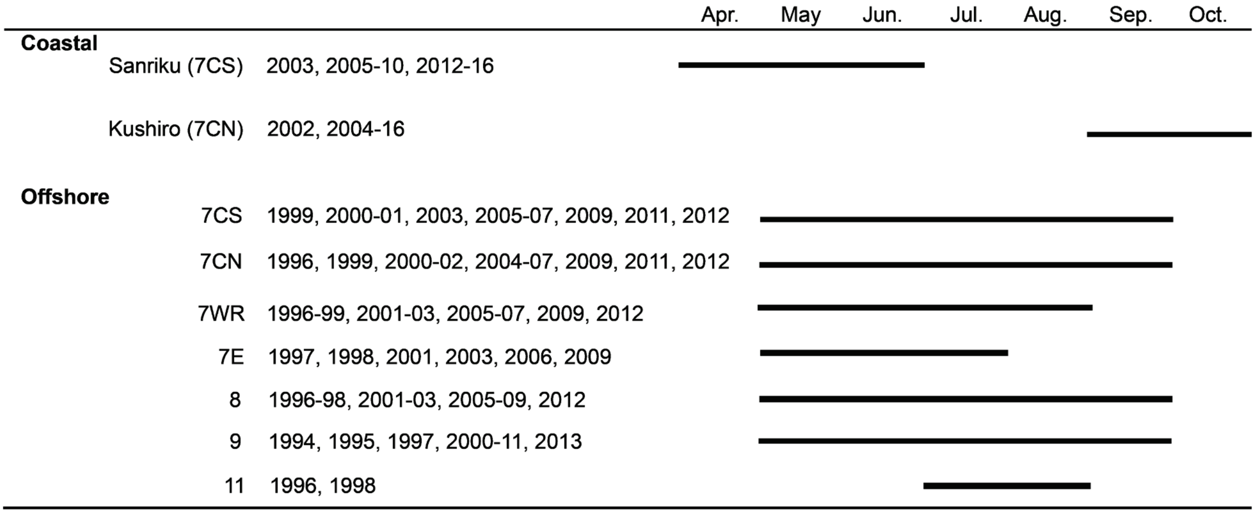
[8] There are several examples of this kind of overlappping migration, such as humpback whales in California where Alaska whales are migrating through ‘California’ whales that are feeding.

Annex F
Effort Information

KOREA: NUMBER OF SET NET FISHERY LICENSES IN KOREA BETWEEN 1994 AND 2017

Year	5	6W	Total
1994	168	464	632
1995	159	447	606
1996	149	443	592
1997	144	438	582
1998	142	433	575
1999	138	427	565
2000	129	426	555
2001	128	425	553
2002	135	417	552
2003	134	422	556
2004	133	421	554
2005	132	421	553
2006	131	420	551
2007	141	414	555
2008	126	414	540
2009	125	411	536
2010	125	411	536
2011	121	405	526
2012	121	399	520
2013	115	398	513
2014	115	393	508
2015	117	385	502
2016	115	381	496
2017	114	380	494

JAPAN: SAMPLING EFFORT FOR SPECIAL PERMIT CATCHES BY SURVEY TYPE, SUB-AREA AND MONTH



Coastal		
	Sanriku (7CS)	2003, 2005-10, 2012-16
	Kushiro (7CN)	2002, 2004-16
Offshore		
	7CS	1999, 2000-01, 2003, 2005-07, 2009, 2011, 2012
	7CN	1996, 1999, 2000-02, 2004-07, 2009, 2011, 2012
	7WR	1996-99, 2001-03, 2005-07, 2009, 2012
	7E	1997, 1998, 2001, 2003, 2006, 2009
	8	1996-98, 2001-03, 2005-09, 2012
	9	1994, 1995, 1997, 2000-11, 2013
	11	1996, 1998

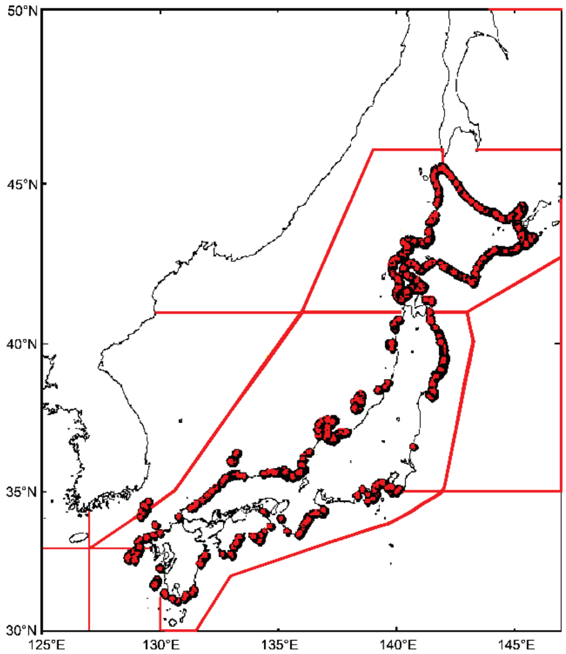


Fig. 1. Position data of all settled large and salmon set nets around the Japanese coast collected by the Japanese coast guard in 2014. Information by type of set net, subarea (position with lat./long.), season/month and area/circumference of set nets are also available.

Annex G

Comparing Expected and Observed Parent-Offspring (P-O) Pairs in Relation to Subarea and Data Source, with a Note on Genetic Assignment of Parents in Subarea 7CS

Ralph Teidemann

The table compares (by χ^2-Test) the number of expected (Exp) *vs* observed (Obs) Parent-Offspring (P-O) pairs. Bycatch individuals from sub-areas 7CN and 7CS are separated out (7bc).

(1) There are fewer than expected P-O pairs among sub-areas 6 and 7CN (red highlight).
(2) There are more than expected P-O pairs among sub-areas 7CN and 9, as well as within sub-area 7CS (green highlight).
(3) Separating out bycaught individuals did not yield any partition, where P-O numbers differed significantly from expectations.

	Exp		Obs		χ^2		seq. Bonferroni
6-6	2.4	501,498.6	5	501,496	0.085808	ns	ns
6-7CN	4.9	1,051,093	0	1,051,098	**0.026128**	*	ns
6-7CS	3.2	685,364.8	3	685,365	0.899864	ns	ns
6-7bc	2.3	485,967.7	1	485,969	0.394632	ns	ns
6-9	2.6	542,079.4	0	542,082	0.110184	ns	ns
7CN-7CN	2.6	549,673.4	1	549,675	0.32373	ns	ns
7CN-7CS	3.4	717,512.6	3	717,513	0.83732	ns	ns
7CN-7bc	2.4	508,762.6	5	508,760	0.092272	ns	ns
7CN-9	2.7	567,506.3	7	567,502	**0.008084**	**	ns
7CS-7CS	1.1	233,584.9	5	233,581	**0.000199**	***	**
7CS-7bc	1.6	331,738.4	1	331,739	0.653187	ns	ns
7CS-9	1.7	370,042.3	3	370,041	0.340407	ns	ns
7bc-9	1.2	262,383.8	3	262,382	0.112249	ns	ns
Rest	21.0	4,452,624.0	16.0	4,452,629.0	0.278762	ns	ns

There are 7 inferred P-O pairs within sub-area 7CS (*cf* SC/F19/WNPM/03; thereof 5 7CS-7CS; 1 7CS-7CSBC; 1 7CSBC-7CSBC). The respective parents distribute randomly among the different inferred GENELAND clusters present in subarea 7CS:

	N	Exp		Obs		Chi^2	
Green	0	0	0	0	0	n/a	
Orange	101	0.8	100.2	1	100	0.86524215	ns
Blue	513	4.3	508.7	5	508	0.73079788	ns
Red	223	1.9	221.1	1	222	0.52473733	ns
Blue/Red combined	736	6.2	729.8	6	730	0.94987315	ns

The detected overrepresentation of P-O pairs within sub-area 7CS may hence be explained by the existence of genetic clusters, some of which (i.e. blue and red) with a geographically more restricted distribution (accounting for 6 out of 7 parents in P-O pairs), while only one parent in a PO pair was from the more widely distributed orange cluster.

Annex H

Updated mtDNA Analyses

Bold text indicates statistical significance at α= 0.05 after FDR correction.

Upper: Phi_{ST}		BLUE			GREEN			ORANGE			RED			LESS90		
Lower: F_{ST}		J	O	Unas.	J	O	Unas.	J	O	Unas.	J	O	Unas.	J	O	Unas.
BLUE	J		**0.364**	**0.257**	-0.001	**0.330**	-0.002	0.010	**0.364**	**0.341**	-0.002	**0.354**	**0.040**	0.005	**0.368**	**0.248**
	O	**0.088**		**0.027**	**0.366**	-0.003	**0.336**	**0.416**	0.000	0.001	**0.380**	0.000	**0.242**	**0.407**	0.001	**0.032**
	Unas.	**0.069**	0.001		**0.260**	0.002	**0.218**	**0.305**	**0.030**	**0.012**	**0.279**	**0.023**	**0.125**	**0.312**	**0.033**	0.002
GREEN	J	-0.001	**0.096**	**0.075**		**0.329**	-0.001	0.018	**0.367**	**0.343**	-0.001	**0.359**	**0.045**	0.010	**0.373**	**0.252**
	O	**0.101**	0.002	-0.002	**0.107**		**0.280**	**0.381**	-0.004	-0.017	**0.357**	-0.024	**0.155**	**0.408**	-0.013	-0.011
	Unas.	-0.001	**0.073**	**0.054**	0.004	**0.083**		0.029	**0.337**	**0.304**	0.001	**0.315**	**0.030**	**0.020**	**0.332**	**0.203**
ORANGE	J	0.001	**0.122**	**0.101**	0.000	**0.145**	0.018		**0.416**	**0.385**	0.019	**0.393**	0.034	0.000	**0.410**	**0.274**
	O	**0.086**	0.000	0.000	**0.093**	-0.001	**0.071**	**0.119**		0.004	**0.380**	0.000	**0.245**	**0.407**	-0.001	**0.029**
	Unas.	**0.084**	0.000	0.000	**0.092**	-0.001	**0.068**	**0.116**	0.001		**0.364**	-0.001	**0.195**	**0.395**	0.005	0.018
RED	J	-0.002	**0.094**	**0.074**	-0.001	**0.108**	0.001	0.008	**0.092**	**0.091**		**0.376**	**0.055**	0.003	**0.387**	**0.271**
	O	**0.089**	0.002	0.004	**0.097**	0.006	**0.072**	**0.123**	0.003	0.001	**0.096**		**0.210**	**0.404**	-0.002	0.016
	Unas.	0.005	**0.050**	**0.035**	0.008	**0.064**	0.004	0.005	**0.048**	**0.043**	0.010	**0.049**		**0.068**	**0.230**	**0.100**
LESS90	J	0.000	**0.108**	**0.088**	0.001	**0.127**	0.007	-0.004	**0.105**	**0.105**	0.000	**0.109**	0.013		**0.413**	**0.306**
	O	**0.084**	-0.001	0.001	**0.092**	0.004	**0.067**	**0.117**	-0.001	0.000	**0.091**	0.000	**0.044**	**0.104**		**0.025**
	Unas.	**0.056**	0.009	0.005	**0.061**	0.023	**0.041**	**0.086**	0.008	0.005	**0.060**	0.000	**0.022**	**0.075**	0.003	

Annex I

Maps of the Genetic Data

André Punt

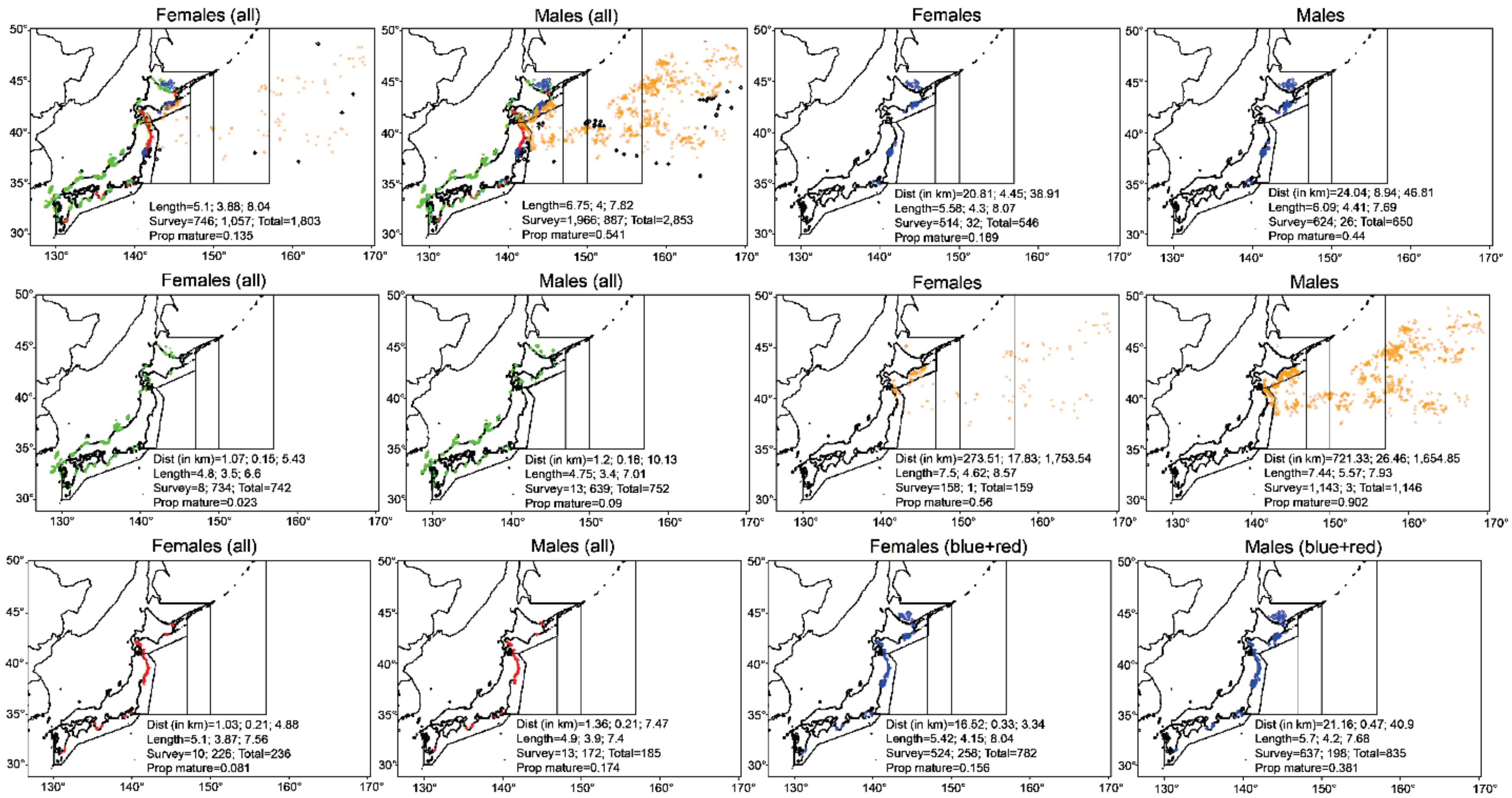


Fig. 1. Locations of the four putative clusters identified by Geneland ('green', 'orange', 'red', 'blue') and unassigned animals ('black'). Results are shown by sex and when a 90% threshold is applied as the basis for assignment. The top left two panels show results for all clusters, the top right two panels results for the 'blue' cluster, the centre left panels results for the 'green' cluster, the centre right panels results for the 'orange' cluster, the lower left panels results for the 'red' cluster, and the lower right panels results for the 'blue' and 'red' clusters combined. Each panel reports the median and 90% intervals for length, the sample size of animals taken during scientific catches and as bycatch, the proportion mature, and (except for the panel with all clusters) the median and 90% intervals for minimum distance to the coast.

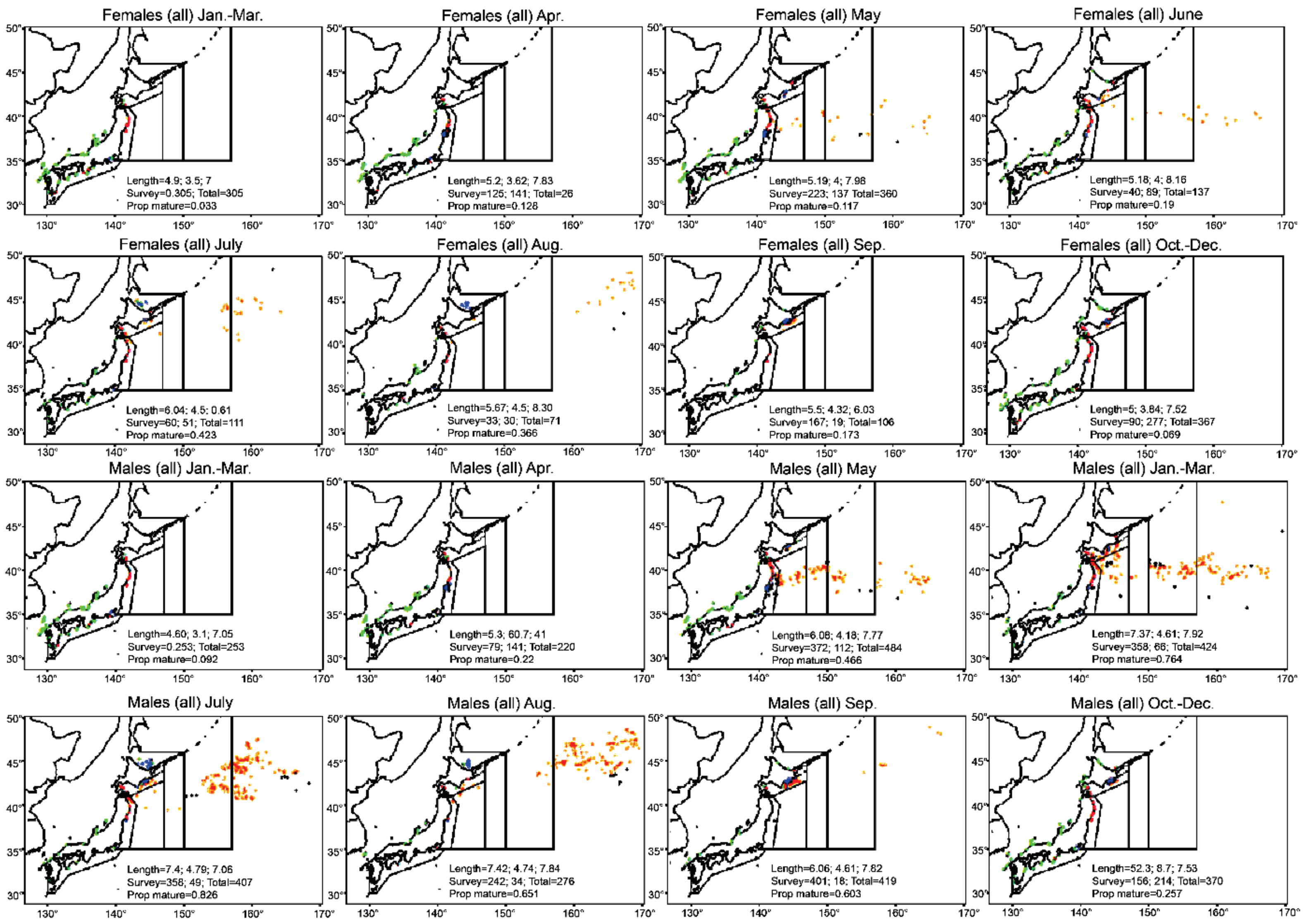


Fig. 2a. Distributions of samples by sex and month for the four putative clusters identified by Geneland ('green', 'orange', 'red', 'blue') and unassigned animals ('black') when a 90% threshold is applied as the basis for assignment. Each panel reports the median and 90% intervals for length, the sample size of animals taken during scientific catches and as bycatch, the proportion mature, and (except for the panel with all clusters) the median and 90% intervals for minimum distance to the coast. Empty panels denote zero sample size.

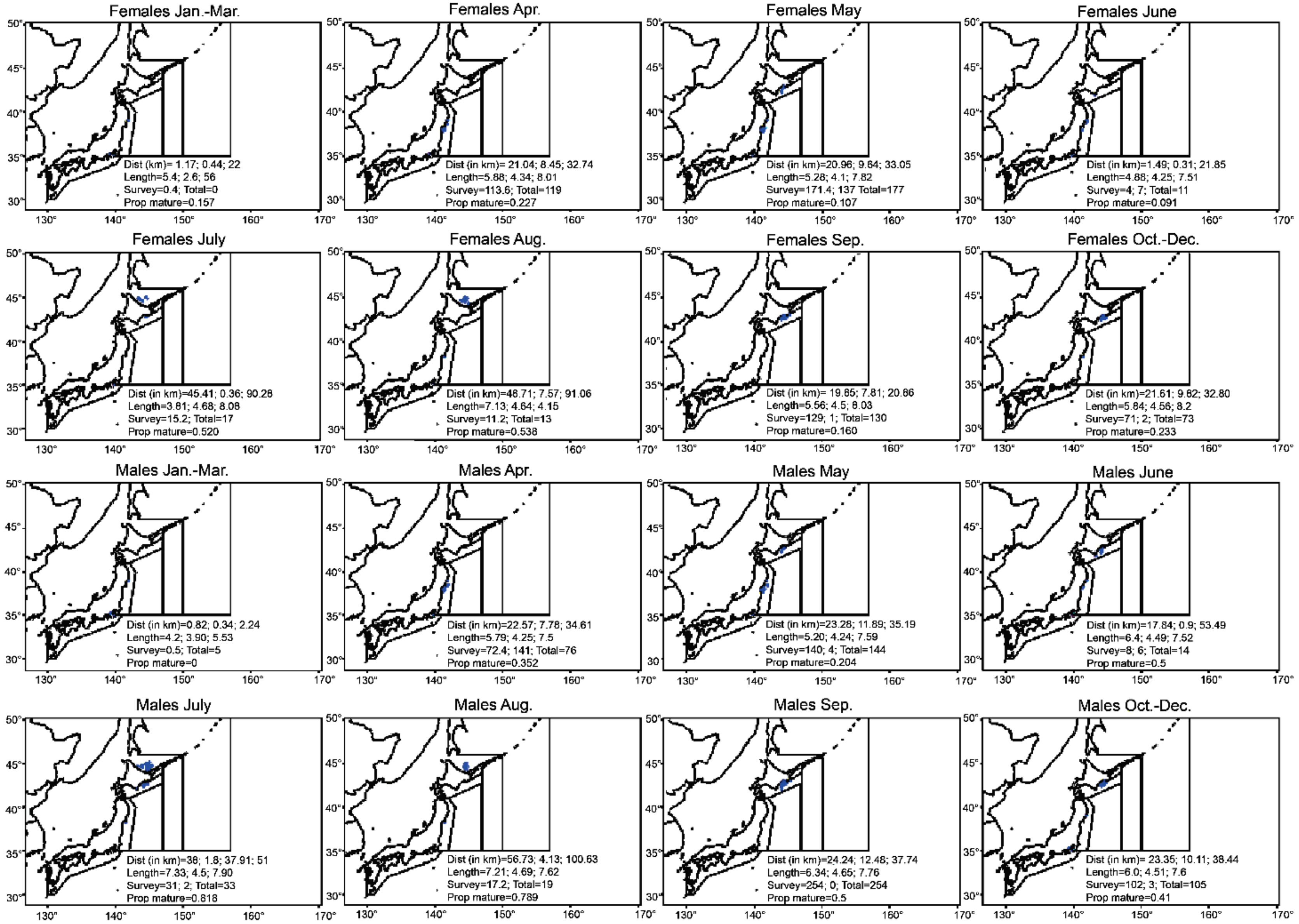


Fig. 2b. As for Fig. 2a, except results are shown for the ‘blue’ cluster.

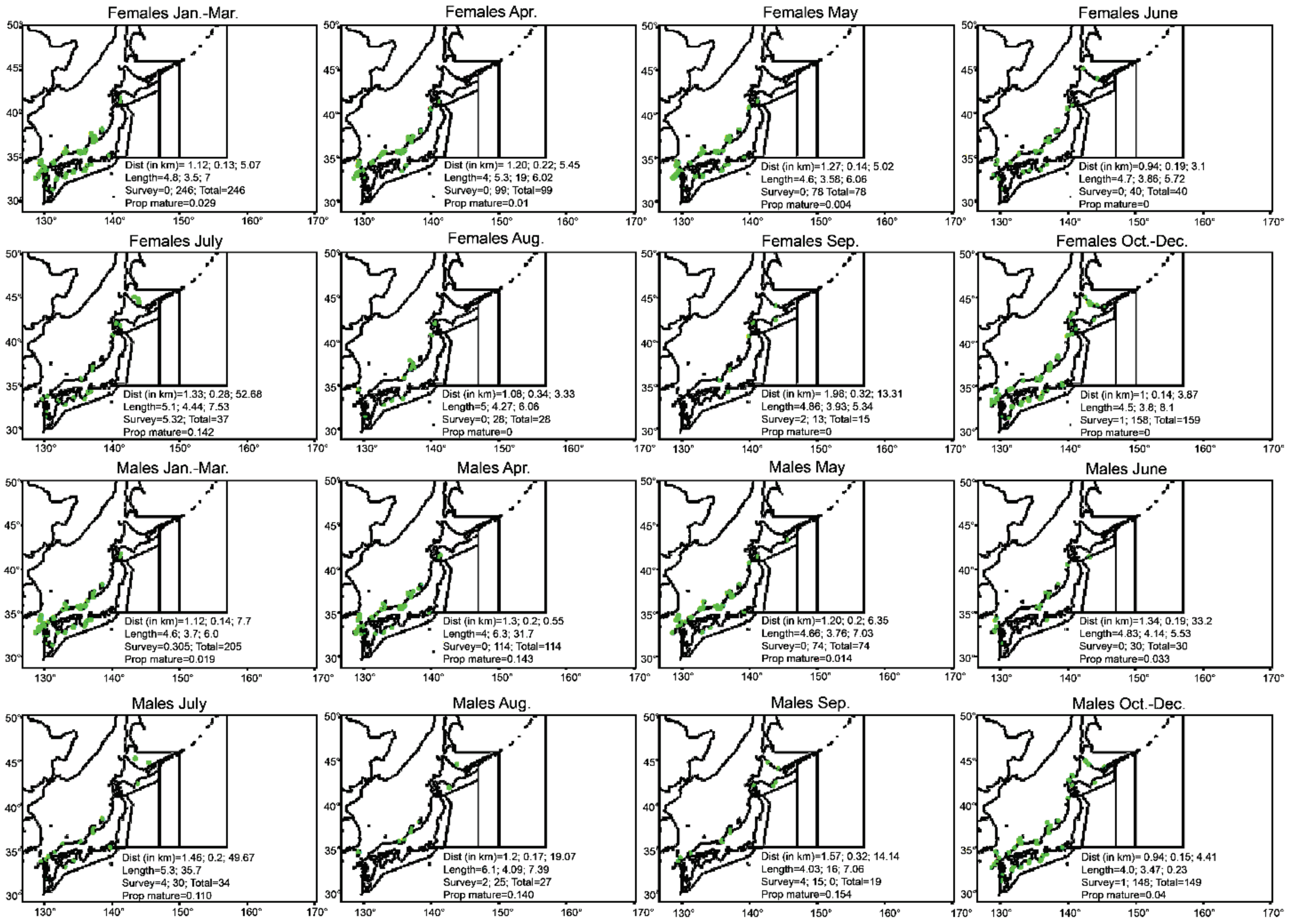


Fig. 2c. As for Fig. 2a, except results are shown for the 'green' cluster.

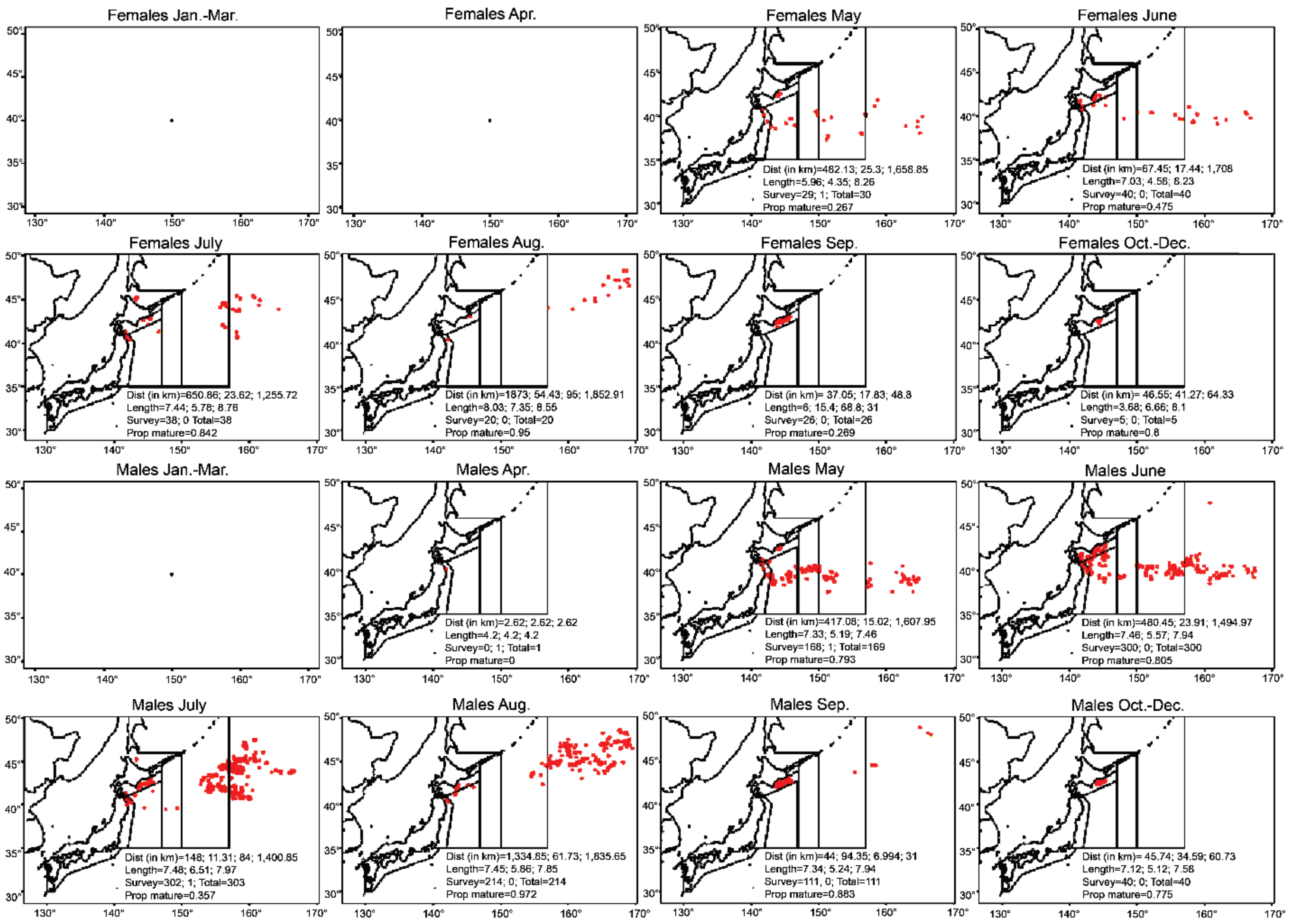


Fig. 2d. As for Fig. 2a, except results are shown for the ‘orange’ cluster.

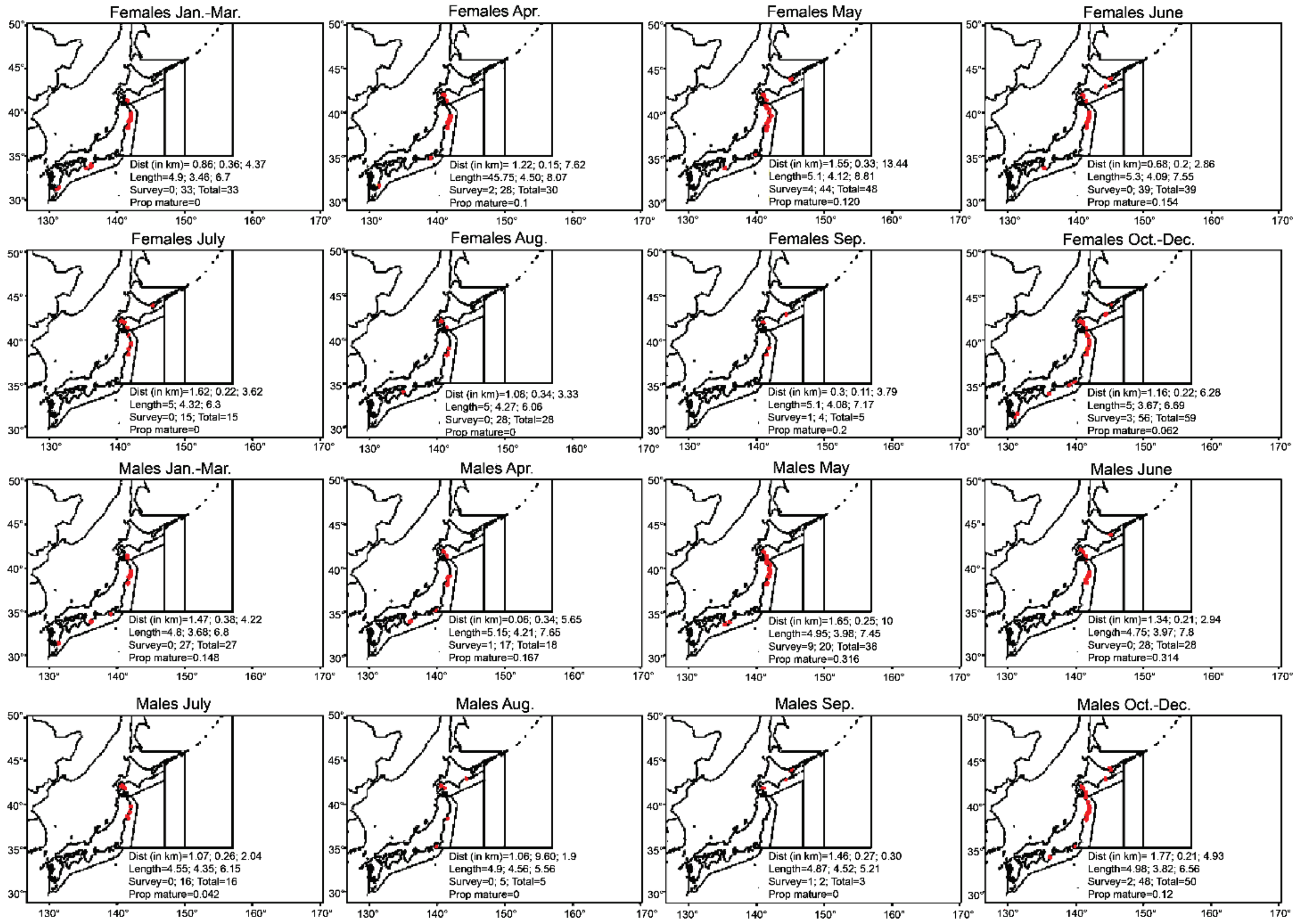


Fig. 2e. As for Fig. 2a, except results are shown for the ‘red’ cluster.

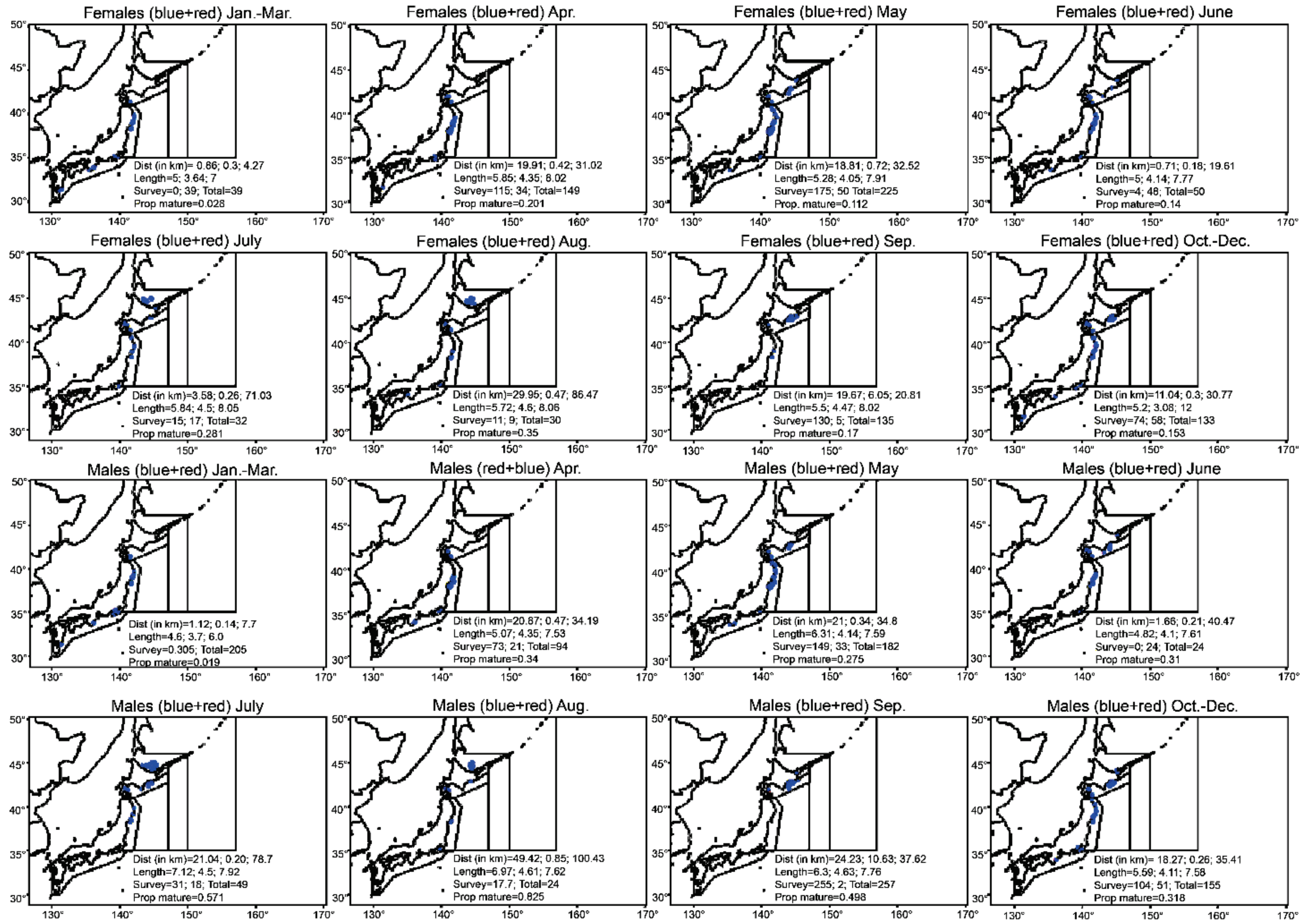


Fig. 2f. As for Fig. 2a, except results are shown for the ‘blue’ and ‘red’ clusters.

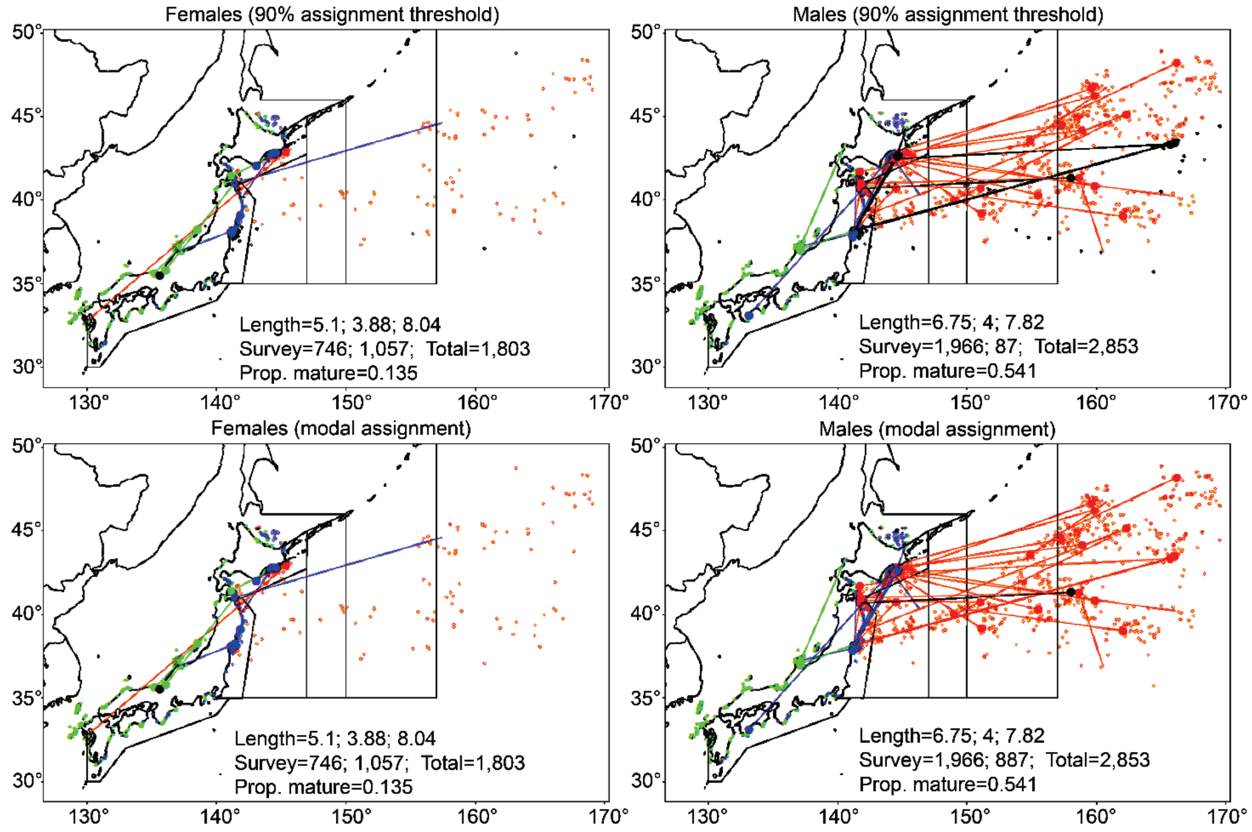


Fig. 3. Locations of the three putative clusters identified by Geneland ('green', 'orange', 'purple') and unassigned animals ('black'). Results are shown by sex and when a 90% threshold is applied as the basis for assignment (upper panels) and when the cluster is assigned based on the most likely assignment (lower panels). The lines connect parent-offspring pairs, with the colour assigned based on the parent.

Annex J

Abundance Estimates

Abundance estimates by sub-area for use in the *Implementation Review*. Note that the Workshop's recommendations on acceptance of the abundance estimates for use in the current *Implementation Simulation Trials* are reflected in the final two columns of the Table in the form of yes/no agreement/no, followed by a brief rationale for any disagreement. The notation * indicates that further analysis needs to be considered for an estimate to become acceptable for use in a real application. The Standard (STD) estimate based on Top and Upper bridge will be used as given in the catch limit calculations (when conditioning, the estimates are adjusted for *g*(0)). CV does not consider any process errors. Cmin: used as minimum estimate in conditioning; C: used in conditioning; T: used in 2013 trials.

Sub-area and Year	Season	Areal coverage (%)	STD estimate[1]	CV	Used in 2013	Use in current trials	Rationale and notes
5							
2001	Apr.-May	13.0	1,534	0.523	Cmin, T*	Cmin	Low area coverage. Only area completed. Needs further analysis.
2004	Apr.-May	13.0	799	0.321	Cmin, T*	Cmin	Low area coverage. Only area completed. Needs further analysis.
2008	Apr.-May	13.0	680	0.372	Cmin, T*	Cmin	Low area coverage. Only area completed. Needs further analysis.
2011	Apr.-May	13.0	587	0.405	T*	Cmin	Only area completed. Needs further analysis.
6W							
2000	Apr.-May	14.3	549	0.419	Cmin, T*	Cmin	Low area coverage. Use inshore segment only with adjustment for differential extent of inshore coverage (no extrapolation).
2002	Apr.-May	14.3	391	0.614	Cmin, T*	Cmin	As above
2003	Apr.-May	14.3	485	0.343	Cmin, T*	Cmin	As above
2005	Apr.-May	14.3	336	0.317	Cmin, T*	Cmin	As above
2006	Apr.-May	14.3	459	0.516	Cmin, T*	Cmin	As above
2007	Apr.-May	14.3	575	0.437	Cmin, T*	Cmin	As above
2009	Apr.-May	14.3	884	0.286	Cmin, T*	Cmin	As above
2010	Apr.-May	23.6	1,014	0.397	T*	Cmin	As above
6E							
2002	May-Jun.	79.1	891	0.608	C, T	Yes*	Poor coverage and analysis difficulties. Poor availability. Only use northern part (original estimate was based only on northern part).
2003	May-Jun.	79.1	935	0.357	C, T	Yes	Northern part only used to avoid double counting.
2004	May-Jun.	79.1	727	0.372	C, T	Yes	(Incomplete coverage). Only N offshore block used.
10W							
2006	May-Jun.	59.9	2,476	0.312	C, T	Yes	-
10E							
2002	May-Jun.	100	816	0.658	C, T	Yes	61% of pre-determined track line was covered on effort and is sufficient to retain the estimate.
2003	May-Jun.	100	405	0.566	C, T	Yes	-
2004	May-Jun.	100	474	0.537	C	No	Design question: (most sightings in concentration near coast), poor coverage. Not for use with RMP.
2005	May-Jun.	64.6	599	0.441	C, T	Yes	In 2005, survey blocks were surveyed twice. (No. of primary sightings: 1st part: 1 over 387n.miles, 2nd part: 9 over 842 n.miles). To avoid double counting the estimate was recalculated using 2nd part and only in offshore block. Area, *n* and *L* were recalculated; ESW and *s* were the same as for the whole area.
2007	May-Jun.	80.1	575	0.327	(C)	No	Estimate only used in 2013 to condition a sensitivity trial.
7CS							
1991	Aug.-Sep.				T	See 7W	See combined estimate for sub-area 7W.
2004	May	36.7	504	0.291	C	Yes*	Estimate recalculated for the northern part only (using estimates of ESW & S from the whole area). Not used by *CLA* because of timing.
2006	Jun.-Jul.	100	3,690	1.199	C	Yes*	Analysis for non-random start. Estimate not used by *CLA* because of timing.
2012	May-Jun.	100	537	0.346	-	Yes*	Estimate not available for conditioning in 2013; not used by *CLA* because of timing.
7CN							
1991	Aug.-Sep.				T	See 7W	See combined estimate for sub-area 7W.
2003	May	75.4	184	0.805	C	Cmin	Inadequate and heterogeneous coverage.
2012	May-Jun.	66.7	542	0.601	-	Yes*	Estimate not available for conditioning in 2013.
2012	Sep.	66.7	599	0.525	T	Yes*	Estimate not available for conditioning in 2013.
7WR							
1991	Aug.-Sep.				T*	See 7W	See combined estimate for sub-area 7W.
2003	May-Jun.	26.7	267	0.700	Cmin	No	Low area coverage. Estimate recalculated for northern part only with analysis for non-random starts; not used by *CLA* because of timing.
2004	May-Jun.	88.8	863	0.648	C	Yes	Not used by *CLA* because of timing.
2007	Jun.-Jul.	88.8	546	0.953	C	Yes*	Analysis for non-random start. Not used by *CLA* because of timing.

Subarea and Year	Season	Areal coverage (%)	STD estimate[1]	CV	Used in 2013	Use in current trials	Rationale and notes
7W							
1991	Aug.-Sep.	-	1,164	0.183	T*	Yes	Estimate from combined surveys in 1990-92, should not be split, except was prorated for trials: 7CS 0; 7CN 853 CV=0.23; 7WR 311 CV=0.23.
7E							
1990	Aug.-Sep.		791	1.848	(2003)	No	CV too high to be meaningful. Used in conditioning in 2003.
2004	May-Jun.	57.1	440	0.779	C	Yes	Estimate not used by *CLA* because of timing.
2006	May-Jun.	57.1	247	0.892	C	Yes	Estimate not used by *CLA* because of timing.
2007	Jun.-Jul.	57.1	0		T*	See 7W+8	Conditioning used 7E+8 combined. Estimate OK to use with analysis (non-random start; no planned coverage in Russian EEZ (upper left)) but not used by *CLA* because of timing.
7E+8							
2007	Jun.-Jul.	-	391	1.013	C	Yes*	With analysis: non-random start; no planned coverage in upper left (Russian EEZ).
8							
1990	Aug.-Sep.	62.2	1,057	0.706	C, T	Yes	Agreed in 2003. In other years, no whales observed in area not covered.
2002	Jun.-Jul.	65.0	0	(482)	C	Yes	Estimate not used by *CLA* because of timing. Conditioning: fit using normal distribution (se 482=average for non-zero estimates).
2004	Jun.	40.5	1,093	0.576	C	Yes	In other years, no whales observed in area not covered.
2005	May-Jul.	65.0	132	1.047	C	Yes*	With analysis: non-random start; no planned coverage in upper left (Russian EEZ), 2 sets of lines in lower blocks.
2006	May-Jul.	65.0	309	0.677	C	Yes	-
9							
1990	Aug.-Sep.	35.1	8,264	0.396	C, T	Yes	-
2003	Jul.-Sep.	33.2	2,546	0.276	Cmin, T	Cmin	Survey not co-incident with density peak in Aug.-Sep.
9N							
2005	Aug.-Sep.	67.8	420	0.969	C	Yes	-
11							
1990	Aug.-Sep.	100.0	2,120	0.449	C, T	Yes	Agreed in 2003.
1999	Aug.-Sep.	100.0	1,456	0.565	C, T	Yes	Agreed in 2003.
2003	Aug.-Sep.	33.9	882	0.820	C, T	Yes*	Potentially biased due to weather induced coverage omission to North. Agreed: not acceptable to include coastal transect in analysis. Confirmed: estimate refers only to surveyed part of subarea and excludes transit legs.
2007	Aug.-Sep.	20.2	377	0.389	Cmin, T	Cmin	Low area coverage. Estimate was confirmed to have come from transect lines only.
12SW							
1990	Aug.-Sep.	100.0	5,244	0.806	C, T	Yes*	Agreed in 2003.
2003	Aug.-Sep.	100.0	3,401	0.409	C, T	Yes*	Low area coverage. Confirmed: estimate refers only to part of sub-area with had adequate coverage.
12NE							
1990	Aug.-Sep.	100.0	10,397	0.364	C, T	Yes*	Agreed in 2003.
1992	Aug.-Sep.	89.4	11,544	0.380	T	Yes*	Agreed (IWC, 2003, pp.470-2 with CV recalculated; Miyashita). Miyashita and Shimada (1994) estimate for SA 12: 10,897 CV 0.46 91.2% areal coverage was scaled up (=11,948) 'to render it comparable to that from 1989/90' (IWC, 1997, p.211) and split between 12SW (404) and NE (11,544). [$]Wrong year (1999) used when conditioning trials (IWC, 2012, p.424).
1999	Aug.-Sep.	63.8	5,088	0.377	C, T	Yes*	Omit E block – inadequate coverage. Limit N block to area surveyed. Estimate recalculated using only those parts of the various strata which had been covered effectively.
2003	Aug.-Sep.	46.0	13,067	0.287	C, T	Yes*	Agreed: 2 blocks should be omitted due to inadequate coverage. Question concerning coverage in the other 3 blocks (2 NW and one E). Confirmed: the estimate is based on the 3 blocks with adequate survey coverage, and for the northernmost block only includes the area covered by completed transects.

REFERENCES

International Whaling Commission. 1997. Report of the Scientific Committee, Annex J. Report of the Working Group on North Pacific minke whale trials. *Rep. Int. Whal. Comm.* 47:203-26.

International Whaling Commission. 2003. Report of the Workshop on North Pacific common minke whale (*Balaenoptera acutorostrata*) *Implementation Simulation Trials*. *J. Cetacean Res. Manage. (Suppl.)* 5:455-87.

International Whaling Commission. 2012. Report of the First RMP Intersessional Workshop for Western North Pacific Common Minke Whales, Pusan, Republic of Korea, 14-17 December 2010. *J. Cetacean Res. Manage. (Suppl.)* 13: 411-460.

Miyashita, T. and Shimada, H. 1994. Minke whale abundance in the Okhotsk Sea, the Sea of Japan and off the Pacific coast of Northern Japan estimated from sighting data. Paper SC/46/NP6 presented to the IWC Scientific Committee, May 1994 (unpublished). 9pp. [Paper available from the Office of this Journal].

Annex K

North Pacific Minke Whale *Implementation Simulation Trial* Specifications

C. Allison, C.L. de Moor and A.E. Punt

DRAFT – the details of some of these specifications remain to be finalised

A. Basic concepts and stock structure

The objective of the North Pacific minke whale *Implementation Simulation Trials* is to examine the performance of the RMP in scenarios that relate to the actual problem of managing a likely fishery for minke whales in the North Pacific. The trials attempt to bound the range of plausible hypotheses regarding the number of minke whale stocks in the North Pacific, how they feed (by sex, age and month) and recruit and how surveys index them. The underlying dynamics model is age- and sex-structured and allows for multiple stocks.

The region to be managed (the western North Pacific) is divided into 22 sub-areas (see Fig. 1). Future surveys are unlikely to cover sub-areas 1, 2, 3, 4 and 13 (see Table 3) so these sub-areas are taken to be *Residual Areas* in the current trials (although allowance is made for future bycatches from some of these sub-areas – see section D). The term 'stock' refers to a group of whales from the same breeding ground.

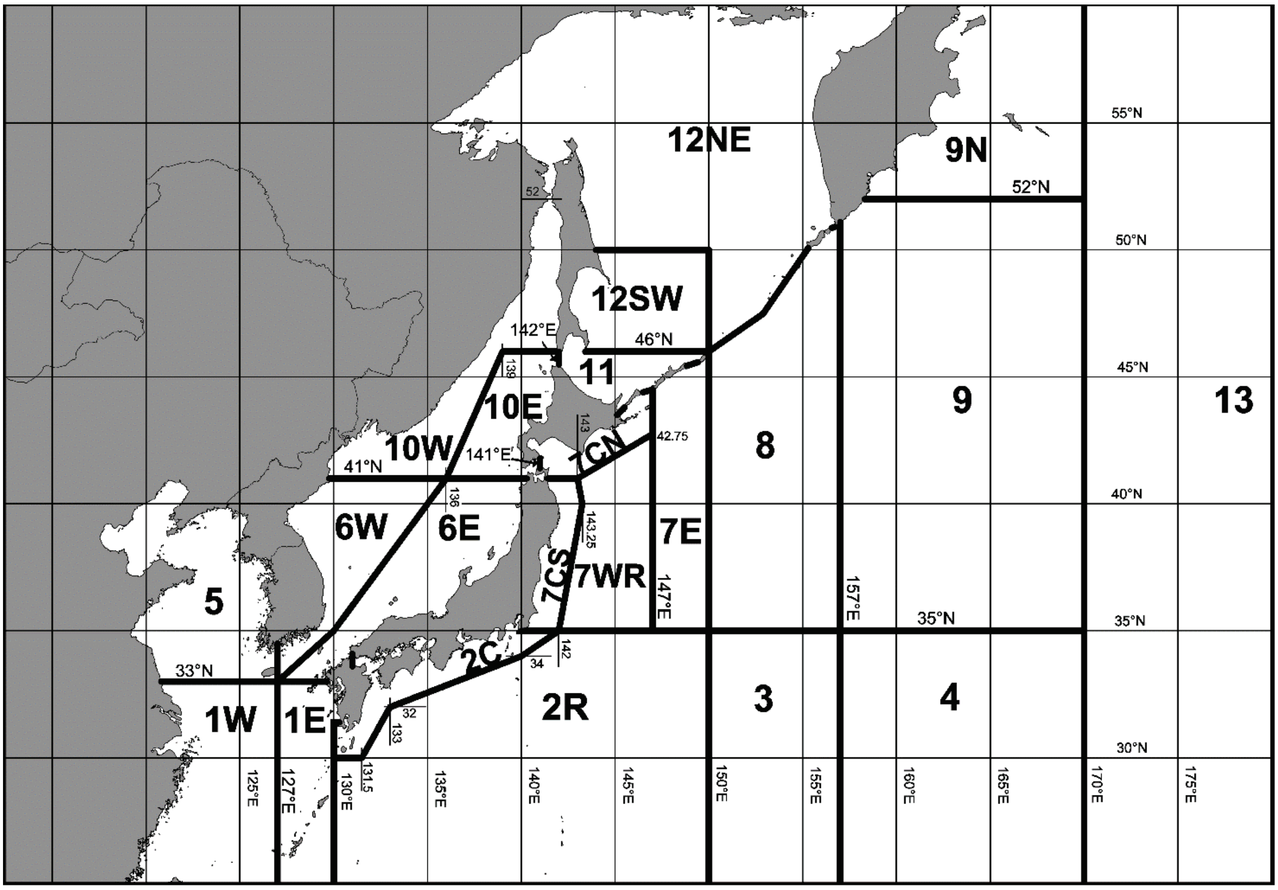


Fig. 1. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales.

Three fundamental hypotheses are considered to account for patterns observed in the results from the genetic analyses[1]:

(A) there is a single J-stock that occurs to the west of Japan (Sea of Japan and Yellow Sea) and the Pacific coast of Japan (sub-areas 2C, 7CS, 7CN, 11 and 12SW) and a single O-stock in sub-areas to the east and north of Japan (2C, 2R, 3, 4, 7CS, 7CN, 7WR, 7E, 8, 9, 9N, 10E, 11, 12SW, 12NE and 13) (referred to as hypothesis A);

(B) as for hypothesis (A), but there is a third stock (Y) that resides in the Yellow sea (sub-areas 1W, 5 and 6W) and overlaps with J-stock in the southern part of sub-area 6W (referred to as hypothesis B); and

(E) there are four stocks, referred to Y, J, P, and O, two of which (Y and J) occur in the Sea of Japan, and three of which (J, P, and O) are found to the east of Japan (referred to as hypothesis E). Stock P is a coastal stock.

Sensitivity tests in which there is a C-stock are also conducted based on stock structure hypotheses A and E. The C-stock is found in sub-areas 9 and 9N for the sensitivity test based on stock structure hypothesis A and in these sub-areas as well as sub-area 12NE for the sensitivity test based on stock structure hypothesis E. There is uncertainty regarding whether C-stock is found in sub-area 12NE because of the lack of genetics data for this sub-area.

---

[1] See this report, Item 3 (pp.376-381) for details of the data and analyses used in the development of these hypotheses.

B. Basic dynamics

Further details of the underlying age-structured model and its parameters can be found in IWC (1991, p.112), except that the model has been extended to take sex-structure and dispersal into account. The dynamics of the animals in stock *j* are governed by equations B.1(a) for stocks for which there is no dispersal (permanent movement) between stocks as is the case in all the base case trials. Stocks for which there is dispersal are governed by Equations B.1(b)[2]:

$$N^{g,j}_{t+1,a} = \begin{cases} 0.5\, b^j_{t+1} & \text{if } a = 0 \\ (N^{g,j}_{t,a-1} - C^{g,j}_{t,a-1})\tilde{S}_{a-1} & \text{if } 1 \le a < x \\ (N^{g,j}_{t,x} - C^{g,j}_{t,x})\tilde{S}_x + (N^{g,j}_{t,x-1} - C^{g,j}_{t,x-1})\tilde{S}_{x-1} & \text{if } a = x \end{cases} \qquad \text{(B.1a)}$$

$$N^{g,j}_{t+1,a} = \begin{cases} 0.5\, b^j_{t+1} & \text{if } a = 0 \\ \sum\limits_{j \ne j'} [\left(1 - D^{j,j'}\right)(N^{g,j}_{t,a-1} - C^{g,j}_{t,a-1})\tilde{S}_a + D^{j',j}(N^{g,j'}_{t,a-1} - C^{g,j'}_{t,a-1})\tilde{S}_a] & \text{if } 1 \le a < x \\ \sum\limits_{j \ne j'} [\left(1 - D^{j,j'}\right)\left((N^{g,j}_{t,x} - C^{g,j}_{t,x})\tilde{S}_x + (N^{g,j}_{t,x-1} - C^{g,j}_{t,x-1})\tilde{S}_{x-1}\right) & \\ \qquad + D^{j',j}\left((N^{g,j'}_{t,x} - C^{g,j'}_{t,x})\tilde{S}_x + (N^{g,j'}_{t,x-1} - C^{g,j'}_{t,x-1})\tilde{S}_{x-1}\right)] & \text{if } a = x \end{cases} \qquad \text{(B.1b)}$$

where $N^{g,j}_{t,a}$ is the number of animals of gender *g* and age *a* in stock *j* at the start of year *t*;

$C^{g,j}_{t,a}$ is the catch (in number) of animals of gender *g* and age *a* in stock *j* during year *t* (whaling is assumed to take place in a pulse at the start of each year);

b^j_t is the number of calves born to females from stock *j* at the start of year *t*;

$\tilde{S}_a$ is the survival rate = e^{-M_a} where M_a is the instantaneous rate of natural mortality (assumed to be independent of stock and sex); and

x is the maximum age (treated as a plus-group); and

$D^{j,j'}$ is the dispersal rate (i.e. the probability of an animal moving permanently) from stock *j* to *j'*. There is only dispersal between the P- and J-stocks and between the P- and O-stocks and assuming that the numbers dispersing from the P-stock to the J-stock and to the O-stock are the same at unexploited equilibrium. In addition, the proportion of calves dispersing from the P- to the J- and O-stocks is the same.

Note that *t*=0, the year for which catch limits might first be set, corresponds to 2020.

For computational ease, the numbers-at-age by sex are updated at the end of each year only, even though catching is assumed to occur from March to October. This simplification is unlikely to affect the results substantially for two reasons: (1) catches are at most only a few percent of the number of animals selected to the fisheries; and (2) sightings survey estimates are subject to high variability so that the resultant slight positive bias in abundance estimates is almost certainly inconsequential.

C. Births

Density-dependence is assumed to act on the female component of the mature population. The convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition.

$$b^j_t = B^j N^{\mathrm{f},j}_t \{1 + A^j (1 - (N^{\mathrm{f},j}_t / K^{\mathrm{f},j})^{z^j})\} \qquad \text{(C.1)}$$

where B^j is the average number of births (of both sexes) per year for a mature female in stock *j* in the pristine population;

A^j is the resilience parameter for stock *j*;

z^j is the degree of compensation for stock *j*;

$N^{\mathrm{f},j}_t$ is the number of 'mature' females in stock *j* at the start of year *t*:

$$N^{\mathrm{f},j}_t = \sum_{a=a_m}^{x} N^{\mathrm{f},j}_{t,a} \qquad \text{(C.2)}$$

a_m is the age-at-first-parturition; and

$K^{\mathrm{f},j}$ is the number of mature females in stock *j* in the pristine (pre-exploitation, written as *t*=-∞) population:

$$K^{\mathrm{f},j} = \sum_{a=a_m}^{x} N^{\mathrm{f},j}_{-\infty,a} \qquad \text{(C.3)}$$

The values of the parameters A^j and z^j for each stock are calculated from the values for $MSYL^j$ and $MSYR^j$ (Punt, 1999). Their calculation assumes harvesting equal proportions of males and females.

---

[2] These trials do not include any models with dispersal but the control program retains the option to allow dispersal so it is included here.

D. Catches

The operating model considers two sources for non-natural mortality: direct catches and bycatches (which are also referred to as incidental catches). In future ($t \geq 2020$), the former are set by the RMP, while the latter are a function of abundance and future fishery effort. In cases in which the catch limit set by the RMP is less than the level of incidental catch, the total removals are taken to be the incidental catch only whereas if the RMP catch limit exceeds the incidental catch (if any), the level of the commercial removals is taken to be the difference between the RMP catch limit and the best estimate of the incidental catch (see 'Future incidental catches' below).

Direct catches

The direct historical (pre-2020) catch series used are listed in Adjunct 1 and include both commercial and special permit catches. Details of the sources of the catch data are given in Allison (2011). The baseline trials use the 'best' direct catch series and an alternative 'high' catch series is used in Trial 4. Trials 8 and 9 test the effect of the method used to allocate historical catches between sub-areas 5 and 6W. The RMP will use the 'best' series in all trials. Consequently, the RMP will use what are in effect incorrect catches for Trials 4, 8 and 9 in order to examine the implications of uncertainty about historical catches.

Catch limits are set by *Small Area*. (Catches are always reported by *Small Area*, i.e. the RMP is not provided with catches by sub-area for cases in which sub-areas are smaller than *Small Areas*.) As it is assumed that whales are homogeneously distributed across a sub-area, the catch limit for a sub-area is allocated to stocks by sex and age relative to their true density within that sub-area, and a catch mixing matrix V that depends on sex, age and time of the year (and may also depend on year), i.e.

$$C^{g,j}_{t,a} = \sum_{k}\sum_{q} F^{g,k,q}_{t} \sum_{a} V^{g,j,k,q}_{t,a} S^{g}_{a} \tilde{N}^{g,j}_{t,q,a} \tag{D.1}$$

$$F^{g,k,q}_{t} = \frac{C^{g,k,q}_{t}}{\sum_{j'}\sum_{a'} V^{g,j',k,q}_{t,a'} S^{g}_{a'} \tilde{N}^{g,j'}_{t,q,a'}} \tag{D.2}$$

where $F^{g,k,q}_{t}$ is the exploitation rate in sub-area k on fully recruited ($S^g_a \rightarrow 1$) animals of gender g during month q of year t;

S^g_a is the selectivity on animals of gender g and age a :

$$S^{g}_{a} = (1+e^{-(a-a^{g}_{50})/\delta^{g}})^{-1} \tag{D.3}$$

$\tilde{N}^{g,j}_{t,q,a}$ is the number of animals of gender g and age a in stock j at the start of month q in year t after removal of catches in earlier months and after any bycatches have been removed;

$$\tilde{N}^{g,j}_{t,q,a} = \ddot{N}^{g,j}_{t,q,a}\left(1 - V^{g,j,k,q}_{t,a} F^{g,k,q}_{B,t}\right) \quad \text{for all sub-areas except 7CS and 7CN and}$$

$$\tilde{N}^{g,j}_{t,q,a} = \ddot{N}^{g,j}_{t,q,a}\left(1 - F^{g,k,q,j}_{B,t}\right) \quad \text{for sub-areas 7CS and 7CN,}$$

a^g_{50}, δ^g are the parameters of the (logistic) selectivity ogive for gender g;

$C^{g,k,q}_{t}$ is the catch of animals of gender g in sub-area k during month q of year t (see Adjunct 1 for the historical catches);

$\ddot{N}^{g,j}_{t,q,a}$ is the number of animals of gender g and age a in stock j at the start of month q in year t after removal of bycatches and catches in any earlier months;

$F^{g,k,q}_{B,t}$ is the removal rate due to bycatch of gender g in sub-area k (all sub-areas except 7CS and 7CN) during month q of year t

$$F^{g,k,q}_{B,t} = \frac{C^{g,k,q}_{B,t}}{\sum_{j'}\sum_{a'} V^{g,j',k,q}_{t,a'} \ddot{N}^{g,j'}_{t,q,a}}$$

$F^{g,k,q,j}_{B,t}$ is the removal rate due to bycatch of gender g and stock j in sub-area k (sub-areas 7CS and 7CN) during month q of year t.

$$F^{g,k,q,j}_{B,t} = \frac{p^{k,q,j}_{B} C^{g,k,q}_{B,t}}{\sum_{a'} \ddot{N}^{g,j}_{t,q,a}} \quad \text{where } p^{k,q,j}_{B} \text{ is given by Table 2b; and}$$

$C^{g,k,q}_{B,t}$ is the bycatch of animals of gender g in sub-area k during month q of year t (given by equation D.5).

Each entry in the catch mixing matrix, $V^{g,j,k,q}_{t,a}$, is the fraction of males/females of age a from stock j that are found in sub-area k during month q of year t. The catch mixing matrix is different for each month to reflect the effects of migration between the breeding and the feeding grounds and back. Adjunct 2 lists the catch mixing matrices considered. The matrices are based on the presence/absence matrices developed at the First Intersessional Workshop (see this report, p.385) and represent the relative fraction of an age-class in each of the sub-areas during the months March-October. Once the values of the parameters related to mixing rates (the γs – see section F) are specified (these are estimated separately for each trial and each replicate in the conditioning process), the catch mixing matrices can be converted to fractions of each age-class in each sub-area. The values for the γ parameters are selected to mimic available data (see Section F).

Catch mixing matrices are specified for ages 4 and 10 (these being three years below and above the assumed age-at-50%-maturity). Few animals of age 4 are mature while most of age 10 are. The catch mixing matrices for ages 0-3 are assumed to be the same as that for age 4, and those for ages 11+ the same as that for age 10. The catch mixing matrices for ages 5-9 are set by interpolating linearly between those for ages 4 and 10.

The trials model whale movements in the eight-months from March to October. In order to account for historical direct and incidental catches outside these months, all catches in January-March are modelled as being taken in March and the catches after October are assumed to have been taken in October. The historical direct catches by sex, sub-area, month and year are given in Adjunct 1.

The trials are conducted assuming that the sub-areas for which future catch limits might be set are:

sub-area	7CS and 7CN	April to October (coastal/pelagic whaling outside a specified distance[3])
	7WR and 7E	April to October (pelagic whaling)
	8 and 9	April to October (pelagic whaling)
	11	April to October (coastal and pelagic whaling)
	12	April to October (coastal and pelagic whaling)

The future ($t \geq 2020$) commercial catches by sex, sub-area, month and year are calculated using the equation:

$$C_t^{g,k,q} = C_t^k \, Q^{g,k,q} \tag{D.4}$$

$Q^{g,k,q}$ is the fraction of the commercial catch in sub-area k of gender g that is taken during month q, the values of which are given in Table 1a; and

C_t^k is the commercial catch limit for sub-area k and year t ($t \geq 2020$). Note that C_t^k is equal to the catch limit set by the RMP less any reported incidental catch (constrained to be non-negative).

Entries in the Q matrix are determined by the options related to the sub-areas for which catch limits might be set, The non-zero entries in the Q matrix (see Table 1a) reflect the historical breakdown of catches over the last 10 years of commercial whaling (1978-87) within each sub-area. In sub-areas for which there was no catch between 1978-87 (7E, 8 and 9), the entries in the Q matrix are set using the entire historical commercial and scientific catch in these sub-areas. In some instances where regulations limited the commercial whaling season, the matrix entries have been adjusted using the special permit data.

The future commercial catches in sub-areas 7CS and 7CN are removed based on the mixing proportions from the offshore (>10nm to be confirmed) samples only.

Denote the modelled mixing proportion used when conditioning to be R^k as:

$$R^k = \sum_{t=1996}^{2007} P_{1+,t}^{J/JE,k} \Big/ \sum_j \sum_{t=1996}^{2007} P_{1+,t}^{j,k}$$ where $P_{1+,t}^{j,k}$ is the average number of 1+ animals from stock j in sub-area k in year t.

The mixing proportions obtained from the offshore samples, $\tilde{R}^k$, are given in Table 2a. The proportion of J-stock animals in some future year would normally be $P_{1+,t}^{J,k} \big/ (P_{1+,t}^{J,k} + P_{1+,t}^{P,k} + P_{1+,t}^{O,k})$. For sub-areas 7CS and 7CN in future this equation is adjusted to

$$(\tilde{R}^k \neq R^k):\ \alpha^k P_{1+,t}^{J,k} \big/ (\alpha^k P_{1+,t}^{J,k} + P_{1+,t}^{P,k} + P_{1+,t}^{O,k}) \quad \text{where} \quad \alpha^k = \frac{(1-R^k)\tilde{R}^k}{(1-\tilde{R}^k)R^k} \tag{D4.a}$$

The α^k factor is then applied to the recruited population from J-stock in sub-area k when setting the commercial catch by stock using equations D.1 and D.2.

In order to comply with RMP specifications regarding the sex ratio in catches (IWC, 1999), if the proportion, P_f, of females in the total direct catch (i.e. commercial and/or special permit) taken from a *Small Area* in the five years prior to the catch limit calculation exceeds 50%, the catch limits are adjusted downwards by the ratio $0.5/P_f$.

Table 1a

The Q matrix: the percentage of the future commercial catch in sub-area k that is taken by sex and month for sub-areas other than *Residual Areas*. Dashes indicate sub-areas/months for which catch limits are defined to be zero. See text for description of how the entries are set.

Sub-area	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
				Males								**Females**				
7CS	-	24.3	21.5	10.1	4.8	0.8	0.3	-	-	21.7	12.6	2.8	0.7	0.3	-	-
7CN	-	-	0.8	8.2	15.5	15.3	23.9	11.9	-	0.1	0.4	4.9	6.9	3.5	5.3	3.1
7WR	-	0.9	45.0	30.3	2.8	0.9	6.4	-	-	-	8.3	2.8	2.8	-	-	-
7E	-	-	32.9	19.3	1.9	7.2	12.6	1.0	-	-	3.9	1.9	5.3	5.3	8.7	-
8	-	-	12.8	33.6	31.9	4.4	3.0	2.0	-	-	2.7	2.0	3.4	2.0	0.7	1.7
9	-	-	5.4	13.6	30.4	36.3	2.9	-	-	-	1.5	1.8	2.7	4.9	0.5	-
11	-	1.3	5.5	9.6	9.6	4.0	3.0	0.6	0.1	10.6	19.3	18.5	10.7	4.5	2.3	0.4

Incidental catches

Incidental catches of minke whales are known to occur off Japan (in sub-areas 1E, 2C, 6E, 7CS, 7CN, 10E and 11 and small numbers in 6W) and the Republic of Korea (sub-areas 5 and 6W and small numbers in 1W).

---

[3] Operations preliminarily being considered would be limited 'to outside a certain distance from the coast to minimise catch of J-stock whales' (see this report, Item 7 (p.387). The 2013 trials were conducted assuming whaling would be outside 10 n.miles.

Japan. It has been obligatory to report bycatches in Japan since 2001 since when the bycatch numbers are considered to be reliable. Earlier bycatches are believed to be under-reported based on the sudden increase in reported bycatches in 2001. In view of this, the relationship between bycatch and set-net effort is integrated into the conditioning process, with the advantage that the method is independent of the reporting rate prior to 2001. The reporting rate since 2001 is assumed to be constant at 100% (except in Trial 4 – see below).

Almost all of the reported bycatch off Japan occurred in set-net fisheries. Three types of set nets are used off Japan: large-scale (excluding salmon nets), salmon nets and small scale. For fishing gears other than set-nets, incidental catch, retention and marketing of whales are prohibited by the 2001 regulation and a diagnostic DNA registry is used to deter illegal distribution of whales caught. Ideally, the catch by each gear type should be modelled separately to allow the historical (pre-2001) bycatch to be predicted. However, information on numbers of catches by net type is not available. Therefore, the historical bycatches for each sub-area are set using the total number of incidental catches and the combined number of large-scale and salmon nets in each sub-area. For the best effort series, the number of nets from Japan is extrapolated from 1946 to 1969 assuming a linear relationship from 0 in 1935 to the known number in 1970 (Tobayama *et al.*, 1992). Incidental catches before 1946 are ignored because although some set-nets were in operation before 1946 (Brownell, pers. comm.) the numbers are highly uncertain and are sufficiently small that they are unlikely to effect the implementation. The years 2007-19 are excluded from the fitting as the number of nets is incomplete, and 2001 is excluded because the catch data are incomplete (as the new regulations date from June 2001). A high effort series is also generated, for use in Trial 4, in which the number of nets is double the best-case values from 1946-1969, up to a maximum equal to the number of nets in 1969. In Trial 4 all bycatches are assumed to be under-reported and are adjusted upward by a factor of 2.

Table 1b. To be updated to include recent bycatches

QB matrix: the percentage of the incidental catch in sub-area *k* that is taken by sex and month. The values are set using all the available bycatch data known by sub-area, sex and month. There is no incidental catch in the other sub-areas.

Sub-area	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Sample size
	Males								**Females**								
1E	18.6	14.0	0.0	4.7	0.0	0.0	0.0	4.7	20.9	2.3	9.3	7.0	7.0	2.3	0.0	9.3	43
2C	12.0	3.4	2.4	0.5	1.4	1.0	0.0	14.4	27.9	1.4	4.3	1.9	3.4	1.4	0.5	24.0	208
5	4.8	0.0	9.6	13.3	7.2	3.6	2.4	12.0	13.3	0.0	4.8	12.0	2.4	0.0	3.6	10.8	83
6W	10.3	5.4	5.7	5.1	3.1	2.5	5.1	14.4	11.3	5.6	6.4	7.2	2.0	1.6	1.8	12.5	610
6E	14.5	6.7	5.8	2.1	2.9	2.5	1.7	9.1	18.9	6.7	7.3	4.0	2.1	2.3	1.2	12.1	519
7CS	6.5	7.1	9.7	9.0	1.9	1.3	0.6	10.3	11.0	10.3	7.7	9.7	3.2	1.3	1.3	9.0	155
7CN	5.5	4.4	5.5	7.7	5.5	3.3	1.1	7.7	4.4	8.8	9.9	11.0	7.7	3.3	2.2	12.1	91
10E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.7	0.0	0.0	0.0	8.3	0.0	0.0	0.0	50.0	12
11	0.00	0.00	0.00	0.00	0.00	0.00	5.41	29.73	0.00	0.00	16.22	16.22	2.70	0.00	0.00	29.73	37

Korea. The same method is used as for Japan above except the incidental catch numbers from 1996-2018 (sub-area 6W) and 2000-2018 (sub-area 5) are used to extrapolate backwards and the catch numbers are adjusted to allow for underreporting. The bycatches in sub-area 6W (the East Sea) are adjusted upward by a factor of 2. The factor 2 is based on DNA profiling and a capture-recapture analysis of market products which estimated a total of 887 whales going through Korean markets from 1999-2003, in comparison to the reported catch of 458 whales (Baker *et al.*, 2007). The baseline trials assume that the bycatches in the Yellow Sea (sub-area 5) are fully reported as there is no evidence of under-reporting. The 'high' effort series for sub-area 5 used in Trial 4 will apply the same estimate of under-reporting as for sub-area 6W (i.e. a factor of 2) and the number of nets is set to the maximum of either double the base-case values or the number of nets in 1969.

To account for bycatch prior to 1996, the average for the *adjusted* takes are used to extrapolate backwards to 1946 based on fisheries effort using the same approach as for Japan. Incidental catches before 1946 are ignored as for Japan.

China. There are no data on incidental catches off China, although they are known to occur. The trials therefore consider two [essentially arbitrary] scenarios: (i) the incidental catch by China is twice that reported by Korea in sub-area 5); and (ii) incidental catches off China are ignored. The first of the options forms part of the baseline specifications and the second is included in a sensitivity test (see Trial 12) to determine the effects of the base case assumptions.

Allocation to sex and month. Bycatches by sex, sub-area (except for sub-areas 7CS and 7CN in future years), month and year are calculated using the equation:

$$C_{B,t}^{g,k,q} = C_{B,t}^{k}\, Q_B^{g,k,q} \tag{D.5}$$

$Q_B^{g,k,q}$ is the fraction of the bycatch of gender g in sub-area k which is taken during month q and, the values of which are given in Table 1b; and

$C_{B,t}^{k}$ is the bycatch in sub-area k and year t (as estimated by the model).

To avoid a proliferation of sub-areas and to avoid the need for finer time-steps than month, the probability of the bycatch in sub-areas 7CS and 7CN being one of the two stocks in the sub-area is assumed to be time-invariant while the incidental catches in sub-areas other than 7CS and 7CN are apportioned to stock and age class in the same way as for the commercial catches (i.e. using Equations D.1 and D.2, but assuming that the bycatch is taken uniformly from all age classes (i.e. selectivity=1)). The bycatches in sub-areas 7CS and 7CN are split to stock using mixing proportions calculated from the weighted average of the mixing proportions obtained from mtDNA haplotype and microsatellite allele bycatch samples, as listed in the final columns of Table 2b.

The historical bycatch model: The historical bycatch $C_{B,t}^{k}$ in sub-area k in year t is given by:

$$C_{B,t}^{k} = A^k\, P_t^k E_t^k \tag{D.6}$$

where A^k is the bycatch constant, E^k_t is the number of nets in sub-area *k* in year *t* and P^k_t is the total population size (including calves) in sub-area *k* in year *t* averaged over all 8 time periods. In Trial 17, the abundance P^k_t in equation D.6 is replaced by $\sqrt{(P^k_t)}$ to test a different assumption for the relationship between bycatch and abundance and the impact of possible saturation effects. The values of the bycatch constants are set by fitting during the conditioning process (see section F).

The recent by catches and the numbers of set-nets by type, year and area are listed in Adjunct 1. Further details are given in Annex H of IWC (2012a).

Table 2a

Time invariant fixed proportions by stock to be used in removing **future commercial catches** from sub-areas 7CS and 7CN for each for Hypothesis, based on the number of sampled whales that were assigned to each stock using the genetic data[4] limited to Scientific Permit samples only [in the 2013 trials this was limited to >10n.miles]. The values are set using data from 1996-2016.

			Sample size		Proportion	
Hypothesis	Sub-Area	Months	J-Stock	O-Stock	J-Stock	O-Stock
A & B	7CS	Apr	48	138	0.258	0.742
A & B	7CS	May	89	225	0.259	0.741
A & B	7CS	Jun-Sep	4	75	0.051	0.949
A & B	7CN	Apr-Jun	12	139	0.079	0.921
A & B	7CN	Jul-Dec	169	645	0.208	0.792

			Sample size			Proportion		
Hypothesis	Sub-Area	Months	J-Stock	P-Stock	O-Stock	J-Stock	P-Stock	O-Stock
E	7CS	Apr	0	188	0	0.000	1.000	0.000
E	7CS	May	0	303	24	0.000	0.927	0.073
E	7CS	Jun-Sep	0	5	73	0.000	0.064	0.936
E	7CN	Apr-Jun	2	28	109	0.014	0.201	0.784
E	7CN	Jul-Dec	10	574	225	0.012	0.710	0.278

Table 2b

Time invariant fixed proportions by stock to be used in removing **bycatch** from sub-areas 7CS and 7CN for each for Hypothesis, based on the number of sampled whales that were assigned to each stock using genetic data[5] limited to bycatch only, using data from 2001-2016.

			Sample size		Proportion	
Hypothesis	Sub-Area	Months	J-Stock	O-Stock	J-Stock	O-Stock
A & B	7CS	Jan-Apr	43	34	0.558	0.442
A & B	7CS	May	16	31	0.340	0.660
A & B	7CS	Jun-Dec	86	34	0.717	0.283
A & B	7CN	Jan-Jun	38	44	0.463	0.537
A & B	7CN	Jul-Dec	51	15	0.773	0.227

			Sample size			Proportion		
Hypothesis	Sub-Area	Months	J-Stock	P-Stock	O-Stock	J-Stock	P-Stock	O-Stock
E	7CS	Jan-Apr	0	73	1	0.000	0.986	0.014
E	7CS	May	0	49	2	0.000	0.961	0.039
E	7CS	Jun-Dec	0	118	1	0.000	0.992	0.008
E	7CN	Jan-Jun	12	69	0	0.148	0.852	0.000
E	7CN	Jul-Dec	13	59	0	0.181	0.819	0.000

Future bycatches: Future bycatches by sub-area (except in sub-areas 7CS and 7CN) are generated assuming that the exploitation rate due to bycatch in the future equals that estimated for the trial in question for the most recent five-years of data used in the conditioning process, i.e.:

$$C^k_{B,t} = \overline{F}^k \, P^k_t \tag{D.7}$$

where $C^k_{B,t}$ is the bycatch in sub-area *k* in year *t,* P^k_t is the total population (including calves) in sub-area *k* in year *t* averaged over all 8 time periods (March-October), and $\overline{F}^k$ is the average exploitation rate (sum over years of the known bycatch divided by the sum over years of P^k_t) over the last five years of the period used for conditioning (2012-16 for sub-areas off Japan and 2014-18 for those off Korea i.e. *F* is reset for each of the 100 simulations within a trial. Thus, the future bycatch by sex, month and sub-area is given by:

$$C^{g,k,q}_{B,t} = Q^{g,k,q}_{B} \overline{F}^k \, P^k_t \tag{D.7a}$$

For Trial 17, the abundance P^k_t in equation D.7a is replaced by $\sqrt{(P^k_t)}$.

---

[4] From the data file 'Data_NPM_190226_v3.csv', based on 'stock90' for Hypotheses A&B and 'geneland.stock2' for Hypothesis E, using Scientific Permit data only. The months are based on the same month-split used in 2013 for commercial catches. There were no Scientific Permit catches in 7CN & 7CS in Jan-Mar or in 7CS in Oct-Dec.

[5] From the data file 'Data_NPM_190226_v3.csv', based on 'stock90' for Hypotheses A&B and 'geneland.stock2' for Hypothesis E, using Scientific Permit data only. The months are based on the same month-split used in 2013 for bycatches.

To avoid possible dis-proportionate bycatches of J- to O-stock whales, equation (D.7a) is replaced with (D.7b) in sub-areas 7CS and 7CN [to come: 3 stock version of this equation for hypothesis E].

$$C_{B,t}^{g,k,q} = \tilde{P}_t^{k,q}\,\overline{F}^k\,Q_B^{g,k,q} \tag{D.7b}$$

where $\tilde{P}_t^{k,q}$ is the availability-weighted population size in sub-area *k* during month *q*:

$$\tilde{P}_t^{k,q} = (P_t^{k,q,J} + \lambda^{k,q} P_t^{k,q,O})\,\frac{\overline{P}^{k,q,J} + \overline{P}^{k,q,O}}{\overline{P}^{k,q,J} + \lambda^{k,q}\,\overline{P}^{k,q,O}} \tag{D.8}$$

where $\overline{P}^{k,q,j}$ is the average number (including calves) of stock *j* animals in sub-area *k* during month *q* over the last five years of the period used for conditioning;

$P_t^{k,q,j}$ is the total population (including calves) of stock *j* in sub-area *k* during month *q* of year *t*;

$\lambda^{k,q}$ is a relative availability factor for J whales relative to O whales:

$$\lambda^{k,q} = \frac{(1-\ddot{P}^{k,q})}{\ddot{P}^{k,q}}\,\frac{\overline{P}^{k,q,J}}{\overline{P}^{k,q,O}} \tag{D.9}$$

$\ddot{P}^{k,q}$ is the weighted mean proportion of J-stock in sub-area *k* during month *q* (as given in Table 2b).

This bycatch is allocated to stock as follows:

$$C_{B,t}^{g,k,q,J} = \frac{P_t^{g,k,q,J}}{\lambda^{k,q} P_t^{g,k,q,O} + P_t^{g,k,q,J}}\,C_{B,t}^{g,k,q} \tag{D.10a}$$

$$C_{B,t}^{g,k,q,O} = \frac{\lambda^{k,q} P_t^{g,k,q,O}}{\lambda^{k,q} P_t^{g,k,q,O} + P_t^{g,k,q,J}}\,C_{B,t}^{g,k,q} \tag{D.10b}$$

where $P_t^{g,k,q,j}$ is the total population size (including calves) of animals of gender *g* from stock *j* in sub-area *k* during month *q* of year *t*.

Reported bycatches

A single series of historical bycatches will be used for all of the trials when applying the RMP (i.e. for calculating catch limits), irrespective of the true values of the bycatches, which differ both among trials and simulations within trials. The estimate of the historical bycatches used by the CLA will be set to the averages of the predicted bycatches based on the fit to the actual data[6] of the operating model for the six baseline trials (i.e. using the 'best fit' simulation (0)). The series will be generated after conditioning is complete (see Adjunct 1).

The future bycatches used when applying the RMP are the true bycatches in all sub-areas[7], except for Trial 4 (in which the estimated bycatches are in error to reflect the under-estimation of bycatch inherent in these trials) and Trial 12 (in which the bycatch by China is taken to be zero).

E. Generation of data

The plan for future sightings surveys is listed in Table 3a. Surveys will be conducted by Japan in sub-areas 7CS, 7CN, 7WR, 7E, 8, 9, 11, 12SW and 12N. Additional surveys will be conducted by Japan in sub-areas 6E, 10W, 10E and by Korea in sub-areas 5 and 6W (see this report, Table 3a, p.382), but they are not listed here as they are not required for setting future catch limits and so are not modelled in the trials. Table 3b shows how surveys will be combined for areas that are combinations of sub-areas.

The estimates of absolute abundance (and their associated CVs) for the years prior to 2019 provided to the *CLA* are given in Table 4a. To allow for results of surveys already conducted, but for which the results are not yet available, estimates of abundance are generated for surveys listed for 2019 in sub-areas 7WR, 7E and 12NE using the same method as for future estimates.

The sightings mixing matrix for a year in which a survey takes place is the average of the catch mixing matrices over the two survey months in that year (April-May for surveys to the west of Japan or August-September for the remainder). The values for the parameters of the various distributions have been selected to achieve CVs for *Small Areas* comparable to those for the surveys in Table 6(a). The future estimates of abundance for a *Small Area* (say *Small Area E*) are generated using the formula:

$$\hat{P} = P\,Y\,w/\mu = P^*\,\beta^2\,Y\,w \tag{E.1}$$

Y is a lognormal random variable $Y = e^{\varepsilon}$ where $\varepsilon \sim N[0,\sigma^2]$ and $\sigma^2 = Ln(\alpha^2+1)$;

w is Poisson random variable with $E(w) = \mathrm{var}(w) = \mu = (P/P^*)/\beta^2$; (*Y* and *w* are independent);

P is the average current total (1+) population size in the *Small Area* (*E*) over the survey period:

$$P = P_t^E = \frac{1}{2}\sum_{k\in F}\;\sum_{q\in SurveyPeriod}\;\sum_j\;\sum_g\sum_{a=1}^{x}\left(V_{t,a}^{g,j,k,q} N_{t,a}^{g,j}\right) \tag{E.2}$$

P^* is the reference population level, and is equal to the mean total (1+) population size in the *Small Area* prior to the commencement of exploitation in the area being surveyed; and

---

[6] In the case of sub-area 6W the actual data is the *adjusted* bycatch data.

[7] Including sub-area 6W since the best estimate of bycatches in this area is the adjusted figure.

F is the set of sub-areas making up *Small Area E*.

Note that under the approximation $CV^2(ab) \cong CV^2(a) + CV^2(b)$: $E(\hat{P}) \cong P$ and $CV^2(\hat{P}) \cong \alpha^2 + \beta^2 P^* / P$

For consistency with the first stage screening trials for a single stock (IWC, 1991, p.109; 1994, pp.85-86), the ratio $\alpha^2 : \beta^2 = 0.12:0.025$, so that:

$$CV(\hat{P}) = \tau(0.12 + 0.025P^* / P)^{1/2} \tag{E.3}$$

and the CV of a survey estimate prior to the commencement of exploitation in the area being surveyed would be:

$$\sqrt{(\alpha^2 + \beta^2)} = 0.38\tau \tag{E.4}$$

The values of τ applicable to each sub-area are calculated separately for each replicate once the conditioning has been accomplished by substituting the true value of the CV for each abundance estimate used in conditioning (Table 6a)[8] and the corresponding model depletion level into equation E.3. If more than one abundance estimate exists for a particular sub-area, the value assumed for τ is calculated taking the true CV to be the root mean square of the values obtained from the abundance estimates for that sub-area, and the depletion to be the mean value over the corresponding years.

An estimate of the *CV*, X_t is also generated for each sightings estimate, $\hat{P}_t$:

$$X_t = \sqrt{(\sigma_t^2 \chi^2 / n)} \tag{E.5}$$

where $\sigma_t^2 = Ln(1 + \alpha^2 + \beta^2 P^* / \hat{P}_t)$, and χ^2 is a random number from a Chi-square distribution with n=10 degrees of freedom. The value 10 is chosen to roughly indicate the number of trackline segments in a sightings survey in a *Small Area*.

The trials will be based on the use of two alternative values for $g(0)$ in the conditioning process: $g(0) = 0.798$ (the base case value) and $g(0)=1$ (Trial 3) (IWC, 2012a, p.417; Okamura *et al.*, 2010). When $g(0) = 0.798$ the values of the operating model abundances are multiplied by this factor when setting the future survey estimates of abundance.

Table 3a

Past and planned future Japanese surveys to the North and East of Japan. The survey coverage is given in parentheses. Future coverage in sub-areas 7CN, 7WR and 7E is expected to be similar to the values below (because of territorial issues). Coverage in sub-areas 8 and 9 assumes that future surveys include the Russian EEZ. Future coverage in sub-areas 11 and 12SW (of 30.1% and 48.9% respectively) excludes areas in the Russian EEZ which cannot be surveyed until the resolution of territorial issues with Japan. Future coverage in sub-area 12NE (of 46.4) reflects the area which cannot be surveyed in the North and East because of Russian restrictions. *Estimate=0; $^{\#}$surveys covered different parts of sub-area 12NE each year.

	7CS	7CN	7WR	7E	8	9	11	12SW	12NE
1990	-	-	-	-	Aug-Sep (62%)	Aug-Sep (35%)	Aug-Sep(100%)	Aug-Sep(100%)	Aug-Sep(100%)
1991	Aug-Sep*(100%)	Aug-Sep(100%)	Aug-Sep(100%)	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	Aug-Sep (89%)
1999	-	-	-	-	-	-	Aug-Sep(100%)	-	Aug-Sep (64%)
2000	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	Jun-Jul (65%)*	-	-	-	-
2003	-	-	May-Jun (27%)	-	-	Jul-Sep (33%)	Aug-Sep (34%)	Aug-Sep(100%)	Aug-Sep (46%)
2004	May (37%)	-	May-Jun (89%)	My-Jun (57%)	Jun (40%)	-	-	-	-
2005	-	-	-	-	May-Jul (65%)	-	-	-	-
2006	Jun-Jul (100%)	-	-	My-Jun (57%)	May-Jul (65%)	-	-	-	-
2007	-	-	Jun-Jul (89%)	Jun-Jul (65%)*	Jun-Jul (65%)	-	Aug-Sep (20%)	-	-
2008	Jul-Aug* (100%)	Jul-Aug*(75%)	Jul-Aug*(89%)	Jul-Aug*(57%)	Jul-Aug*(65%)	Jul-Aug (87%)	-	-	-
2009	May-Jun (100%)	May-Jun (75%)	May-Jun (89%)	May-Jun (57%)	May-Jun (65%)	May-Jun (87%)	-	-	-
2010	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	May-Jun-(65%)	May-Jun (87%)	-	-	-
2012	May-Jun (100%)	May-Jun (75%) Aug-Sep (75%)	May-Jun (89%)	May-Jun*(57%)	-	-	-	-	-
2013	-	-	May-Jun (89%)	May-Jun (57%)	May-Jun (65%)	-	-	-	-
2014	-	Aug-Sep (73%)	-	-	-	-	Aug-Sep (35%)	-	-
2015	-	-	-	-	-	May-Jun (87%)	-	-	Aug-Sep$^{\#}$(17%)
2016	Jul-Aug(100%)	Jul-Aug (75%)	Jul-Aug (89%)	-	-	-	-	-	Aug-Sep$^{\#}$(28%)
2017	May-Jun(100%)	May-Jun (75%)	-	-	-	-	-	-	Aug$^{\#}$ (14%)
2018	May-Jun(100%)	May-Jun (75%)	-	-	-	-	May-Jun (35%)	-	Aug$^{\#}$ (11%)
2019	-	-	May-Jun (89%)	May-Jun (57%)	-	-	-	-	Aug-Sep$^{\#}$(16%)
2020	-	-	-	-	-	-	Aug-Sep	Aug-Sep	Aug-Sep
2021	-	-	Aug-Sep	Aug-Sep	Aug-Sep	Aug-Sep	-	-	-
2022	Aug-Sep	Aug-Sep	-	-	-	-	-	-	-
2023	-	-	-	-	-	-	-	-	-
2024	-	-	-	-	-	-	Aug-Sep	Aug-Sep	Aug-Sep
2025	-	-	Aug-Sep	Aug-Sep	Aug-Sep	Aug-Sep	-	-	-
2026	Aug-Sep	Aug-Sep	-	-	-	-	-	-	-
2027	-	-	-	-	-	-	-	-	-

Continue in future in the same pattern.

---

[8] Excluding zero, minimum and maximum estimates and those assumed to apply to adjacent areas, except for sub-areas 5 and 6W where the pooled minimum values are used.

Table 3b

Component survey estimates to include in estimates for areas that are combinations of sub-areas

	C4 = 7,8	C5 = 7WR,7E,8	C6 = 7,8,9,11	C7 = 7,8,9,11,12
1991	Yes [a]: 1990-91	Yes [a]: 1990-91	Yes [a]: 1990-91	Yes [a]: 1990-92
2003	Yes: 2002-04	Yes: 2002-04	Yes: 1999-04	Yes: 1999-04
2006	Yes[b]: 2005-07	Yes[b]: 2005-07	- (see[c])	- (see[c])
2013	Yes: 2012-3	Yes: 2013	Yes: 2012-14	Yes: 2012-14
2016	-	-	-	-
2017	Yes: 2016-17	Yes: 2017	Yes: 2016-18	Yes: 2016-18
2018	-	-	-	-
2019	-	-	-	-
2020	-	-	-	-
2021	Yes: 2020-21	Yes: 2021	Yes: 2020-22	Yes: 2020-22
2022	-	-	-	-
2023	-	-	-	-

Continue in future in the same pattern.

a) The abundance estimates set for the combined sub-areas in 1990-92 assume a zero contribution from sub-area 7E as there is no available estimate for sub-area 7E to include.

b) The abundance estimates set for combined areas C4 and C5 in 2005-07 assume a zero contribution from sub-area 7CN as there is no sub-area 7CN estimate to include.

c) There are no 2005-2011 abundance estimate for sub-areas 9 and 12 to include in combination estimates C6 and C7; no C6 or C7 estimates are generated in this period.

Table 4a

List of historical abundance estimates agreed in 2013 for use by the *CLA* (*= zero estimate – see text and Table 4b). Further details are given in IWC, 2014a, pp.126-9. All estimates are calculated assuming a value of 1.0 for *g*(0) but the trials (except Trial 3) assume that *g*(0) = 0.798. Requires updating after consideration of the estimates available since the 2013 trials

Year	SubA	Period	Est.	CV	Year	SubA	Period	Est.	CV	Year	SubA	Period	Est.	CV
1991	7CS	Aug-Sep	42*	0.603	1990	8	Aug-Sep	1,057	0.705	1990	11	Aug-Sep	2,120	0.449
2004	7CS	May	504	0.291	2002	8	Jun-Jul	63.6*	0.603	1999	11	Aug-Sep	1,456	0.565
2006	7CS	Jun-Jul	3,690	1.199	2004	8	Jun	1,093	0.576	2003	11	Aug-Sep	882	0.820
2012	7CS	May-Jun	890	0.393	2005	8	May-Jul	132	1.047	2007	11	Aug-Sep	377	0.389
1991	7CN	Aug-Sep	853	0.23	2006	8	May-Jul	309	0.677	1990	12SW	Aug-Sep	5,244	0.806
2012	7CN	Sept	398	0.507	2007	8	Jun-Jul	391	1.013	2003	12SW	Aug-Sep	3,401	0.409
1991	7WR	Aug-Sep	311	0.23	1990	9	Aug-Sep	8,264	0.396	1990	12NE	Aug-Sep	10,397	0.364
2003	7WR	May-Jun	267	0.700	2003	9	Jul-Sep	2,546	0.276	1992	12NE	Aug-Sep	11,544	0.380
2004	7WR	May-Jun	863	0.648						1999	12NE	Aug-Sep	5,088	0.377
2007	7WR	Jun-Jul	546	0.953						2003	12NE	Aug-Sep	13,067	0.287
2004	7E	May-Jun	440	0.779										
2006	7E	May-Jun	247	0.892										
2007	7E	Jun-Jul	52.6*	0.603										

Table 4b

Population estimates which replace any zero estimates in the historical series or which are generated in future. A default value of 42 is used to replace a future zero estimate generated in any other sub-area.

Sub-area	7CS	7CN		7WR		7E	8		11	
Season		1991	1992	1991	1992	2006	2006	2007	2003	2007
n		11	6	1	2	2	3	2	10	19
P		976	730	188	434	247	309	391	882	377
Scaled		37.8	51.8	80.1	92.4	52.6	43.9	83.3	37.6	8.5
Average	42.0	44.8		86.3		52.6	63.6		23.0	

The trials assume that it takes two years for the results of a sighting survey to become available to be used by the management procedure, i.e. a survey conducted in 2018 would first be used for setting the catch limit in 2020. Table 3 lists the pattern for future surveys and also shows how results of surveys from different sub-areas are combined for use in variants in which *Small Areas* are comprised of more than one sub-areas. If a *Small Area* is comprised of sub-areas that are surveyed in different years, the combination abundance estimate is taken to be a summation of the estimates of abundance in the sub-areas over the years and taken to refer to the mean year (where the mean year is defined as the centre year in the set, or the later of two if this yields a half-integral year) (IWC, 1999). In cases in which the combined survey used more than one abundance estimate from the same sub-area, the abundance estimates are pooled using inverse variance weighting. For example, for the management variant in which the RMP sets a catch limit for the combined 7+8 sub-area, an estimate dated 2007 will be generated using of the abundances from the constituent sub-areas for 2003 to 2010 for combinations C1 and C2 (and from 2003-11 for combination C3).

In cases where a zero abundance estimate occurs (either in the historical series or in the generated future estimates), a fixed standard deviation of 0.603 is assumed, and the zero estimate is replaced by a value that depends on the what the population estimates would have been for recent surveys in the areas had there been only one minke whale sighting made. Specifically, the averages taken over such population estimates are calculated separately for each of the surveys listed and then scaled by 42/98.6 as given in Table 4b. Details of the rationale are given in IWC (2014b, pp.493-6) and Butterworth and Miyashita (2014)[9].

F. Parameter values and Conditioning

The biological parameters (natural mortality, age-at-maturity) and the technological parameters (selectivity) will be the same as for the previous *Implementations* (IWC, 1992a, p.160; IWC, 2014a, pp.133-180) (based on those for N Atlantic minke whales, IWC, 1992b, p.249)[10] i.e.:

Table 5
The values for the biological and technological parameters that are fixed.

Parameter	Value
Plus group age, x	20 yrs
Age-at-first-parturition, a_m	$m_{50} = 7$; $\sigma_m = 1.2$; first age at which a female can be mature is three,
Selectivity: Males and Females	$r_{50} = 4$; $\sigma_r = 1.2$
Maximum Sustainable Yield Level, *MSYL*	0.6 in terms of mature female component of the population

Natural mortality is age-dependent, and identical to that for the North Atlantic minke trials:

$$M_a = \begin{cases} 0.085 & \text{if } a \le 4 \\ 0.0775 + 0.001875a & \text{if } 4 < a < 20 \\ 0.115 & \text{if } a \ge 20 \end{cases}$$

The MSYR scenarios are specified in Section G.

The ‘free’ parameters of the above model are the initial (pre-exploitation) sizes of each of the stocks, the values that determine the mixing matrices (i.e. the γ parameters), the bycatch constants (A_k). The process used to select the ‘free’ parameters is known as conditioning. The conditioning process involves first generating 100 sets of ‘target’ data as detailed in steps (a) and (b) 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 guessed values of the initial population sizes and projecting the operating model forward to 2019 in order to obtain values of abundance etc. for comparison with the generated data[11]. (When performing the projections, the direct catches from each sub-area are set to their historical values – Adjunct 1 and the bycatches are set as detailed below).

The information used in the conditioning process is as follows.

(a) Abundance estimates

The target values for the historical abundance by sub-area (excepting for the minimum and maximum values – see below) are generated using the formula:

$$P_t^k = O_t^k \exp[\mu_t^k - (\sigma_t^k)^2/2] \qquad \mu_t^k \sim N[0;(\sigma_t^k)^2] \qquad \text{(F.1)}$$

P_t^k is the abundance for sub-area k in year t (or sub-areas 7E+8 for the 2007 abundance estimate)

O_t^k is the actual survey estimate for sub-area k in year t (see Table 6a); and

σ_t^k is the CV of O_t^k.

The abundance estimate for sub-area 8 in 2002 is zero. The value of O_t^k is set to 0 for all trials when fitting to this datum, and the likelihood is assumed to be normal rather than log-normal.

The trials are based on the two alternative values for $g(0)$ in the conditioning process: $g(0)$=0.798 (the base case value) and $g(0)$=1 (Trial 3) (IWC, 2012a, p.417; Okamura *et al.*, 2010). When $g(0)$=0.798 the values of the operating model abundances (P_t^k) are multiplied by this factor for comparison with the conditioning targets.

Minimum abundance estimates:

The levels of abundance listed in Table 6(a) for sub-areas 5 and 6W, and for sub-areas 7WR and 9 in 2003 and sub-area 11 in 2007 are assumed to be minima – in the conditioning process the terms for those sub-areas/years are not added to the log-likelihood but the ‘true’ abundance in those sub-areas must exceed a value that is one standard error below the specified values. The values are listed in Table 6(b). Where there is more than one estimate for a sub-area, the estimates for the area were pooled using inverse variance weighting. The minimum estimate is the same across all replicates.

---

[9] The approach is based on that for the zero abundance estimate obtained in sub-area 7CS in 1991 for which there was a final output negative log – likelihood component of P/98.6 where P is the true abundance present. This form was replaced by a negative log-likelihood based on the assumption of a log-normally distributed pseudo estimate, which as with the Poisson form would yield a value of 1when P = 98.6. Since this is not sufficient to define this likelihood term unambiguously, the mean was fixed at 42 (D. Adams, 1995) which resulted in a standard deviation of 0.603.

[10] The values are consistent with the results from JARPN. Japanese scientists advised that the above approach is appropriate given the well-known practical difficulties in using earplugs for age determination of North Pacific common minke whales. However, they also noted that technical advances mean that it may be possible to obtain age estimates in the future (IWC, 2014b, p.492).

[11] In order to check that the conditioning exercise has been successfully achieved, plots such as those shown in IWC (2003, pp.473-80) will be examined, together with time-trajectories of the fraction of each stock in each sub-area.

Table 6a

Abundance data used to condition the trials. These estimates were all calculated assuming $g(0)=1$. In all trials, except Trial 3, it is assumed that $g(0) = 0.798$. See IWC, 2014a, pp. 126-9 for details of estimates used in the 2013 implementation.

Sub-area	Year	Season	Mode[a]	Areal coverage (%)	STD estimate[b]	CV[c]	Conditioning	Source
5	2006	Apr-May	NC	13.0	779[d]	0.194	Min[e]	An *et al*, 2010, Park *et al*, 2012.
6W	2005	Apr-May	NC	14.3	574[d]	0.136	Min[e]	An *et al*, 2010, An *et al*, 2011.
6E	2002	May-Jun	NC	79.1	891	0.608	Yes[f]	Miyashita *et al*, 2009
	2003	May-Jun	NC	79.1	935	0.357	Yes[f]	Miyashita *et al*, 2009
	2004	May-Jun	NC	79.1	727	0.372	Yes[f]	Miyashita *et al*, 2009
10W	2006	May-Jun	IO-PS	59.9	2,476	0.312	Yes	Miyashita and Okamura 2011
10E	2002	May-Jun	NC	100.0	816	0.658	Yes	Miyashita *et al*, 2009
	2003	May-Jun	NC	100.0	405	0.566	Yes	Miyashita *et al*, 2009
	2004	May-Jun	NC	100.0	474	0.537	No: Qu re survey design	Miyashita *et al*, 2009
	2005	May-Jun	NC	64.6	599	0.441	Yes	IWC, 2014a, pp.126-9
	2007	May-Jun		80.1	575	0.327	No – except see Trial 14	Miyashita *et al*, 2009
	2014	Sep		100	872	0.585	Yes	Miyashita, 2019
	2018	May-Jun		100	620	0.478	Yes	Hakamada *et al*, 2019
7CS	2004	May	NC	36.7	504	0.291	Yes	IWC, 2014a, pp.126-9
	2006	Jun-Jul	NC	100	3,690	1.199	Yes	Hakamada & Kitakado, 2010
	2012	May-Jun		100	537	0.346	Yes	Hakamada *et al*, 2016
	2016	Aug-Sep		100	0		Yes	Hakamada *et al*, 2019
	2017	May		100	284	0.497	Yes	Hakamada *et al*, 2019
	2018	May-Jun		100	245	0.828	Yes	Hakamada *et al*, 2019
7CN	2003	May	NC	75.4	184	0.805	Min/No	Hakamada & Kitakado, 2010
	2012	May-Jun		66.7	542	0.601	Yes	Hakamada *et al*, 2016
	2012	Sep		66.7	599	0.525	Yes	Hakamada *et al*, 2016
	2014	Sep		75	244	0.454	Yes	Miyashita, 2019
	2016	Jul-Aug		75	185	0.423	Yes	Hakamada *et al*, 2019
	2017	Apr-May		75	179	0.377	Yes	Hakamada *et al*, 2019
	2018	May		75	212	0.784	Yes	Hakamada *et al*, 2019
7WR	2003	May-Jun	NC	26.7	267	0.700	No: low coverage	IWC, 2014a, pp.126-9
	2004	May-Jun	NC	88.8	863	0.648	Yes	Hakamada & Kitakado, 2010
	2007	Jun-Jul	NC	88.8	546	0.953	Yes	Hakamada & Kitakado, 2010
	2012	May-Jun			378	0.79	Yes	Hakamada & Matsuoka 2016
	2013	May-Jun		89	65	1.007	Yes	Hakamada *et al*, 2019
	2016	Jul-Aug		89	75	1.062	Yes	Hakamada *et al*, 2019
7W: 7CS+ 7CN+7WR	1991	Aug-Sep			1,164	0.183	Yes	Butterworth & Miyashita, 2014
7E	1990	Aug-Sep			791	1.848	No	IWC, 2014a, pp.126-9
	2004	May-Jun	NC	57.1	440	0.779	Yes	Hakamada & Kitakado, 2010
	2006	May-Jun	NC	57.1	247	0.892	Yes	Hakamada & Kitakado, 2010
	2012	May-Jun		57	0		Yes	Hakamada & Matsuoka 2016
	2013	Jun		57	0		Yes	Hakamada *et al*, 2019
	2016	Aug-Sep		57	0		Yes	Hakamada *et al*, 2019
7	2008	Jul-Sep			0		Yes	Hakamada & Kitakado, 2016
	2009	May-Jun			215	0.942	Yes	Hakamada & Matsuoka 2016
7E+8	2007	Jun-Jul	NC		391[8]	1.013	Yes	Hakamada & Kitakado, 2010
8	1990	Aug-Sep	NC	62.2	1,057	0.706	Yes	IWC, 2004, p.124
	2002	Jun-Jul	NC	65.0	0	482[h]	Yes	Hakamada & Kitakado, 2010
	2004	Jun	NC	40.5	1,093	0.576	Yes	Hakamada & Kitakado, 2010
	2005	May-Jul	NC	65.0	132	1.047	Yes	Hakamada & Kitakado, 2010
	2006	May-Jul	NC	65.0	309	0.677	Yes	Hakamada & Kitakado, 2010
	2008	Jul-Sep		65	0		Yes	Hakamada & Matsuoka 2016
	2009	May-Jun		65	602	0.725	Yes	Hakamada & Matsuoka 2016
	2011	May-Jun		65	121	0.966	Yes	Hakamada & Matsuoka 2016
	2013	May-Jun		65	413	0.586	Yes	Hakamada *et al*, 2019
9	1990	Aug-Sep	NC	35.1	8,264	0.396	Yes	IWC, 2004, p.124
	2003	Jul-Sep	NC	33.2	2,546	0.276	Min[e]	Hakamada & Kitakado, 2010
	2008	Jul-Sep		87	2,458	0.664		Hakamada *et al*, 2016
	2009	May-Jun		63	2,079	0.688	Yes	Hakamada *et al*, 2016
	2011	May-Jun			0		No [i]	Hakamada *et al*, 2016
	2015	Apr-May		87	140	0.963	Yes	Hakamada *et al*, 2019
9N	2005	Aug-Sep	IO-PS	67.8	420	0.969	Yes	Miyashita and Okamura 2011
	2011	May-Jun			115	1.05	Yes	Hakamada et al, 2016
11	1990	Aug-Sep	NC	100.0	2,120	0.449	Yes	IWC, 2004, p.124
	1999	Aug-Sep	IO	100.0	1,456	0.565	Yes	IWC, 2004, p.124
	2003	Aug-Sep	IO-AC	33.9	882	0.820	Yes	Miyashita & Okamura, 2011
	2007	Aug-Sep	IO-PS	20.2	377	0.389	Min[e]	Miyashita & Okamura, 2011
	2014	Aug		35	306	0.679		Miyashita, 2019
	2018	May		35	235	0.481		Hakamada *et al*, 2019
12SW	1990	Aug-Sep	NC	100.0	5,244	0.806	Yes	IWC, 2004, p.124
	2003	Aug-Sep	IO-AC	100.0	3,401	0.409	Yes	Miyashita & Okamura, 2011
12NE	1990	Aug-Sep	NC	100.0	10,397	0.364	Yes	IWC, 2004, p.124
	1992	Aug-Sep	NC	89.4	11,544	0.380	Yes	Miyashita & Shimada, 1994
	1999	Aug-Sep	NC	63.8	5,088	0.377	Yes	IWC, 2014a, pp.126-9
	2003	Aug-Sep	IO-AC	46.0	13,067	0.287	Yes	Miyashita & Okamura, 2011

Table 6a continued

Sub-area	Year	Season	Mode[a]	Areal coverage (%)	STD estimate[b]	CV[c]	Conditioning	Source
Trial 13: Use estimates in full area in 2002 & 2003 (originally 100% coverage) and one extrapolated to the full area in 2004 (79.1% coverage)								
6E	2002	May-Jun	NC	100.0	1,795	0.458	Yes	Miyashita, 2010
	2003	May-Jun	NC	100.0	1,059	0.322	Yes	Miyashita, 2010
	2004	May-Jun	NC	100.0	919	0.372	Yes	Miyashita, 2010
Trial 14: Use only in sensitivity test as an estimate extrapolated to the full area								
10E	2007	May-Jun	IO-PS	100.0	552	0.159	Yes	Miyashita, pers. comm.

[a] Mode: NC=Normal-closing, IO-PS=Passing with IO mode, IO-AC=Abeam-closing with IO mode. (STD estimates by different modes, NC, IO-AC, IO-NC, are considered comparable.).

[b] Standard (STD) estimate based on ‘Top and Upper bridge’, which will be corrected by estimate of $g(0)$ for the combined platform ‘Top and Upper bridge’.

[c] CV does not consider any process errors.

[d] Pooled estimates: sub-area 5 from 2001, 2004, 2008 and 2011; sub-area 6W from 2000, 2002, 2003, 2005, 2006, 2007, 2009 and 2010.

[e] Minimum value used in conditioning – see Table 6b for minimum values used.

[f] Alternative values used in Trial 13.

[g] The estimate of 0 from sub-area 7E was combined with the estimate of 391 from sub-area 8.

[h] Average of the SEs for the non-zero estimates.

[i] Only southern portion of sub-area surveyed.

Table 6b

The minimum and maximum abundance estimates used

Sub-area	Year	Season		STD estimate	CV	Minimum = Mean-SE	Maximum = Mean*5
5	2006	Apr-May	Pooled	779	0.194	629	3897
6W	2005	Apr-May	Pooled	574	0.136	496	2871
9	2003	Jul-Sep		2,546	0.276	1,843	na
11	2007	Aug-Sep		377	0.389	230	na
2R	2009	Aug-Sep		-	-	-	500[#]

[#] A maximum abundance of 500 whales in sub-area 2R in August-September 2009 was imposed in hypothesis C in the 2013 trials, to avoid undesirably high number of animals in this area. A need for such a requirement will be reviewed on inspection of the conditioning results.

Maximum abundance estimates.
Bounds need to be placed on the maximum size of populations in sub-areas 5 and 6W. These bounds are generated by multiplying the inverse variance weighted estimate (i.e. the 779 and 574) by 5 (see Table 6b). The maximum estimate is the same across all replicates.

There is insufficient information in the trials to estimate the abundance in sub-areas 5 and 6W, given the absence of a population estimate (only a minimum and a maximum given). Thus, for stochastic trials, the conditioning process will fit to a low variance (CV=0.1) pseudo-estimate of abundance for sub-area 5 and for sub-area 6 which are drawn from a uniform distribution across [minimum; maximum] for each of the 100 simulated projections within each trial. For ‘deterministic’ projections, the conditioning will fit to (maximum+minimum)/2. Trials 15 and 16 investigate sensitivities to the baseline assumptions and replace the random draws above by a fixed value equal to the-‘maximum’ estimate for the sub-area 5 abundance (Trial 15) or the sub-area 6W abundance (Trial 16). (In the 2013 implementation minimum values for the estimates were also tested but are not included here as they were considered to be of low plausibility).

(b) Proportion estimates
Estimates of the number of genetic samples assigned by stock in sub-areas 2C, 6W, 7CS, 7CN, 7WR, 10E and 11 are generated from a multinomial distribution that correspond to the observed data (see Tables 7a,b). Some of the mixing proportions are based on data from several years so the model estimates to which these proportions are fitted during conditioning are sample size-weighted year-specific proportions.

Estimates of the proportion of recruited J-stock whales in sub-areas 6W (see Adjunct 3 for how these proportions are estimated) are generated from appropriately truncated normal distributions that correspond to the observed data and are based on mtDNA and other genetic information (see Table 7c). Some of the mixing proportions are based on data from several years so the model estimates to which these proportions are fitted during conditioning are sample size-weighted year-specific proportions. A minimum standard error for the mixing proportions of 0.05 was imposed so as to prevent a few of the mixing proportions from dominating the conditioning processes – see IWC (2012c, p.106).

(c) Fixed stock proportion in sub-area 12SW
The data for sub-area 12SW is limited and so the proportion of J-stock in sub-area 12SW in June is fixed at 20% in the baseline trials. The value reflects a rough average of the J-stock mixing proportions for sub-area 11 (J-stock animals in sub-area 12SW need to pass through sub-area 11). Since the proportions for sub-area 11 are calculated from the 1984-1999 data, the 20% will be taken as an average over these same years. Sensitivity trials test different levels of the sub-area 12SW proportion. In Trial 10 the proportion is 10 % (with 0% J-stock in sub-area 12NE as for the base case) and in Trial 11 the proportion is 30% (with 10% J-stock in sub-area 12NE in the same months/years; the mixing matrix is adjusted accordingly). In Trial 21 the proportion of J-stock in sub-area 12NE in May-July is fixed at 10%.

(d) Fixed stock proportion in sub-area 9 and 9N
The data for sub-area 9 is also limited. For Trials 2 and 23 which assume a C-stock that mixes with the O-stock in sub-area 9 and 9N, the proportion of O-stock is assumed to be 0.5 during August and September in 1995. This is based on the ratio assumed in 9W in 2003. For hypothesis E, Trial 2 the same proportion is also assumed in 12NE in August and September 1995 (but not in Trial 23).

Table 7a

The number of sampled whales that were assigned to each stock using the genetic assignment data based on STRUCTURE (Hypothesis A & B) and Geneland (Hypothesis E) using a 90% probability of assignment. In sub-areas 7CS and 7CN the baseline and Trial 5 proportion of whales assigned to each stock is weighted by 5/60 of the bycatch proportion and 55/60 of the special permit proportion. The number assigned by stock is then taken as this proportion multiplied by the total number of assigned animals. In Trial 6 the proportion of whales assigned to each stock is weighted by 2/60 of the bycatch proportion and 58/60 of the special permit proportion, while in Trial 7 10/60 of the bycatch proportion and 50/60 of the special permit proportion was used. These data are used to condition the trials.

Hypothesis	Trial	Area	Years	Months	Sex	Total Sample	J-Stock	O-Stock
A & B	Baseline	2C	2002-16	Jan-Apr	M+F	155	127	28
A & B	Baseline	2C	2001-16	May-Sep	M+F	56	46	10
A & B	Baseline	2C	2001-16	Oct-Dec	M+F	134	122	12
A & B	Baseline	7CS	2002-16	Jan-Apr	M+F	263	74	189
A & B	Baseline	7CS	2001-16	May	M+F	391	104	287
A & B	Baseline	7CS	1999-2016	Jun-Dec	M+F	199	21	178
A & B	Baseline	7CN	2002-16	Jan-May	M+F	100	17	83
A & B	Baseline	7CN	1999-2016	Jun	M+F	133	12	121
A & B	Baseline	7CN	1996-2016	Jul-Sep	M+F	610	127	483
A & B	Baseline	7CN	2001-16	Oct-Dec	M+F	270	91	179
A & B	Baseline	10E	2001-16	Jun-Dec	M+F	15	14	1
A & B	Baseline	11	1996-2012	May-Dec	M	57	28	29
A & B	Baseline	11	1996-2015	May-Dec	F	58	28	30
A & B	5	2C	2002-16	Jan-Apr	M+F	170	138	32
A & B	5	2C	2001-16	May-Sep	M+F	57	47	10
A & B	5	2C	2001-16	Oct-Dec	M+F	141	129	12
A & B	5	7CS	2002-16	Jan-Apr	M+F	291	80	211
A & B	5	7CS	2001-16	May	M+F	431	116	315
A & B	5	7CS	1999-2016	Jun-Dec	M+F	212	22	190
A & B	5	7CN	2002-16	Jan-May	M+F	105	19	86
A & B	5	7CN	1999-2016	Jun	M+F	139	14	125
A & B	5	7CN	1996-2016	Jul-Dec	M+F	660	138	522
A & B	5	7CN	2001-16	Oct-Dec	M+F	283	94	189
A & B	5	7WR+7E	1996-2006	May	M+F	87	3	84
A & B	5	7WR+7E	1996-2012	Jun-Aug	M+F	49	0	49
A & B	5	8	1998-2012	May-Jun	M+F	139	1	138
A & B	5	8	1996-2009	Jul-Sep	M+F	106	1	105
A & B	5	9	1995-2011	May-Jun	M+F	125	1	124
A & B	5	9	1994-2010	Jul	M+F	190	4	186
A & B	5	9	1994-2013	Aug-Sep	M+F	212	0	212
A & B	5	10E	2001-16	Jun-Dec	M+F	16	15	1
A & B	5	11	1996-2012	May-Dec	M	64	30	34
A & B	5	11	1996-2015	May-Dec	F	63	30	33
A & B	6	7CS	2002-16	Jan-Apr	M+F	263	71	192
A & B	6	7CS	2001-16	May	M+F	391	102	289
A & B	6	7CS	1999-2016	Jun-Dec	M+F	199	14	185
A & B	6	7CN	2002-16	Jan-May	M+F	100	15	85
A & B	6	7CN	1999-2016	Jun	M+F	133	9	124
A & B	6	7CN	1996-2016	Jul-Sep	M+F	610	116	494
A & B	6	7CN	2001-16	Oct-Dec	M+F	270	82	188
A & B	7	7CS	2002-16	Jan-Apr	M+F	263	81	182
A & B	7	7CS	2001-16	May	M+F	391	106	285
A & B	7	7CS	1999-2016	Jun-Dec	M+F	199	32	167
A & B	7	7CN	2002-16	Jan-May	M+F	100	19	81
A & B	7	7CN	1999-2016	Jun	M+F	133	16	117
A & B	7	7CN	1996-2016	Jul-Sep	M+F	610	146	462
A & B	7	7CN	2001-16	Oct-Dec	M+F	270	106	144

Hypothesis	Trial	Area	Years	Months	Sex	Total Sample	J-Stock	P-Stock	O-Stock
E	Baseline	2C	2002-16	Jan-Apr	M+F	138	107	31	-
E	Baseline	2C	2001-16	May-Sep	M+F	49	32	17	-
E	Baseline	2C	2001-16	Oct-Dec	M+F	122	105	17	-
E	Baseline	7CS	2002-16	Jan-Apr	M+F	262	-	262	0
E	Baseline	7CS	2001-16	May	M+F	378	-	351	27
E	Baseline	7CS	1999-2016	Jun-Dec	M+F	197	-	28	169
E	Baseline	7CN	1999-2016	Jan-Jun	M+F	220	6	56	158
E	Baseline	7CN	1996-2016	Jul-Dec	M+F	881	23	633	225
E	Baseline	11	1996-2012	May-Dec	M	59	13	45	1
E	Baseline	11	1996-2015	May-Dec	F	63	18	41	4

Table 7a contd.

Hypothesis	Trial	Area	Years	Months	Sex	Total Sample	J-Stock	P-Stock	O-Stock
E	5	2C	2002-16	Jan-Apr	M+F	150	116	33	1
E	5	2C	2001-16	May-Sep	M+F	54	36	18	0
E	5	2C	2001-16	Oct-Dec	M+F	125	108	17	0
E	5	7CS	2002-16	Jan-Apr	M+F	282	3	278	1
E	5	7CS	2001-16	May	M+F	411	1	376	34
E	5	7CS	1999-2016	Jun-Dec	M+F	211	0	36	175
E	5	7CN	1999-2016	Jan-Jun	M+F	237	6	59	172
E	5	7CN	1996-2016	Jul-Dec	M+F	915	26	641	247
E	5	11	1996-2012	May-Dec	M	63	14	48	1
E	5	11	1996-2015	May-Dec	F	64	18	42	4
E	6	7CS	2002-16	Jan-Apr	M+F	262	-	262	0
E	6	7CS	2001-16	May	M+F	378	-	351	27
E	6	7CS	1999-2016	Jun-Dec	M+F	197	-	19	178
E	6	7CN	1999-2016	Jan-Jun	M+F	220	4	49	167
E	6	7CN	1996-2016	Jul-Dec	M+F	881	16	628	237
E	7	7CS	2002-16	Jan-Apr	M+F	262	-	261	1
E	7	7CS	2001-16	May	M+F	378	-	352	26
E	7	7CS	1999-2016	Jun-Dec	M+F	197	-	43	154
E	7	7CN	1999-2016	Jan-Jun	M+F	220	8	68	144
E	7	7CN	1996-2016	Jul-Dec	M+F	881	36	641	204

Table 7b

Estimates of the proportion of recruited ‘J’-whales used to condition the trials based on mtDNA and Allele samples.

Hypothesis	Area	Years	Months	Sex	Ratio	CV[12]	Data Type	Stock	
B and E	6W	1999-2007	Jan-Mar	M+F	0.584	0.131	mtDNA	J:Total	Bycatch samples
B and E	6W	1999-2007	Jan-Mar	M+F	0.672	0.05	Allelle	J:Total	Bycatch samples
B and E	6W	1999-2007	Apr-Jun	M+F	0.496	0.126	mtDNA	J:Total	Bycatch samples
B and E	6W	1999-2007	Apr-Jun	M+F	0.812	0.05	Allelle	J:Total	Bycatch samples
B and E	6W	1999-2007	Jul-Aug	M+F	1.000	0.05	mtDNA	J:Total	Bycatch samples
B and E	6W	1999-2007	Jul-Aug	M+F	0.749	0.077	Allelle	J:Total	Bycatch samples
B and E	6W	1999-2007	Sep-Dec	M+F	0.593	0.123	mtDNA	J:Total	Bycatch samples
B and E	6W	1999-2007	Sep-Dec	M+F	0.761	0.05	Allelle	J:Total	Bycatch samples

(f) Calculation of likelihood

The objective function consists of three components: Objective Function = -(L_1+L_2+L_3) Equations F.4-6 list the negative of the logarithm of the objective function for each of the three components:

Abundance estimates

$$L_1 = 0.5\sum_n \frac{1}{(\sigma_t^k)^2} \ln\left(P_n / \hat{P}_n\right)^2 \tag{F.4}$$

where $\hat{P}_n$ is the model estimate of the abundance in the same year, period and sub-area as the *n*th estimate of abundance P_n.

Stock proportions

For sub-areas 2C, 7CN, 7CS, 10E and 11:

$$L_2 = \sum_j N_{j,n}^k ln(\hat{p}_{j,n}^k) \tag{F.5a}$$

where $\hat{p}_{j,n}^k$ is the model estimate of the proportion of *j*-stock whales in the same year, period, sub-area and gender as the *n*th set of data with $N_{j,n}^k$ denoting the observed number of samples of *j*-stock whales in the *n*th set of data.

For sub-area 6W in Hypotheses B and E only:

$$L_2 = 0.5\sum_n \frac{1}{(\sigma_n^k)^2}\left(p_n^k - \hat{p}_n^k\right)^2 \tag{F.5b}$$

where $\hat{p}_n$ is the model estimate of the proportion of whales in the same year, period and sub-area as the *n*th proportion estimate p_n.

Bycatch estimates

$$L_3 = 0.5\sum_n \left(B_n^k - \hat{B}_n^k\right)^2 / 10 \tag{F.6}$$

where $\hat{B}_n^k$ is the model estimate of the total bycatch in sub-area *k* over the years being fitted and B_n^k is the observed bycatch in the same area and period.

---

[12] In cases when the sample size used to generate the proportion estimates is small and the se's are small (which will overweight such results), the standard error is set to 0.05.

G. Trials

The factors considered in the trials are listed in Table 8 and the set of trials in Table 9. The sensitivity trials are variants of the base-case trials A01-1 etc. (see section A).

Table 8

The factors to be considered in the *Implementation Simulation Trials*

Factor
Stock structure hypothesis
Stock structure hypotheses A, B and E
MSYR
$1\%_{1+}$; $4\%_{mat}$
***g*(0)**
0.798; 1.00 (Trial 3)
Other stock structure issues
With a C-stock i.e. from a putative ‘Central’ North Pacific population (Trial 2)
Alternative basis for mixing rates (Trial 5)
10% J-stock in sub-area 12SW in June (Trial 10)
30% J-stock in sub-area 12SW in June (Trial 11)
No C-stock (i.e. from a putative ‘Central’ North Pacific population) in sub-area 12NE (Trial 23)
10% J-stock in sub-area 12NE in May-July (Trial 21)
Catches and bycatches
High direct catches + alternative Korean + Japanese bycatch level (Trial 4)
More Korean catches in sub-area 5 (and fewer in 6W) (Trial 8)
More Korean catches in sub-area 6W (and fewer in 5) (Trial 9)
Chinese incidental catch = 0 (Trial 12) (Baseline value = 2* Korean bycatch in sub-area 5)
Number of bycaught animals is proportional to square root of abundance (Trial 17)
Mixing and dispersion
Mixing proportion in sub-areas 7CS and 7CN calculated using 2/60 weight for bycatch (Trial 6)
Mixing proportion in sub-areas 7CS and 7CN calculated using 10/60 weight for bycatch (Trial 7)
A substantially larger fraction of whales 1-4 from O-stock are found in sub-areas 2R, 3 and 4 year round (Trial 18)
Set the proportion of O-stock animals of ages 1-4 in sub-areas 9 and 9N to zero (Trial 19)
Time-varying mixing matrix for the bycatch (Trial 22) (requires specification)
Abundance estimates
Alternative abundance estimates for sub-area 6E (Trial 13)
Alternative abundance estimates for sub-area 10E in 2007 (Trial 14)
Abundance estimate in sub-area 5 = ‘maximum’ (Trial 15)
Abundance estimate in sub-area 6W = ‘maximum’ (Trial 16)
The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (Trial 20)

H. Management options

Two issues relate to specifying the management options: (a) the designation of *Areas* (*Small*, *Medium* and *Large*); and (b) the management procedure variants to consider.

The RMP variants include specifications regarding the *Small Areas* (combinations of sub-areas), the use of the capping and cascading options of the RMP, and when and where harvesting will occur.

The set of RMP variants considered in the 2013 *Implementation* (IWC, 2014a) for catches off Japan and the sub-areas from which catches are taken when a *Small Area* consists of more than one sub-area were:

(1) *Small Areas* equal sub-areas. For this option, the *Small Areas* for which catch limits would be set are 7CS, 7CN, 7WR, 7E, 8, 9^*, and 11.
(2) 7+8, 9^*, and 11 are *Small Areas* and catches are taken from sub-areas 7CN, 9, and 11.
(3) 7+8, 9^*, and 11 are *Small Areas* and catches are taken from sub-areas 7CS, 9, and 11.
(4) 7CS, 7CN, 7WR+7E+8, 9^* and 11 are *Small Areas* and catches are taken from sub-areas 7CS, 7CN, 7WR, 9^* and 11.
(5) 7+8+9^*+11+12 is a combination area and catches are cascaded to the sub-areas within the combination area. The catch limits for sub-areas 12SW and 12NE are not taken.
(6) 7+8, 9^*, and 11 are *Small Areas* except that the catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading to allocate the catch across the two sub-areas.
(7) 7+8+9^*+11 is a *Small Area*; catches are taken in the sub-area 7CN.
(8) 7+8+9^*+11+12 is a *Small Area*; are taken from sub-areas 8 and 9 using the same method as for catch cascading to allocate the catch across the two sub-areas.
(9) 7+8+9^*+11+12 is a *Small Area;* catches are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across the five sub-areas.
(10) 7+8+9^*+11+12 is a *Small Area;* catches are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using the same method as for catch cascading to allocate the catch across the six sub-areas. The catch from sub-area 11 is taken in May and June [note: use of this variant will require a revised entry to the Q matrix].
(11) 7+8+9^*+11+12 is a *Small Area;* catches are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across the five sub-areas but the catch taken from sub-areas 7CS, 7CN, 7WR and 7E is reduced by 50% after first subtracting the bycatches in these sub-areas.

*: 9^* refers to sub-area 9 alone (i.e. excluding 9N) in the definitions of the variants given above.

Note that the proportions of the whales in a sub-area that belong to each stock will differ from sub-area to sub-area (as well as from year to year). Thus, when a *Small Area* is specified which consists of a number of sub-areas, the impact on the various stocks of the catch allowed under the RMP will differ depending on how this catch is distributed amongst the constituent sub-areas. In such cases trials are specified which attempt to bound the extremes of such catch distributions in terms of their likely impact on stocks. The trials above incorporate an attempt to address this aspect, e.g. variants (2) and (3) reflect likely alternative 'extremes' in this context regarding a catch taken from 7+8.

Simulations of future catch limit calculations will be performed (i.e. catch limits will be set by the CLA) every 6 years, beginning in 2020. No phaseout will be applied so as not to confound comparison of the different management variants.

Table 9

The list of trials (MSYR 1% is defined in terms of the total (1+) component and 4% on the mature female component of the population).

Stock hypothesis	Trial no.	MSYR	Mix matrix:	Description
A	A01-1 & A01-4	1%/ 4%	Baseline	Baseline A: 2 stocks (J- and O-); $g(0) = 0.798$; including Chinese bycatch
B	B01-1 & B01-4	1%/ 4%	Baseline	Baseline B: 3 stocks (J-, O,- and Y-); $g(0) = 0.798$; including Chinese bycatch
E	E01-1 & E01-4	1%/ 4%	Baseline	Baseline E: 5 stocks (J-, P-, O-, and Y-); $g(0) = 0.798$; including Chinese bycatch
AE	A02-1 etc	1% / 4%	Trial 2	With a C- ('Central' North Pacific) stock.
ABE	A03-1 etc	1% / 4%	Baseline	Assume $g(0) = 1$
ABE	A04-1 etc	1% / 4%	Baseline	High direct catches + alternative Korean & Japanese bycatch levels.
ABE	A05-1 etc	1% / 4%	Trial 5	Alternative (70% probability) thresholds for assignment of stock proportions.
ABE	A06-1 etc	1% / 4%	Baseline	No. of genetic samples assigned to stock in sub-areas 7CS and 7CN calculated using 2/60 weight for bycatch.
ABE	A07-1 etc	1% / 4%	Baseline	No. of genetic samples assigned to stock in sub-areas 7CS and 7CN calculated using 10/60 weight for bycatch.
ABE	A08-1 etc	1% / 4%	Baseline	More Korean catches in sub-area 5 (and fewer in sub-area 6W). Rationale: the baseline uses the best split. Trials 8 and 9 test alternatives in both directions.
ABE	A09-1 etc	1% / 4%	Baseline	More Korean catches in sub-area 6W (and fewer in 5).
ABE	A10-1 etc	1% / 4%	Baseline	10% J -stock in sub-area 12SW in June (base case value = 20%). See section F(c).
ABE	A11-1 etc	1% / 4%	Trial 11	30% J -stock in sub-area 12SW in June (base case value = 20%) with 10% J-stock in 12NE in May-June. See section F(c).
ABE	A12-1 etc	1% / 4%	Baseline	Chinese incidental catch = 0 (the base case value = twice that of Korea in sub-area 5).
ABE	A13-1 etc	1% / 4%	Baseline	Alternative abundance estimates in sub-area 6E (see Table 6a).
ABE	A14-1 etc	1% / 4%	Baseline	Additional abundance estimate in sub-area 10E in 2007 (see Table 6a).
ABE	A15-1 etc	1% / 4%	Trial 15	Abundance estimate in sub-area 5 = 'maximum' value listed in Table 6b (= 5 * baseline value), with CV=0.1 [$]
ABE	A16-1 etc	1% / 4%	Trial 16	Abundance estimate in sub-area 6W = 'maximum' value listed in Table 6b (= 5 * baseline value), with a CV=0.1 [$]
AE	A17-1 etc	1% / 4%	Baseline	The number of bycaught animals is proportional to the square-root of abundance rather than to abundance (in order to examine the impact of possible saturation effects).
ABE	A18-1 etc	1% / 4%	Trial 18	A substantially larger fraction of whales ages 1-4 from O-stock are found in sub-areas 2R, 3 and 4 year-round (so the proportion of 1-4 whales in sub-area 9 is closer to expectations given the length-frequencies of catches from sub-area 9). The mixing matrices are adjusted such that the numbers of age 1-4 of O-stock animals in sub-areas 9 and 9N are no more than half the base case numbers; juveniles are allowed into sub-areas 2R, 3 and 4 in the corresponding months.
ABE	A19-1 etc	1% / 4%	Trial 19	Set the proportion of O animals of ages 1-4 in sub-areas 9 and 9N to zero and allow the abundance in sub-areas 7CS and 7CN to exceed the abundance estimates for these sub-areas. Projections for these sub-areas will need to account for the implied survey bias.
ABE	A20-1 etc	1% / 4%	Trial 20	The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (if large numbers of whales were found in 2C, the historical catch would be expected to be much greater).
ABE	A21-1 etc	1% / 4%	Trial 21	10% J-stock in sub-area 12NE in May-July. See section F(c).
ABE	A22-1 etc	1% / 4%	Trial 22	Time-varying mixing matrix for the bycatch [details to be specified].
E	E23-1 & 4	1% / 4%	Trial 23	With a putative C ('Central North' Pacific) stock, but no C animals in sub-area 12NE.

[$] The baseline fits to a low variance pseudo-estimate of abundance drawn from U[minimum : maximum] where the 'minimum' and 'maximum' values are those listed in Table 6b.

I. Output statistics

Population-size and continuing catch statistics are produced for each stock, and catch-related statistics for each sub-area. Catch related statistics are produced both for the total catches (commercial and incidental) and for the commercial catches alone.

(1) Total catch (TC) distribution: (a) median; (b) 5th value; (c) 95th value.

(2) Initial mature female population size (P_{2000}) distribution: (a) median; (b) 5th value; (c) 95th value.

(3) Final mature female population size (P_f) distribution: (a) median; (b) 5th value; (c) 95th value.

(4) Lowest mature female population over 100 years (P_{low}) distribution: (a) median; (b) 5th value; (c) 95th value.

(5) Average catch over the last 10 years of the 100-year management period: (a) median; (b) 5th value; (c) 95th value.

(6) Catch by sub-area, stock and catch-type (incidental or commercial): (a) median; (b) 5th value; (c) 95th value.

(7) The median percentage of mature J-stock females being in sub-area 12 in June-August 1973-75.

(8) The median annual rate of decline in the number of whales assumed recruited to the Korean fishery over the period 1973-1986.

(9) The median 1+ population size for animals in sub-areas 6 and 10 in August-September in 1992 and in 2000 (corresponding to Sea of Japan surveys).

(10) Proportion Mature: compare the numbers of mature animals by sub-area and time period with the (approximate) proportion mature in the available observation data.

(11) The mean proportion of 'J' whales in the total (scientific, commercial and incidental) catch taken by Japan from 1993-98 is output in trials, for comparison with results obtained from market samples.

REFERENCES

Allison, C. 2011. Direct catch data for western North Pacific minke whale simulation trials. Paper SC/D11/NPM3 presented to the First Intersessional Workshop for the *Implementation Review* of western North Pacific common minke whales, 12-16 December 2011, Tokyo, Japan (unpublished). [Paper available from the Office of this Journal].

An, Y.R., Choi, C.D., Moon, D.Y. and Park, K.H. 2010. Summary of the information on Korean dedicated sighting surveys for abundance estimates of common minke whales. Paper SC/D10/NPM15 presented to the First Intersessional Workshop for Western North Pacific Common Minke Whales, 14-17 December 2010, Pusan, Republic of Korea (unpublished). 7pp. [Paper available from the Office of this Journal].

An, Y.-R., Park, K.-Y., Choi, S.-G., Kim, H.-W. And Moon, D.-Y. 2011. Abundance estimation of western North Pacific minke whales using the Korean sighting survey in 2010. 4pp. Paper SC/63/RMP28 presented to the IWC Scientific Committee, June 2011, Tromsø, Norway (unpublished). 4pp. [Paper available from the Office of this Journal].

Baker, C.S., Cooke, J.G., Lavery, S., Dalebout, M.L., Ma, Y.U., Funahashi, N., Carraher, C. and Brownell, J., R.L. 2007. Estimating the number of whales entering trade using DNA profiling and capture-recapture analysis of market produce. *Mol. Ecol.* 16(13): 2617-26.

Butterworth D. and Miyashita T. 2014. Derivation of revised estimate for subarea 7 in 1991 and zero abundance estimates. Annex F. *J. Cetacean Res. Manage. (Suppl.)* 15:502-3.

Hakamada, T. 2010. The number of set nets in the coast of Japan by sub-areas and years during 1979-2006. Paper SC/D10/NPM13 presented to the First Intersessional Workshop for Western North Pacific Common Minke Whales, 14-17 December 2010, Pusan, Republic of Korea (unpublished). 1pp. [Paper available from the Office of this Journal].

Hakamada, T. and Kitakado, T. 2010. Abundance estimation for western North Pacific common minke whales using sighting information from JARPN and JARPN II. Paper SC/D10/NPM12rev 25pp. [Paper available from the Office of this Journal].

Hakamada, T. and Matsuoka, K. 2016. The number of western North Pacific common minke, Bryde's and sei whales distributed in JARPN II Offshore survey area. Paper SC/F16/JR12. 13pp. [Paper available from the Office of this Journal].

Hakamada, T., Matsuoka, K., Toshiya, K. and Miyashita, T. 2016. The number of the western North Pacific common minke whales (Balaenoptera acutorostrata) distributed in JARPN II coastal survey areas. Paper SC/F16/JR11. 7pp. [Paper available from the Office of this Journal].

Hakamada, T., Katsumata, T., Takahashi, M. and Matsuoka, K. 2019. Common minke whale abundance estimates based on dedicated sightings surveys during 2013-2018. Paper SC68a/ASI/14rev (unpublished). [Paper available from the Office of this Journal].

International Whaling Commission. 1991. Report of the Sub-Committee on Management Procedures, Appendix 4. Report of the *ad-hoc* trials subgroup. *Rep. int. Whal. Commn* 41:108-12.

International Whaling Commission. 1992a. Report of the Scientific Committee, Annex F. Report of the Sub-Committee on North Pacific Minke Whales. *Rep. int. Whal. Commn* 42:156-77.

International Whaling Commission. 1992b. Report of the Scientific Committee, Annex K. Report of the Working Group on North Atlantic Minke Trials. *Rep. int. Whal. Commn* 42:246-51.

International Whaling Commission. 1994. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on Management Procedures, Appendix 2. Minimum Standards Trials. *Rep. int. Whal. Commn* 44:85-88.

International Whaling Commission. 1999. Report of the Scientific Committee. Annex N. The Revised Management Procedure (RMP) for Baleen Whales. *J. Cetacean Res. Manage. (Suppl.)* 1:251-58.

International Whaling Commission. 2004. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 6: 75-184.

International Whaling Commission. 2012a. Report of the first RMP intersessional workshop for western North Pacific common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 13:411-60.

International Whaling Commission. 2012b. Report of the first RMP intersessional workshop for western North Pacific common minke whales. Annex G. NPM mixing matrices. *J. Cetacean Res. Manage. (Suppl.)* 13:445-48.

International Whaling Commission. 2012c. Report of the Scientific Committee. Annex D1. Report of the Working Group on the *Implementation Review* for western North Pacific common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 13:102-29.

International Whaling Commission. 2014a. Report of the Scientific Committee. Annex D1. Report of the Working Group on the *Implementation Review* for western North Pacific common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 15: 112-88.

International Whaling Commission. 2014b. Report of the 'Second' Intersessional Workshop on the Implementation Review for western North Pacific Common Minke Whales, 19-23 March 2013, La Jolla, California, USA. *J. Cetacean Res. Manage. (Suppl.)* 15:489-506.

Miyashita, T. 2010. Summary of the information on Japanese dedicated sighting surveys for abundance estimation. Paper SC/D10/NPM11 presented to the First Intersessional Workshop for Western North Pacific Common Minke Whales, 14-17 December 2010, Pusan, Republic of Korea (unpublished). 6pp. [Paper available from the Office of this Journal].

Miyashita, T. and Okamura, H. 2011. Abundance estimates of common minke whales using the Japanese dedicated sighting survey data for RMP Implementation and CLA - Sea of Japan and Sea of Okhotsk. Paper SC/63/RMP11 presented to the IWC Scientific Committee, June 2011, Tromsø, Norway (unpublished). 34pp. [Paper available from the Office of this Journal].

Miyashita, T., Okamura, H. and Kitakado, T. 2009. Abundance of J-stock common minke whales in the Sea of Japan using the Japanese sighting data with $g(0)=1$. Paper SC/61/NPM7 presented to the IWC Scientific Committee, June 2009, Madeira, Portugal (unpublished). 10pp. [Paper available from the Office of this Journal].

Miyashita, T. and Shimada, H. 1994. Minke whale abundance in the Okhotsk Sea, the Sea of Japan and off the Pacific coast of Northern Japan estimated from sighting data. Paper SC/46/NP6 presented to the IWC Scientific Committee, May 1994 (unpublished). 9pp. [Paper available from the Office of this Journal].

Miyashita, 2019. Abundance estimate of common minke whales in sub-areas 11, 10E and 7CN in 2014. Paper SC/68a/ASI/15 presented to the IWC Scientific Committee, May 2019, Niarobi, Kenya (unpublished). [Paper available from the Office of this Journal].

Okamura, H., Miyashita, T. and Kitakado, T. 2010. $g(0)$ estimates for western North Pacific common minke whales. Paper SC/62/NPM9 presented to the IWC Scientific Committee, June 2010, Agadir, Morocco (unpublished). 7pp. [Paper available from the Office of this Journal].

Park, K.J., An, Y.R., Kim, H.W., Kim, D.N., Sohn, H.S. And An, D.H. 2012. Abundance estimation of common minke whales in the Yellow Sea using the Korean sighting data in 2011. 4pp. Paper SC/64/NPM7. [Paper available from the Office of this Journal].

Punt, A.E. 1999. Report of the Scientific Committee. Annex R. A full description of the standard BALEEN II model and some variants thereof. *J. Cetacean Res. Manage. (Suppl.)* 1: 267-76.

Tobayama, T., Yanagisawa, F. and Kasuya, T. 1992. Incidental take of minke whales in Japanese trap nets. *Rep. int. Whal. Commn* 42: 433-36.

Adjunct 1

The Historical Catch Series

C. Allison

Direct catches

The baseline trials use the ‘best’ estimates of the historical direct catch, which are summarised in Tables 1 and 2. Details of the sources and construction of the catch series are given in Allison (2011). The data are taken from the IWC individual catch database (Allison, 2013) where available.

An alternative ‘high’ catch series is used in Trial 4. Table 3 lists the ‘high’ catch numbers for the years and sub-areas where they differ from the ‘best’ catch series. The catches are identical to the ‘best’ series for all other areas and years. The Japanese coastal catch from 1930-1 and 1936-45 (in sub-areas 7CS, 7CN and 11) is estimated (Ohsumi 1982) and the values are doubled in the ‘high’ catch series. The catch series off Korea assumes a linear increase from 60 whales in 1946 to 249 in 1957 in the 'best' series whereas the 'high' series assumes an annual catch of 249 minke whales over this period.

The split between sub-areas 5 and 6W is unknown for most of the catches taken off Korea. The ‘best’ catch series includes 19,349 minke whales taken off Korea, of which 3,902 are recorded in the Yellow Sea and 4,199 in the Sea of Japan (East Sea) and Southern waters. The remaining 11,248 of unknown area are allocated between sub-areas 5 and 6W in the ratio of the catches known by area from 1940-79[13] (2,028:2,517). Trials 8 and 9 test the sensitivity to this assumption. In Trial 8 the number of whales allocated to sub-area 5 is reduced by 20% and reallocated to sub-area 6W. In Trial 9, 20% fewer animals are allocated to sub-area 6W and are reallocated to sub-area 5. The resulting catch series are given in Table 4.

Table 1

Summary of the final western North Pacific Minke Whale Direct Catch Series (1930-2011) by sub-area, sex and month.

	Males								Females										
Area	J-M	Apr	May	Jun	Jul	Aug	Sep	O-D	J-M	Apr	May	Jun	Jul	Aug	Sep	O-D	Total	M	F
1E	17	0	0	0	1	0	0	0	11	0	0	0	0	0	0	0	29	18	11
2C	3	2	2	3	2	0	1	0	2	2	0	0	1	0	0	0	18	13	5
2R	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	4	2	2
5	981	1,280	906	671	568	322	102	174	1,128	1,457	1,244	757	570	300	121	185	10,766	5,004	5,762
6W	181	383	1,325	1,167	392	202	557	1,063	178	364	1,300	1,136	376	189	545	1,009	10,367	5,270	5,097
6E	181	223	135	13	21	0	8	2	95	144	95	16	3	0	6	1	943	583	360
7CS	210	999	1,811	768	129	8	1	0	164	1,123	1,357	464	27	1	0	0	7,062	3,926	3,136
7CN	0	0	61	228	380	424	899	188	0	19	79	98	158	118	305	108	3,065	2,180	885
7W	0	1	49	33	3	1	7	0	0	0	9	3	3	0	0	0	109	94	15
7E	0	0	37	21	3	0	13	1	0	0	7	2	0	0	9	0	93	75	18
8	0	0	39	101	99	21	11	6	0	0	8	10	17	4	5	6	327	277	50
9	0	0	32	82	183	218	17	0	0	0	9	11	16	29	3	0	600	532	68
9N	0	0	1	2	5	8	0	1	0	0	0	6	0	11	0	0	34	17	17
10W	0	0	6	12	1	0	2	0	0	2	0	9	0	0	0	0	32	21	11
10E	2	25	42	119	83	26	5	3	0	1	28	60	26	9	7	0	436	305	131
11	0	62	248	498	560	226	143	29	2	465	872	882	607	271	113	25	5,003	1,766	3,237
12SW	0	0	0	1	11	9	1	0	0	0	1	5	16	27	5	0	76	22	54
12NE	0	0	0	0	36	9	10	0	0	0	0	3	33	14	6	0	111	55	56
13	0	0	0	0	0	2	0	0	0	0	0	0	1	3	0	0	6	2	4
Total	1,576	2,976	4,694	3,719	2,477	1,476	1,777	1,467	1,581	3,577	5,009	3,462	1,854	976	1,126	1,334	39,081	20,162	18,919

---

[13] The period 1940-79 is used in view of a comment by Gong (1982) that, in 1980, Government policy led to a shift to the western sector in order to direct the minke whale fishery away from areas where the (protected) fin whale might also be caught.

Table 2
Summary of the 'Best' Direct Catch Series for western North Pacific Minke Whales by Year, sub-area and sex. Catches in 2012 were not available when the conditioning was performed and so are assumed to be equal to the catch in 2011.

Males:

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
1930	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	1	0	0	0	8
1931	0	0	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	8
1932	0	0	0	0	9	0	13	1	0	0	0	0	0	0	0	0	0	0	0	23
1933	0	0	0	0	8	0	13	1	0	0	0	0	0	0	0	0	0	0	0	22
1934	0	0	0	1	21	0	20	1	0	0	0	0	0	0	0	0	0	0	0	43
1935	0	0	0	9	9	0	20	1	0	0	0	0	0	0	0	1	0	0	0	40
1936	0	0	0	12	14	0	15	0	0	0	0	0	0	0	0	0	0	0	0	41
1937	0	0	0	13	17	0	37	0	0	0	0	0	0	0	0	1	0	0	0	68
1938	0	0	0	15	20	0	44	0	0	0	0	0	0	0	0	1	0	0	0	80
1939	0	0	0	18	24	0	44	1	0	0	0	0	2	0	0	0	0	0	0	89
1940	0	0	0	15	33	0	52	0	0	0	0	0	0	0	0	1	0	0	0	101
1941	0	0	0	40	40	0	37	1	0	0	0	0	2	0	0	0	0	0	0	120
1942	0	0	0	53	67	0	44	0	0	0	0	0	1	0	0	1	0	0	0	166
1943	0	0	0	42	51	0	67	1	0	0	0	0	0	0	0	0	0	0	0	161
1944	0	0	0	38	47	0	52	0	0	0	0	0	0	0	0	1	0	0	0	138
1945	0	0	0	3	2	0	44	0	0	0	0	0	0	0	0	0	0	0	0	49
1946	0	0	0	11	21	14	51	4	0	0	0	0	1	0	0	4	0	0	0	106
1947	0	0	0	19	21	27	57	7	0	0	0	0	0	0	0	8	0	0	0	139
1948	0	3	0	22	26	56	57	1	0	0	1	0	0	0	0	26	0	0	0	192
1949	0	0	0	25	31	20	61	0	0	0	1	0	2	0	5	6	0	2	0	153
1950	0	3	0	29	37	15	63	41	0	0	2	0	1	0	13	18	0	0	0	222
1951	1	1	0	31	40	62	87	9	0	3	0	0	0	0	5	14	0	0	0	253
1952	0	1	0	36	45	142	92	1	0	0	0	0	1	0	9	20	0	0	0	347
1953	0	0	0	42	50	90	75	1	0	0	3	0	0	0	38	35	1	0	0	335
1954	0	0	1	43	54	35	24	26	0	0	0	0	0	0	32	59	1	0	0	275
1955	0	0	0	49	60	20	108	11	0	0	2	0	0	0	20	43	1	1	0	315
1956	0	0	0	54	62	16	140	25	0	1	3	0	0	0	47	69	0	0	0	417
1957	17	1	0	59	70	2	111	14	2	0	1	0	0	0	31	33	1	0	0	342
1958	0	0	0	67	65	0	126	13	0	0	1	0	0	0	0	86	0	0	0	358
1959	0	0	0	78	71	0	69	7	0	0	0	0	0	0	0	47	0	0	0	272
1960	0	0	0	72	59	0	64	6	0	1	1	0	0	0	0	41	0	0	0	244
1961	0	0	0	39	28	0	81	9	0	0	0	0	0	0	0	56	0	0	0	213
1962	0	0	0	55	52	0	46	7	0	0	0	0	0	0	0	48	0	0	0	208
1963	0	0	0	122	52	0	49	6	0	0	0	0	0	0	0	40	0	0	0	269
1964	0	0	0	139	95	6	85	6	0	0	0	0	0	0	0	39	0	0	0	370
1965	0	1	0	83	101	11	51	3	0	0	0	0	0	0	0	62	0	0	0	312
1966	0	2	0	76	87	0	81	8	1	0	0	0	0	0	0	71	0	0	0	326
1967	0	0	0	109	73	2	50	6	0	0	0	0	0	0	2	55	0	0	0	297
1968	0	0	0	98	75	8	58	4	1	0	0	0	0	2	0	22	0	0	0	268
1969	0	0	0	118	95	10	27	2	0	0	0	0	3	0	7	43	0	0	0	305
1970	0	0	0	186	188	5	101	5	1	0	0	2	4	0	8	38	0	0	2	540
1971	0	0	0	200	189	3	84	6	0	0	0	0	0	0	8	54	1	0	0	545
1972	0	0	0	252	286	0	35	17	0	0	0	0	0	0	0	78	0	0	0	668
1973	0	0	0	215	244	0	83	26	0	2	14	0	0	0	15	95	2	28	0	724
1974	0	0	0	213	271	0	63	34	0	9	0	0	0	1	5	44	4	22	0	666
1975	0	0	0	196	293	9	35	63	0	3	0	0	0	18	2	62	11	1	0	693
1976	0	0	0	353	174	0	35	27	0	0	0	0	0	0	10	89	0	0	0	688
1977	0	0	0	234	304	0	32	71	0	0	0	0	0	0	0	58	0	0	0	699
1978	0	0	0	181	354	0	93	133	0	0	0	0	0	0	0	19	0	0	0	780
1979	0	0	0	164	379	0	95	150	0	0	0	0	0	0	8	17	0	0	0	813
1980	0	0	0	447	147	0	88	72	0	0	0	0	0	0	10	40	0	0	0	804
1981	0	1	0	188	192	0	148	39	1	0	0	0	0	0	13	28	0	0	0	610
1982	0	0	0	229	210	2	105	56	1	0	0	0	0	0	9	5	0	0	0	617
1983	0	0	0	100	142	3	66	68	0	0	0	0	0	0	6	4	0	0	0	389
1984	0	0	0	87	105	0	64	88	0	0	0	0	0	0	0	46	0	0	0	390
1985	0	0	1	23	29	5	39	123	0	0	0	0	0	0	2	30	0	0	0	252
1986	0	0	0	1	31	20	69	89	0	0	0	0	0	0	0	19	0	0	0	229
1987	0	0	0	0	0	0	80	86	0	0	0	0	0	0	0	16	0	0	0	182
1988	0	0	0	0	0	0	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	0	0	0	0	0	0
1990	0	0	0	0	0	0	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	0	0	0	0	0	0
1992	0	0	0	0	0	0	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	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	18
1995	0	0	0	0	0	0	0	0	0	0	0	91	0	0	0	0	0	0	0	91
1996	0	0	0	0	0	0	0	28	0	0	16	0	0	0	0	19	0	0	0	63
1997	0	0	0	0	0	0	0	0	1	1	30	55	0	0	0	0	0	0	0	87
1998	0	0	0	0	0	0	0	0	22	26	41	0	0	0	0	0	0	0	0	89
1999	0	0	0	0	0	0	2	39	2	0	0	0	0	0	0	28	0	0	0	71
2000	0	0	0	0	0	0	4	15	0	0	0	16	0	0	0	0	0	0	0	35
2001	0	0	0	0	0	0	11	10	19	7	20	26	0	0	0	0	0	0	0	93
2002	0	0	0	0	0	0	0	79	1	0	8	31	0	0	0	0	0	0	0	119
2003	0	0	0	0	0	0	32	0	4	7	35	37	0	0	0	0	0	0	0	115

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
2004	0	0	0	0	0	0	0	62	0	0	0	75	0	0	0	0	0	1	0	138
2005	0	0	0	0	0	0	28	67	2	0	7	52	0	0	0	0	0	0	0	156
2006	0	0	0	0	0	0	41	33	11	1	36	23	0	0	0	0	0	0	0	145
2007	0	0	0	0	0	0	50	67	3	0	15	5	0	0	0	0	0	0	0	140
2008	0	0	0	0	0	0	23	33	0	0	5	48	0	0	0	0	0	0	0	109
2009	0	0	0	0	0	0	29	41	8	3	13	6	0	0	0	0	0	0	0	100
2010	0	0	0	0	0	0	17	40	0	0	0	12	0	0	0	0	0	0	0	69
2011	0	0	0	0	0	0	17	64	0	0	0	1	0	0	0	0	0	0	0	82
2012	0	0	0	0	0	0	47	61	4	0	3	0	0	0	0	0	0	0	0	115
2013	0	0	0	0	0	0	17	41	0	0	0	3	0	0	0	0	0	0	0	61
2014	0	0	0	0	0	0	16	35	0	0	0	0	0	0	0	0	0	0	0	51
2015	0	0	0	0	0	0	10	35	0	0	0	0	0	0	0	0	0	0	0	45
2016	0	0	0	0	0	0	7	8	0	0	0	0	0	0	0	0	0	0	0	15
2017	0	0	0	0	0	0	3	22	6	10	4	17	0	0	0	9	0	0	0	71
2018	0	0	0	0	0	0	28	22	4	1	15	14	0	0	0	16	0	0	0	100
Total	18	13	2	5,004	5,270	583	3,926	2,180	94	75	277	532	17	21	305	1,766	22	55	2	20,162

Females:

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
1930	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	0	0	0	5
1931	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	0	0	0	6
1932	0	0	0	5	4	0	7	0	0	0	0	0	0	0	0	1	0	0	0	17
1933	0	0	0	5	4	0	7	1	0	0	0	0	0	1	0	1	0	0	0	19
1934	0	0	0	9	10	0	10	0	0	0	0	0	0	1	0	1	0	0	0	31
1935	0	0	0	8	14	0	10	0	0	0	0	0	0	0	0	1	0	0	0	33
1936	0	0	0	12	13	0	7	0	0	0	0	0	0	0	0	2	0	0	0	34
1937	0	0	0	14	18	0	18	1	0	0	0	0	0	0	0	1	0	0	0	52
1938	0	0	0	18	20	0	22	0	0	0	0	0	0	0	0	1	0	0	0	61
1939	0	0	0	19	23	0	22	0	0	0	0	0	1	0	0	2	0	0	1	68
1940	0	0	0	13	34	0	25	0	0	0	0	0	0	0	0	1	0	0	0	73
1941	0	0	0	64	38	0	18	0	0	0	0	0	0	0	0	2	0	0	0	122
1942	0	0	0	54	66	0	22	0	0	0	0	0	2	0	0	1	0	0	0	145
1943	0	0	0	39	51	0	32	0	0	0	0	0	0	0	0	2	0	0	0	124
1944	0	0	0	38	45	0	25	0	0	0	0	0	0	0	0	1	0	0	0	109
1945	0	0	0	2	3	0	22	1	0	0	0	0	0	0	0	2	0	0	0	30
1946	0	0	0	10	18	10	24	1	0	0	0	0	1	0	0	13	0	0	0	77
1947	0	0	0	18	19	21	27	3	0	0	0	0	0	0	0	23	0	0	0	111
1948	0	0	0	21	25	38	31	0	0	0	0	0	0	0	0	53	0	0	0	168
1949	0	0	0	25	31	30	32	0	0	0	2	0	0	0	4	27	0	1	0	152
1950	0	1	1	29	34	9	25	19	0	0	0	0	0	0	0	32	0	1	0	151
1951	0	0	0	33	42	39	42	2	0	2	1	0	2	0	2	70	0	1	0	236
1952	0	0	1	37	45	43	78	2	0	0	0	0	1	0	0	97	1	0	0	305
1953	0	0	0	39	49	47	56	2	0	0	3	0	0	0	5	57	1	0	0	259
1954	0	1	0	45	55	27	22	15	0	0	3	0	1	0	4	124	0	0	0	297
1955	0	0	0	58	59	15	80	4	0	0	3	0	0	0	7	119	0	2	0	347
1956	0	0	0	62	66	23	97	7	0	0	1	0	1	0	13	108	0	4	0	382
1957	11	1	0	79	68	0	81	12	2	0	3	0	0	0	13	96	1	0	0	367
1958	0	0	0	101	63	0	128	8	0	0	1	0	0	0	0	153	0	0	0	454
1959	0	0	0	126	73	0	70	4	0	0	0	0	0	0	0	83	0	1	0	357
1960	0	0	0	141	57	0	65	4	0	1	1	0	0	0	0	73	0	0	0	342
1961	0	0	0	82	30	0	83	5	0	0	1	0	0	0	0	98	0	0	0	299
1962	0	0	0	117	52	0	47	5	0	0	0	0	0	0	0	85	0	1	0	307
1963	0	0	0	168	52	0	50	4	0	0	0	0	0	0	0	71	0	0	0	345
1964	0	0	0	186	97	6	86	4	0	0	0	0	0	0	0	69	0	0	0	448
1965	0	1	0	110	102	9	99	3	0	0	0	0	0	0	0	94	0	0	0	418
1966	0	1	0	105	88	2	100	15	0	0	0	0	0	0	0	84	0	0	0	395
1967	0	0	0	139	73	8	65	7	0	0	0	0	0	0	3	87	0	0	0	382
1968	0	0	0	124	73	3	81	3	0	0	0	0	0	7	5	56	0	0	0	352
1969	0	0	0	156	96	10	32	1	0	0	0	0	8	0	5	97	0	0	0	405
1970	0	0	0	216	188	2	87	5	1	0	0	0	0	0	4	70	0	0	2	575
1971	0	0	0	250	190	2	67	4	0	0	0	0	0	0	9	52	0	0	0	574
1972	0	0	0	292	286	0	75	22	0	0	0	0	0	0	1	113	0	0	0	789
1973	0	0	0	239	244	2	90	15	0	2	7	0	0	0	6	116	11	27	0	759
1974	0	0	0	267	272	0	51	19	0	3	0	0	0	0	3	79	17	18	0	729
1975	0	0	0	229	288	2	46	22	0	4	0	0	0	2	4	58	23	0	0	678
1976	0	0	0	445	174	0	46	29	0	0	0	0	0	0	11	113	0	0	1	819
1977	0	0	0	269	303	0	28	14	0	0	0	0	0	0	2	43	0	0	0	659
1978	0	0	0	207	356	0	85	22	0	0	0	0	0	0	0	48	0	0	0	718
1979	0	0	0	130	264	0	38	28	0	0	0	0	0	0	7	64	0	0	0	531
1980	0	0	0	272	109	0	70	12	0	0	0	0	0	0	5	82	0	0	0	550
1981	0	0	0	188	192	0	68	11	0	0	0	0	0	0	2	63	0	0	0	524
1982	0	0	0	236	219	2	58	28	0	0	0	0	0	0	6	56	0	0	0	605
1983	0	0	0	98	138	4	69	30	0	0	0	0	0	0	5	42	0	0	0	386
1984	0	0	0	87	114	0	38	55	0	0	0	0	0	0	0	76	0	0	0	370
1985	0	0	0	26	35	4	20	41	0	0	0	0	0	0	5	66	0	0	0	197
1986	0	0	0	0	15	2	35	43	2	0	0	0	0	0	0	54	0	0	0	151
1987	0	0	0	0	0	0	43	30	0	0	0	0	0	0	0	49	0	0	0	122
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
1989	0	0	0	0	0	0	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	0	0	0	0	0	0
1991	0	0	0	0	0	0	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	0	0	0	0	0	0
1993	0	0	0	0	0	0	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	3	0	0	0	0	0	0	0	3
1995	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	9
1996	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	11	0	0	0	14
1997	0	0	0	0	0	0	0	0	0	0	1	12	0	0	0	0	0	0	0	13
1998	0	0	0	0	0	0	0	0	3	4	4	0	0	0	0	0	0	0	0	11
1999	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	22	0	0	0	29
2000	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	5
2001	0	0	0	0	0	0	0	0	3	0	1	3	0	0	0	0	0	0	0	7
2002	0	0	0	0	0	0	0	31	0	0	0	2	0	0	0	0	0	0	0	33
2003	0	0	0	0	0	0	30	0	1	0	3	2	0	0	0	0	0	0	0	36
2004	0	0	0	0	0	0	0	14	0	0	0	8	0	0	0	0	0	0	0	22
2005	0	0	0	0	0	0	37	19	0	0	7	3	0	0	0	0	0	0	0	66
2006	0	0	0	0	0	0	35	12	1	1	2	1	0	0	0	0	0	0	0	52
2007	0	0	0	0	0	0	46	21	0	0	0	1	0	0	0	0	0	0	0	68
2008	0	0	0	0	0	0	38	18	0	0	0	6	0	0	0	0	0	0	0	62
2009	0	0	0	0	0	0	35	24	0	0	5	1	0	0	0	0	0	0	0	65
2010	0	0	0	0	0	0	28	20	0	0	0	2	0	0	0	0	0	0	0	50
2011	0	0	0	0	0	0	6	37	0	0	0	1	0	0	0	0	0	0	0	44
2012	0	0	0	0	0	0	38	30	1	0	0	0	0	0	0	0	0	0	0	69
2013	0	0	0	0	0	0	17	17	0	0	0	0	0	0	0	0	0	0	0	34
2014	0	0	0	0	0	0	14	16	0	0	0	0	0	0	0	0	0	0	0	30
2015	0	0	0	0	0	0	9	16	0	0	0	0	0	0	0	0	0	0	0	25
2016	0	0	0	0	0	0	9	13	0	0	0	0	0	0	0	0	0	0	0	22
2017	0	0	0	0	0	0	0	13	0	1	0	6	0	0	0	38	0	0	0	58
2018	0	0	0	0	0	0	23	8	0	0	1	8	0	0	0	31	0	0	0	71
Total	11	5	2	5,762	5,097	360	3,136	885	15	18	50	68	17	11	131	3,237	54	56	4	18,919

Table 3

The High Catch Series.

The table shows the catches for the years and sub-areas where they differ from the 'best' catch series (1930-1, 1936-45 in sub-areas 7CS, 7CN and 11; 1947-56 in sub-areas 5 and 6W). Numbers from the 'best' catch series are shown for comparison. The 'high' catch series is identical to the 'best' series for all other areas and years.

Series: Sub-area:	Best 7CS	Best 7CS	High 7CS	High 7CS	Best 7CN	Best 7CN	High 7CN	High 7CN	Best 11	Best 11	High 11	High 11
	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem
1930	7	4	**14**	**8**	0	0	0	0	1	1	**2**	**2**
1931	7	4	**14**	**8**	1	0	**2**	0	0	2	0	**4**
1932	13	7	13	7	1	0	1	0	0	1	0	1
1933	13	7	13	7	1	1	1	1	0	1	0	1
1934	20	10	20	10	1	0	1	0	0	1	0	1
1935	20	10	20	10	1	0	1	0	1	1	1	1
1936	15	7	**30**	**14**	0	0	0	0	0	2	0	**4**
1937	37	18	**74**	**36**	0	1	0	**2**	1	1	**2**	**2**
1938	44	22	**88**	**44**	0	0	0	0	1	1	**2**	**2**
1939	44	22	**88**	**44**	1	0	**2**	0	0	2	0	**4**
1940	52	25	**104**	**50**	0	0	0	0	1	1	**2**	**2**
1941	37	18	**74**	**36**	1	0	**2**	0	0	2	0	**4**
1942	44	22	**88**	**44**	0	0	0	0	1	1	**2**	**2**
1943	67	32	**134**	**64**	1	0	**2**	0	0	2	0	**4**
1944	52	25	**104**	**50**	0	0	0	0	1	1	**2**	**2**
1945	44	22	44	22	0	1	0	**2**	0	2	0	**4**

Series: Sub-area:	Best 5	Best 5	High 5	High 5	Best 6W	Best 6W	High 6W	High 6W
	Male	Fem	Male	Fem	Male	Fem	Male	Fem
1946	11	10	11	10	21	18	21	18
1947	19	18	**55**	**56**	21	19	**70**	**68**
1948	22	21	**55**	**56**	26	25	**70**	**68**
1949	25	25	**55**	**56**	31	31	**70**	**68**
1950	29	29	**55**	**56**	37	34	**70**	**68**
1951	31	33	**55**	**56**	40	42	**70**	**68**
1952	36	37	**55**	**56**	45	45	**70**	**68**
1953	42	39	**55**	**56**	50	49	**70**	**68**
1954	43	45	**55**	**56**	54	55	**70**	**68**
1955	49	58	**56**	**66**	60	59	**70**	**68**
1956	54	62	**57**	**66**	62	66	**70**	**68**
1957	59	79	59	79	70	68	70	68

Table 4

The Catch Series for Trials 8 and 9 used to test the sensitivity to the allocation of catches off Korea between sub-areas 5 and 6W. Catches in the other sub-areas are the same as for the 'Best' catch series.

	Trial 8				Trial 9			
Sub-area:	5	5	6W	6W	5	5	6W	6W
	Male	Fem	Male	Fem	Male	Fem	Male	Fem
1932	0	5	9	4	0	5	9	4
1933	0	5	8	4	0	5	8	4
1934	1	9	21	10	1	9	21	10
1935	9	12	9	10	7	7	12	14
1936	14	15	13	9	9	10	15	17
1937	17	16	14	15	12	9	21	20
1938	19	22	16	16	14	13	24	22
1939	23	23	20	18	15	15	27	27
1940	21	21	27	26	12	11	37	35
1941	48	72	31	31	38	62	41	41
1942	66	66	53	55	43	43	77	77
1943	51	51	40	41	31	33	59	60
1944	48	48	37	35	31	31	53	53
1945	3	2	2	3	3	2	2	3
1946	14	15	15	16	10	8	22	20
1947	24	21	16	16	15	15	23	24
1948	27	26	20	21	18	18	28	30
1949	30	32	25	25	18	22	36	36
1950	34	38	28	29	23	24	42	40
1951	40	40	33	33	26	26	47	47
1952	46	46	37	34	29	30	51	53
1953	50	51	40	39	31	33	58	58
1954	55	54	43	45	35	35	64	63
1955	62	69	46	49	39	48	70	69
1956	67	74	52	51	42	53	75	74
1957	73	92	56	55	49	66	79	82
1958	80	114	51	51	53	89	77	77
1959	93	141	57	57	63	110	86	89
1960	84	152	46	47	63	131	68	67
1961	44	87	24	24	35	77	33	34
1962	65	128	43	40	49	110	58	59
1963	131	179	43	41	104	149	71	70
1964	159	205	77	76	118	162	119	118
1965	102	131	82	81	68	97	116	115
1966	95	121	70	70	64	91	100	101
1967	125	153	59	57	91	120	93	90
1968	112	139	60	59	82	107	91	90
1969	137	176	75	77	98	138	114	115
1970	223	253	151	151	152	183	221	222
1971	239	286	152	152	165	214	225	225
1972	308	348	229	231	230	267	311	308
1973	251	275	208	208	197	220	262	263
1974	251	302	235	235	188	241	297	297
1975	253	287	235	231	159	196	327	324
1976	389	479	139	139	292	384	235	235
1977	294	331	242	243	192	226	346	346
1978	253	276	283	286	152	175	384	387
1979	164	130	379	264	164	130	379	264
1980	447	272	147	109	447	272	147	109
1981	188	188	192	192	188	188	192	192
1982	236	247	202	209	222	229	217	226
1983	100	98	142	138	100	98	142	138
1984	87	87	105	114	87	87	105	114
1985	23	26	29	35	23	26	29	35
1986	1	0	31	15	1	0	31	15

Bycatches

Recent by-catches (also referred to as incidental catches) are listed in Tables 5 and 6. The numbers of nets are listed in Table 7. The numbers of bycatches are only used in the trials if the number of nets is also known. Thus, for Japan, the catches from 2007-9 are not used and are shown greyed out in the table.

The bycatch in sub-area 6W by Japan is small (9 whales) (and there are no corresponding set net numbers) so the numbers are added to the bycatches for sub-area 6E. The bycatch by Korea in sub-area 1W is very small (2 whales in total) and there are no corresponding set net numbers so the numbers are added to the bycatches for sub-area 5. Similarly, the numbers in sub-areas 6E (3 whales) are added to the bycatches for sub-area 6W.

A single series of historical bycatches is used for all of the trials when applying the RMP (i.e. for calculating catch limits), irrespective of the true values of the bycatches, which differ both among trials and simulations within trials. The estimate of the bycatches used by the CLA is set to the averages of the predicted bycatches based on the fit to the actual data of the operating model for the six baseline trials (i.e. using the 'best fit' simulation (0)). This series will be generated once conditioning is complete.

Table 5

Recent by-catches by Japan (some are updates to those listed in progress reports). It is known that the numbers are incomplete for 2001. Bycatches from sub-area 6W are included with those in 6E (see text).

Year	1E	2C	6E	7CN	7CS	10E	11	Total
2001	1	10	25	3	8	4	3	54
2002	7	19	45	13	17	3	5	109
2003	5	17	61	15	18		8	124
2004	4	19	66	9	14		3	115
2005	4	33	55	10	17	3	6	128
2006	3	28	76	16	21		3	147
2007	7	42	69	11	20		6	155
2008	9	23	68	11	17	2	3	133
2009	3	17	69	3	25		1	118
2010	3	18	74	8	17		4	124
2011	6	28	65	9	8		1	117
2012	5	25	56	9	15		4	114
2013	5	20	54	9	15	2		105
2014	3	21	74	16	23	1	2	140
2015	5	28	84	12	26		1	156
2016	7	34	86	17	22	3		169

Table 6

Recent bycatches by Korea. The numbers are taken from the individual records.

	5	6W	1W	Posn.Unk	Total
1996	0	128	0	0	128
1997	0	81	0	0	81
1998	0	47	0	0	47
1999	0	59	0	0	59
2000	14	81	0	0	95
2001	12	150	0	0	162
2002	8	81	0	0	89
2003	10	80	2	0	92
2004	13	56	0	0	69
2005	7	100	0	0	107
2006	11	69	0	2	82
2007	13	66	0	1	80
2008	12	67	0	2	81
2009	12	72	0	3	87
2010	8	67	0	1	76
2011	16	74	0	1	91
2012	9	70	0	0	79
2013	11	46	0	0	57
2014	10	44	0	0	54
2015	7	88	1	1	97
2016	10	89	0	0	99
2017	13	59	0	0	72
2018	8	74	0	0	82

Table 7

Numbers of nets.

	Japan large scale trap nets								Japan salmon trap nets					Korean nets		
	1E	2C	6E	7CS	7CN	10E	11	Total	7CS	7CN	10E	11	Total	5	6W	Total
1946	24	67	103	41	7	9	2	252	3	57	24	44	129	3.5	10	0
1947	26	73	112	44	7	10	2	275	3	62	26	48	140	7	19	13
1948	29	79	122	48	8	11	2	298	3	68	29	52	152	10.5	29	26
1949	31	85	131	52	8	12	2	320	4	73	31	56	164	14	39	40
1950	33	91	141	55	9	12	2	343	4	78	33	60	175	17.5	48	53
1951	35	97	150	59	10	13	2	366	4	83	35	64	187	21	58	66
1952	37	103	159	63	10	14	2	389	4	88	37	68	199	24.5	68	79
1953	40	109	169	66	11	15	3	412	5	94	40	73	210	28	77	92
1954	42	115	178	70	11	16	3	435	5	99	42	77	222	31.5	87	105
1955	44	121	187	74	12	17	3	458	5	104	44	81	234	35	97	119
1956	46	127	197	77	13	17	3	481	5	109	46	85	245	38.5	106	132
1957	48	133	206	81	13	18	3	503	6	114	48	89	257	42	116	145
1958	51	139	216	85	14	19	3	526	6	120	51	93	269	45.5	126	158
1959	53	145	225	88	14	20	3	549	6	125	53	97	280	49	135	171
1960	55	151	234	92	15	21	4	572	6	130	55	101	292	52.5	145	184
1961	57	157	244	96	16	22	4	595	7	135	57	105	304	56	155	198
1962	59	164	253	100	16	22	4	618	7	140	59	109	316	59.5	164	211
1963	62	170	262	103	17	23	4	641	7	146	62	113	327	63	174	224
1964	64	176	272	107	17	24	4	664	7	151	64	117	339	66.5	184	237
1965	66	182	281	111	18	25	4	687	8	156	66	121	351	70	193	250
1966	68	188	291	114	19	26	4	709	8	161	68	125	362	73.5	203	263
1967	70	194	300	118	19	27	5	732	8	166	70	129	374	77	213	277
1968	73	200	309	122	20	27	5	755	8	172	73	133	386	80.5	222	290
1969	75	206	319	125	20	28	5	778	9	177	75	137	397	84	232	303
1970	77	212	328	129	21	29	5	801	9	182	77	141	409	87.5	242	316
1971	80	209	324	127	21	29	5	795	9	190	81	148	428	91	251	329
1972	83	206	321	124	21	29	5	788	9	199	84	154	447	94.5	261	342
1973	86	203	317	122	20	28	5	782	10	207	88	161	465	98	271	356
1974	89	200	314	119	20	28	5	775	10	216	91	167	484	101.5	280	369
1975	92	197	310	117	20	28	5	769	10	224	95	174	503	105	290	382
1976	82	197	320	119	20	33	4	775	11	249	104	196	559	108.5	300	395
1977	72	197	330	122	20	39	3	781	11	274	113	217	615	112	309	408
1978	61	197	339	124	20	44	1	787	12	299	122	239	671	115.5	319	421
1979	45	201	355	120	29	24	11	793	12	324	131	260	727	119	329	435
1980	48	204	365	128	28	23	11	814	0	334	125	263	722	122.5	338	448
1981	50	201	367	131	26	20	9	814	0	327	141	281	749	126	348	461
1982	48	198	381	129	26	21	10	824	0	332	134	277	743	129.5	358	474
1983	53	195	384	130	36	30	14	852	0	330	126	278	734	133	367	487
1984	50	189	387	139	48	41	19	880	0	320	151	250	721	136.5	377	500
1985	46	189	412	139	42	35	16	887	0	348	158	256	762	140	387	514
1986	49	196	408	134	49	42	19	905	0	349	154	255	758	143.5	396	527
1987	47	194	405	137	48	41	19	897	0	357	158	251	766	147	406	540
1988	46	187	400	130	39	33	15	857	0	362	165	252	779	150.5	416	553
1989	55	181	391	139	34	29	13	849	0	369	287	230	886	154	425	566
1990	55	178	404	133	35	29	13	858	0	363	293	226	882	157.5	435	579
1991	60	174	401	132	28	23	11	839	0	373	290	229	892	161	445	593
1992	55	166	392	132	26	22	10	813	0	369	287	231	887	164.5	454	606
1993	61	179	397	132	27	21	10	837	0	369	290	236	895	168	464	619
1994	54	175	378	128	28	22	10	806	0	350	401	217	968	159	447	632
1995	55	175	372	116	26	20	9	782	0	349	400	216	965	149	443	606
1996	56	171	371	129	26	20	9	790	0	335	390	217	942	144	438	592
1997	53	168	368	130	24	19	9	780	0	335	372	210	917	142	433	582
1998	55	164	370	130	26	19	9	782	0	331	372	211	914	138	427	575
1999	54	166	363	128	28	21	10	780	0	322	386	209	917	129	426	565
2000	54	165	360	128	27	21	10	775	0	322	381	209	912	128	425	555
2001	56	149	354	128	28	22	10	770	0	327	368	219	914	135	417	553
2002	51	161	363	129	32	26	12	783	0	316	367	209	892	134	422	552
2003	48	163	360	136	31	25	11	782	0	315	353	207	875	133	421	556
2004	50	159	348	135	26	21	10	759	0	312	354	211	877	132	421	554
2005	52	158	326	131	25	20	9	731	0	313	356	209	878	131	420	553
2006	45	154	310	130	26	21	10	704	0	324	353	209	886	141	414	551
2007	39	132	298	112	7	4	2	654						126	414	555
2008	39	124	301	115	21	16	7	651						125	411	540
2009	41	127	303	118	21	15	41							125	411	536
2010	39	127	306	113	20	14	39							125	411	536
2011	39	126	302	91	20	14	39							121	405	526
2012	38	125	305	93	20	14	38							121	399	520
2013	37	117	300	90	20	14	37							115	398	513
2014	35	117	293	95	19	14	35							115	393	508
2015	35	112	293	98	19	14	35							117	385	502
2016	35	112	261	95	19	14	35							115	381	496
2017														114	380	494

Sources: Japan 1935-70. Set using linear interpolation, assuming 0 in 1935.
Japan 1970-79. Set using linear interpolation between the numbers for 1970 and 1975 from Tobayama *et al*. (1992).

Japan 1979-2016. Goto, pers. comm. Feb. 2019
Korea 1946-1996. Set using linear interpolation, assuming 0 in 1946.
Korea 1996-2017. No. of set net licences

Missing data: where the numbers of nets between 2007-2017 are unknown, the numbers from the last known year are used.

REFERENCES

Allison, C. 2011. Direct catch data for western North Pacific minke whale simulation trials. Paper SC/D11/NPM3 presented to the First Intersessional Workshop for the *Implementation Review* of western North Pacific common minke whales, 12-16 December 2011, Tokyo, Japan (unpublished). [Paper available from the Office of this Journal].

Allison, C. 2013. IWC individual catch database Version 5.5 (12 February 2013).

Gong, Y. 1982. A note on the distribution of minke whales in Korean waters. *Rep int. Whal. Commn* 32:279-82. SC/33/Mi7.

Hakamada, T. 2010. The number of set nets in the coast of Japan by sub-areas and years during 1979-2006. Paper SC/D10/NPM13 presented to the First Intersessional Workshop for Western North Pacific Common Minke Whales, 14-17 December 2010, Pusan, Republic of Korea (unpublished). 1pp. [Paper available from the Office of this Journal].

Tobayama, T., Yanagisawa, F., and Kasuya, T. 1992. Incidental Take of Minke Whales in Japanese Trap Nets. *Rep. Int. Whal. Commn* 42:433-436.

Ohsumi, S. 1982 Minke whales in the coastal waters of Japan, 1980 and a population assessment of the Okhotsk Sea-West Pacific stock. *Rep. Int. Whal. Commn* 32, 1982, pp283-6. SC/33/Mi8.

Adjunct 2

Using the Genetic Stock Assignment by Sub-Area to Inform the Mixing Matrices of the North Pacific Minke Whale *Implementation Simulation Trials*

C.L. de Moor, C. Allison, A.E. Punt

This adjunct details the stock assignment by sub-area and sex used to develop the data used to estimate mixing matrices for the North Pacific minke whale *Implementation Simulation Trials*. The baseline mixing matrices for Hypothesis E were newly developed for these *Implementation Simulation Trials*, largely informed by the genetic assignment tables below. The baseline mixing matrices for Hypotheses A and B were only changed from those used during the 2013 *Implementation Simulation Trials* where the genetic assignment tables below strongly supported such changes.

Baseline Trials, Hypotheses A and B

For the baseline trials, stock assignment for Hypotheses A and B is based on the 'stock90' assignment by STRUCTURE in *Data_NPM_190226_v3.csv*. The number of samples assigned to stock by sub-area is as follows. Table 7a of Annex K details the assigned numbers by stock, sub-area, period and sex used to condition the trials.

Males	**10E**	**11**	**1E**	**2C**	**6E**	**7CN**	**7CS**	**7E**	**7WR**	**8**	**9**
J-stock	8	28	29	107	453	158	135	0	0	0	1
O-stock	1	29	1	26	1	580	281	41	74	207	442
Unassigned	2	7	2	10	41	80	61	3	6	22	44
Females											
J-stock	6	28	42	188	471	112	151	0	1	0	0
O-stock	0	30	0	24	3	263	286	4	8	17	49
Unassigned	1	7	2	17	33	23	49	1	0	6	5

Grey highlight: stock **has** been assigned to a sub-area, but is not modelled in that sub-area in the mixing matrices.

- The singleton assignment of a J-stock female to sub-area 7WR is ignored for the baseline trials, but in Trial 5 J-stock animals are assumed to be found in both sub-areas 7E and 7WR.
- The singleton assignment of an O-stock male to sub-area 1E is ignored for modelling purposes
- The singleton assignment of a J-stock male to sub-area 9 in 1E is small compared to the total sample size, and is therefore ignored for the baseline, but in Trial 5 J-stock animals are assumed to be found in sub-areas 8 and 9
- The assignment of O-stock animals to sub-area 6E are very small compared to the total sample size, and O-stock animals are therefore not modelled to be found in sub-area 6E.

Pink highlight: females of a stock **have not** been assigned to a sub-area, but are modelled in that sub-area in the mixing matrices

- The sample sizes in sub-area 10E are low and one cannot therefore discount the presence of O-stock females in sub-area 10E.

Hypothesis A Baseline

J-Stock Baseline A (Matrix J-A)

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	May	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	Jun	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Jul	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Aug	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Sep	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	O-D	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$			
Ad.M	J-M	2	2	1				2	4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr	0	0	1				2	2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$						γ_6	$2\gamma_7$	γ_8	γ_8		
	May	0	0	1				2	2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$		
	Jun	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$		
	Jul	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Aug	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Sep	2	2	1				2	4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7				
	O-D	4	4	1				2	2		$2\gamma_3$	$2\gamma_5$											
Ad.F	J-M	2	2	1				2	4	$4\gamma_{29}$	γ_1	γ_4						γ_6	γ_7				
	Apr	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_1$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}		
	May	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_2$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$		
	Jun	0	0	1				2	2	$2\gamma_{29}$	γ_3	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$		
	Jul	0	0	1				2	2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Aug	0	0	1				2	2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Sep	2	2	1				2	4	$4\gamma_{29}$	γ_3	γ_5						γ_6	γ_7				
	O-D	4	4	1				2	2		γ_3	γ_5											

Hypothesis A Baseline (contd.)

O-Stock Baseline A (Matrix O-AB). Blue indicates changes since 2013 *ISTs*.

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M			γ_{13}	4	4	4				4	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
	Apr			γ_{14}	2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	May			γ_{14}	2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Jun			γ_{14}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Jul			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Aug			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Sep			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	O-D			γ_{15}	4	4	4				4	$2\gamma_{16}$	0	0	0	0	0		$2\gamma_{30}$	0	0	0	0
Ad.M	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
	Apr			γ_{14}	2	2	2				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0		$2\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May			0	0	0	0				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$2\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
Ad.F	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
	Apr			γ_{14}	2	2	2				1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0		γ_{30}	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May			0	0	0	0				1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		γ_{30}	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0

Hypothesis B Baseline

Y-Stock Baseline B (Matrix Y-BE)

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	4						4	γ_{25}														
	Apr	1						4	γ_{26}														
	May	1						4	γ_{26}														
	Jun	1						4	γ_{26}														
	Jul	1						4	γ_{27}														
	Aug	1						4	γ_{27}														
	Sep	2						4	γ_{28}														
	O-D	4						4	γ_{28}														
AdM	J-M	4						4	γ_{25}														
	Apr	1						4	γ_{26}														
	May	1						4	γ_{26}														
	Jun	1						4	γ_{26}														
	Jul	1						4	γ_{27}														
	Aug	1						4	γ_{27}														
	Sep	2						4	γ_{28}														
	O-D	4						4	γ_{28}														
AdF	J-M	4						4	γ_{25}														
	Apr	1						4	γ_{26}														
	May	1						4	γ_{26}														
	Jun	1						4	γ_{26}														
	Jul	1						4	γ_{27}														
	Aug	1						4	γ_{27}														
	Sep	2						4	γ_{28}														
	O-D	4						4	γ_{28}														

Hypothesis B Baseline (contd.)

J-Stock Baseline B (Matrix J-BE)

Age/	Mon										Sub -	Area											
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M		2	2					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr		2	2					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	May		2	2					2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	Jun		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Jul		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Aug		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Sep		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	O-D		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$			
Ad.M	J-M		2	1					4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr		0	1					2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$						γ_6	$2\gamma_7$	γ_8	γ_8		
	May		0	1					2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$		
	Jun		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$		
	Jul		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Aug		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Sep		2	1					4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7				
	O-D		4	1					2		$2\gamma_3$	$2\gamma_5$											
Ad.F	J-M		2	1					4	$4\gamma_{29}$	γ_1	γ_4						γ_6	γ_7				
	Apr		0	1					2	$2\gamma_{29}$	$2\gamma_1$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}		
	May		0	1					2	$2\gamma_{29}$	$2\gamma_2$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$		
	Jun		0	1					2	$2\gamma_{29}$	γ_3	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$		
	Jul		0	1					2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Aug		0	1					2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Sep		2	1					4	$4\gamma_{29}$	γ_3	γ_5						γ_6	γ_7				
	O-D		4	1					2		γ_3	γ_5											

O-Stock Baseline A (Matrix O-AB). Blue indicates changes since 2013 *ISTs*.

Age/	Mon										Sub -	Area											
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M			γ_{13}	4	4	4				4	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
	Apr			γ_{14}	2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	May			γ_{14}	2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Jun			γ_{14}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Jul			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Aug			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	Sep			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	0
	O-D			γ_{15}	4	4	4				4	$2\gamma_{16}$	0	0	0	0	0		$2\gamma_{30}$	0	0	0	0
Ad.M	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
	Apr			γ_{14}	2	2	2				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0		$2\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May			0	0	0	0				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$2\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
Ad.F	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0
	Apr			γ_{14}	2	2	2				1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0		γ_{30}	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May			0	0	0	0				1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		γ_{30}	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	0

Baseline Trials, Hypothesis E

For the baseline trials, stock assignment for Hypothesis E is based on the 'geneland.stock2' assignment by GENELAND in *Data_NPM_190226_v3.csv*. The number of samples assigned to stock by sub-area is as follows. Table 7a of Annex K details the assigned numbers by stock, sub-area, period and sex used to condition the trials.

Males	**10E**	**11**	**1E**	**2C**	**6E**	**7CN**	**7CS**	**7E**	**7WR**	**8**	**9**
J-stock	8	13	31	88	492	20	0	0	0	0	0
P-stock	0	39	0	10	0	384	217	0	0	0	0
O-stock	0	1	0	0	0	280	83	41	70	207	464
Unassigned	0	6	0	19	0	55	105	0	0	0	0
Females											
J-stock	7	18	44	156	500	17	0	0	0	0	0
P-stock	0	24	0	10	0	216	296	0	0	0	0
O-stock	0	4	0	0	0	54	18	5	7	22	49
Unassigned	0	17	0	26	0	75	118	0	0	0	0

Pink highlight: animals of a stock **have not** been assigned to a sub-area, but are modelled in that sub-area in the mixing matrices.

- It is assumed the J-stock occurs distributed in sub-area 7CS given they have been assigned to sub-areas 7CN and 2C to the east of Japan as well as sub-areas 6E and 10E to the west of Japan.

Hypothesis E Baseline

Y-Stock Baseline E (Matrix Y-BE)

Age/	Mon										Sub - Area												
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	4						4	γ_{25}														
	Apr	1						4	γ_{26}														
	May	1						4	γ_{26}														
	Jun	1						4	γ_{26}														
	Jul	1						4	γ_{27}														
	Aug	1						4	γ_{27}														
	Sep	2						4	γ_{28}														
	O-D	4						4	γ_{28}														
AdM	J-M	4						4	γ_{25}														
	Apr	1						4	γ_{26}														
	May	1						4	γ_{26}														
	Jun	1						4	γ_{26}														
	Jul	1						4	γ_{27}														
	Aug	1						4	γ_{27}														
	Sep	2						4	γ_{28}														
	O-D	4						4	γ_{28}														
AdF	J-M	4						4	γ_{25}														
	Apr	1						4	γ_{26}														
	May	1						4	γ_{26}														
	Jun	1						4	γ_{26}														
	Jul	1						4	γ_{27}														
	Aug	1						4	γ_{27}														
	Sep	2						4	γ_{28}														
	O-D	4						4	γ_{28}														

Hypothesis E Baseline (contd.)

J-Stock Baseline E (Matrix J-BE)

Age/	Mon										Sub -	Area											
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M		2	2					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr		2	2					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	May		2	2					2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	Jun		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Jul		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Aug		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Sep		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	O-D		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$			
Ad.M	J-M		2	1					4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr		0	1					2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$						γ_6	$2\gamma_7$	γ_8	γ_8		
	May		0	1					2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$		
	Jun		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$		
	Jul		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Aug		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Sep		2	1					4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7				
	O-D		4	1					2		$2\gamma_3$	$2\gamma_5$											
Ad.F	J-M		2	1					4	$4\gamma_{29}$	γ_1	γ_4						γ_6	γ_7				
	Apr		0	1					2	$2\gamma_{29}$	$2\gamma_1$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}		
	May		0	1					2	$2\gamma_{29}$	$2\gamma_2$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$		
	Jun		0	1					2	$2\gamma_{29}$	γ_3	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$		
	Jul		0	1					2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Aug		0	1					2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Sep		2	1					4	$4\gamma_{29}$	γ_3	γ_5						γ_6	γ_7				
	O-D		4	1					2		γ_3	γ_5											

P-Stock Baseline E (Matrix P-E)

Age/	Mon										Sub -	Area											
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M			γ_{13}							4	γ_{16}								0			
	Apr			γ_{14}							8	$2\gamma_{16}$								γ_{22}			
	May			γ_{14}							8	$2\gamma_{16}$								γ_{22}			
	Jun			γ_{14}							4	$4\gamma_{16}$								γ_{22}			
	Jul			γ_{15}							4	$4\gamma_{16}$								γ_{22}			
	Aug			γ_{15}							4	$4\gamma_{16}$								γ_{22}			
	Sep			γ_{15}							4	$4\gamma_{16}$								γ_{22}			
	O-D			γ_{15}							4	$2\gamma_{16}$								0			
Ad.M	J-M			γ_{13}							1	γ_{16}								0			
	Apr			γ_{14}							2	$2\gamma_{16}$								γ_{22}			
	May			0							2	$2\gamma_{16}$								γ_{22}			
	Jun			0							2	$4\gamma_{16}$								γ_{22}			
	Jul			0							2	$4\gamma_{16}$								γ_{22}			
	Aug			0							2	$4\gamma_{16}$								γ_{22}			
	Sep			0							2	$4\gamma_{16}$								γ_{22}			
	O-D			γ_{15}							1	γ_{16}								0			
Ad.F	J-M			γ_{13}							1	γ_{16}								0			
	Apr			γ_{14}							1	γ_{16}								γ_{22}			
	May			0							1	γ_{16}								$2\gamma_{22}$			
	Jun			0							1	$2\gamma_{16}$								$2\gamma_{22}$			
	Jul			0							1	$2\gamma_{16}$								$2\gamma_{22}$			
	Aug			0							1	$2\gamma_{16}$								$2\gamma_{22}$			
	Sep			0							1	$2\gamma_{16}$								$2\gamma_{22}$			
	O-D			γ_{15}							1	γ_{16}								0			

Hypothesis E Baseline (contd.)

O-Stock Baseline E (Matrix O-E)

Age/ Sex	Mon	Sub - Area																					
		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M				4	4	4				4	γ_{16}	0	0	0	0	0			0	0	0	0
	Apr				2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0			γ_{22}	γ_{23}	γ_{24}	0
	May				2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	0
	Jun				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	0
	Jul				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	0
	Aug				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	0
	Sep				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	0
	O-D				4	4	4				4	$2\gamma_{16}$	0	0	0	0	0			0	0	0	0
Ad.M	J-M				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	0
	Apr				2	2	2				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0			γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May				0	0	0				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}			γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	0
Ad.F	J-M				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	0
	Apr				2	2	2				1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0			γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May				0	0	0				1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	0

Trial 5

For Trial 5, stock assignment for Hypotheses A and B are based on ‘stock70’ assignment by STRUCTURE in *Data_NPM_190226_v3.csv*. The number of samples assigned to stock by sub-area is as follows. Table 7a of Annex K details the assigned numbers by stock, sub-area, period and sex used to condition the trials.

Males	**10E**	**11**	**1E**	**2C**	**6E**	**7CN**	**7CS**	**7E**	**7WR**	**8**	**9**
J-stock	9	30	30	114	482	171	151	0	2	2	5
O-stock	1	35	1	27	3	625	308	44	76	223	470
Unassigned	1	0	1	2	10	22	18	0	2	4	12
Females											
J-stock	6	30	43	200	495	118	161	0	1	0	0
O-stock	0	33	0	27	5	273	314	5	8	20	52
Unassigned	1	2	1	2	7	7	11	0	0	3	2

Pink highlight: animals of a stock **have not** been sampled in a sub-area, but are allowed in that sub-area in the mixing matrices

Green highlight: indicates sub-areas that differ in presence/absence in Trial 5 from the baseline trials.

- The distribution of J-stock whales is assumed to extend further in Trial 5 compared to the baseline, and are thus assumed to be found in sub-areas 7WR, 8 and 9 and by default therefore also in sub-area 7E.

Grey highlight: stock **has** been assigned to a sub-area, but is not modelled in that sub-area in the mixing matrices

- No further extension in the distribution of O-stock whales from that assumed in the baseline is assumed in Trial 5 (e.g. into sub-areas 1E or 6E) due to the small assignments of O-stock whales for sub-areas 1E and 6E compared to the number of J-stock whales assigned to these sub-areas.

For Trial 5, stock assignment for Hypothesis E is based on ‘geneland.stock4’ assignment by GENELAND in *Data_NPM_190226_v3.csv*. The number of samples assigned to stock by sub-area is as follows. Table 7a of Annex K details the assigned numbers by stock, sub-area, period and sex used to condition the trials.

Males	**10E**	**11**	**1E**	**2C**	**6E**	**7CN**	**7CS**	**7E**	**7WR**	**8**	**9**
J-stock	8	14	31	96	492	21	4	0	0	0	0
P-stock	0	40	0	11	0	390	240	0	0	0	0
O-stock	0	1	0	0	0	308	91	42	77	217	478
Unassigned	0	8	0	20	0	55	111	0	0	0	0
Females											
J-stock	7	18	44	164	501	20	2	0	0	0	0
P-stock	0	24	0	11	0	219	312	0	0	0	0
O-stock	0	4	0	1	0	62	20	5	9	23	52
Unassigned	0	18	0	26	0	77	124	0	0	0	0

Trial 5

O-Stock: as for Baseline (Matrix O-AB, O-E)

J-Stock Trial 5 (Matrix J-A5) Differences from the Baseline trial are highlighted in blue

Age/	Mon										Sub -	Area											
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7				
	Apr	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	May	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	Jun	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Jul	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Aug	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Sep	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	O-D	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$			
Ad.M	J-M	2	2	1				2	4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7				
	Apr	0	0	1				2	2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$	$2\gamma_{31}$	$2\gamma_{35}$	$2\gamma_{32}$	$2\gamma_{33}$		γ_6	$2\gamma_7$	γ_8	γ_8		
	May	0	0	1				2	2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$	$2\gamma_{31}$	$2\gamma_{35}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$		
	Jun	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$	$2\gamma_{31}$	$2\gamma_{35}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$		
	Jul	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	γ_9	$2\gamma_9$		
	Aug	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	γ_9	$2\gamma_9$		
	Sep	2	2	1				2	4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7				
	O-D	4	4	1				2	2		$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{35}	γ_{32}	γ_{33}							
Ad.F	J-M	2	2	1				2	4	$4\gamma_{29}$	γ_1	γ_4	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7				
	Apr	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_1$	γ_4	$2\gamma_{31}$	$2\gamma_{35}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}		
	May	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_2$	γ_4	$2\gamma_{31}$	$2\gamma_{35}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$		
	Jun	0	0	1				2	2	$2\gamma_{29}$	γ_3	γ_4	$2\gamma_{31}$	$2\gamma_{35}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$		
	Jul	0	0	1				2	2	$2\gamma_{29}$	γ_3	γ_5	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Aug	0	0	1				2	2	$2\gamma_{29}$	γ_3	γ_5	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Sep	2	2	1				2	4	$4\gamma_{29}$	γ_3	γ_5	γ_{31}	γ_{35}	γ_{32}	γ_{33}		γ_6	γ_7				
	O-D	4	4	1				2	2		γ_3	γ_5	γ_{31}	γ_{35}	γ_{32}	γ_{33}							

J-Stock Trial 5 (Matrix J-BE5) Differences from the Baseline trial are highlighted in blue

Age/	Mon										Sub -	Area											
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M		2	2					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7				
	Apr		2	2					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	May		2	2					2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	Jun		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Jul		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Aug		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Sep		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	O-D		2	2					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	$2\gamma_9$			
Ad.M	J-M		2	1					4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7				
	Apr		0	1					2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$	$2\gamma_{31}$	$2\gamma_{31}$	$2\gamma_{32}$	$2\gamma_{33}$		γ_6	$2\gamma_7$	γ_8	γ_8		
	May		0	1					2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$	$2\gamma_{31}$	$2\gamma_{31}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$		
	Jun		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$	$2\gamma_{31}$	$2\gamma_{31}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$		
	Jul		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	γ_9	$2\gamma_9$		
	Aug		0	1					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	γ_9	$2\gamma_9$		
	Sep		2	1					4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7				
	O-D		4	1					2		$2\gamma_3$	$2\gamma_5$	γ_{31}	γ_{31}	γ_{32}	γ_{33}							
Ad.F	J-M		2	1					4	$4\gamma_{29}$	γ_1	γ_4	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7				
	Apr		0	1					2	$2\gamma_{29}$	$2\gamma_1$	γ_4	$2\gamma_{31}$	$2\gamma_{31}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}		
	May		0	1					2	$2\gamma_{29}$	$2\gamma_2$	γ_4	$2\gamma_{31}$	$2\gamma_{31}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$		
	Jun		0	1					2	$2\gamma_{29}$	γ_3	γ_4	$2\gamma_{31}$	$2\gamma_{31}$	$2\gamma_{32}$	$2\gamma_{33}$		$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$		
	Jul		0	1					2	$2\gamma_{29}$	γ_3	γ_5	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Aug		0	1					2	$2\gamma_{29}$	γ_3	γ_5	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Sep		2	1					4	$4\gamma_{29}$	γ_3	γ_5	γ_{31}	γ_{31}	γ_{32}	γ_{33}		γ_6	γ_7				
	O-D		4	1					2		γ_3	γ_5	γ_{31}	γ_{31}	γ_{32}	γ_{33}							

Trial 2 (with a 'C' stock): Hypothesis A

J-Stock and O-Stock: As for Baseline A (Matrix J-A and O-AB)

C-Stock Trial A2 (Matrix C-A2)

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M															0	0						1
	Apr															0	0						1
	May															0	0						1
	Jun															0	0						1
	Jul															0	0						1
	Aug															0	0						1
	Sep															0	0						1
	O-D															0	0						1
Ad.M	J-M															0	0						1
	Apr															γ_{33}	0						6
	May															γ_{33}	γ_{31}						5
	Jun															γ_{33}	γ_{31}						4
	Jul															γ_{33}	γ_{31}						4
	Aug															γ_{33}	γ_{31}						4
	Sep															γ_{33}	γ_{31}						3
	O-D															0	0						1
Ad.F	J-M															0	0						1
	Apr															$2\gamma_{33}$	0						6
	May															γ_{33}	$3\gamma_{31}$						3
	Jun															γ_{33}	$3\gamma_{31}$						1
	Jul															γ_{33}	$3\gamma_{31}$						1
	Aug															γ_{33}	$3\gamma_{31}$						1
	Sep															γ_{33}	$3\gamma_{31}$						1
	O-D															0	0						1

Trial 2 (With a 'C' stock): Hypothesis E

Y-Stock, J-Stock, P-Stock and O-Stock: As for Baseline E (Matrix Y-BC, J-BE, P-E & O-E)

C-Stock Trial E2 (Matrix C-E2)

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M															0	0					0	1
	Apr															0	0					0	1
	May															0	0					0	1
	Jun															0	0					0	1
	Jul															0	0					0	1
	Aug															0	0					0	1
	Sep															0	0					0	1
	O-D															0	0					0	1
Ad.M	J-M															0	0					0	1
	Apr															γ_{33}	0					0	2
	May															γ_{33}	γ_{31}					γ_{32}	1
	Jun															γ_{33}	γ_{31}					γ_{32}	0
	Jul															γ_{33}	γ_{31}					γ_{32}	0
	Aug															γ_{33}	γ_{31}					γ_{32}	0
	Sep															γ_{33}	γ_{31}					γ_{32}	0
	O-D															0	0					0	1
Ad.F	J-M															0	0					0	1
	Apr															$2\gamma_{33}$	0					0	2
	May															γ_{33}	$3\gamma_{31}$					$3\gamma_{32}$	1
	Jun															γ_{33}	$3\gamma_{31}$					$3\gamma_{32}$	0
	Jul															γ_{33}	$3\gamma_{31}$					$3\gamma_{32}$	0
	Aug															γ_{33}	$3\gamma_{31}$					$3\gamma_{32}$	0
	Sep															γ_{33}	$3\gamma_{31}$					$3\gamma_{32}$	0
	O-D															0	0					0	1

Trial 11 (30% J-stock in sub-area 12SW, with 10% J-stock in 12NE): Hypothesis A

O-Stock: As for Baseline A (Matrix O-AB)

J-Stock Baseline A (Matrix J-A) Differences from the Baseline trial are highlighted in blue.

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$						γ_{6}	γ_{7}				
	Apr	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$						γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	$2\gamma_{34}$	
	May	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{2}$	$2\gamma_{4}$						γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	$2\gamma_{34}$	
	Jun	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{4}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	Jul	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	Aug	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	Sep	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	O-D	2	2	2				2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$			
Ad.M	J-M	2	2	1				2	4	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$						γ_{6}	γ_{7}				
	Apr	0	0	1				2	2	$2\gamma_{29}$	$4\gamma_{1}$	$2\gamma_{4}$						γ_{6}	$2\gamma_{7}$	γ_{8}	γ_{8}	γ_{34}	
	May	0	0	1				2	2	$2\gamma_{29}$	$4\gamma_{2}$	$2\gamma_{4}$						$2\gamma_{6}$	$2\gamma_{7}$	γ_{8}	$2\gamma_{8}$	$2\gamma_{34}$	
	Jun	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{4}$						$2\gamma_{6}$	$2\gamma_{7}$	γ_{9}	$2\gamma_{9}$	$2\gamma_{34}$	
	Jul	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$						γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	$2\gamma_{34}$	
	Aug	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$						γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	$2\gamma_{34}$	
	Sep	2	2	1				2	4	$4\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$						γ_{6}	γ_{7}				
	O-D	4	4	1				2	2		$2\gamma_{3}$	$2\gamma_{5}$											
Ad.F	J-M	2	2	1				2	4	$4\gamma_{29}$	γ_{1}	γ_{4}						γ_{6}	γ_{7}				
	Apr	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_{1}$	γ_{4}						$2\gamma_{6}$	$2\gamma_{7}$	γ_{10}	γ_{10}	γ_{34}	
	May	0	0	1				2	2	$2\gamma_{29}$	$2\gamma_{2}$	γ_{4}						$2\gamma_{6}$	$2\gamma_{7}$	γ_{11}	$2\gamma_{11}$	$2\gamma_{34}$	
	Jun	0	0	1				2	2	$2\gamma_{29}$	γ_{3}	γ_{4}						$2\gamma_{6}$	$2\gamma_{7}$	γ_{12}	$2\gamma_{12}$	$2\gamma_{34}$	
	Jul	0	0	1				2	2	$2\gamma_{29}$	γ_{3}	γ_{5}						γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	$2\gamma_{34}$	
	Aug	0	0	1				2	2	$2\gamma_{29}$	γ_{3}	γ_{5}						γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	$2\gamma_{34}$	
	Sep	2	2	1				2	4	$4\gamma_{29}$	γ_{3}	γ_{5}						γ_{6}	γ_{7}				
	O-D	4	4	1				2	2		γ_{3}	γ_{5}											

Trial 11 (30% J-stock in sub-area 12SW, with 10% J-stock in 12NE): Hypotheses B & E

Y-Stock, O-Stock, P-Stock: As for Baseline B & E (Matrix Y-BE, O-AB, O-E, P-E)

J-Stock Baseline E (Matrix J-BE) Differences from the Baseline trial are highlighted in blue.

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M		2	2					2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$						γ_{6}	γ_{7}				
	Apr		2	2					2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$						γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	$2\gamma_{34}$	
	May		2	2					2	$4\gamma_{29}$	$2\gamma_{2}$	$2\gamma_{4}$						γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	$2\gamma_{34}$	
	Jun		2	2					2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{4}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	Jul		2	2					2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	Aug		2	2					2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	Sep		2	2					2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	$2\gamma_{34}$	
	O-D		2	2					2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$						γ_{6}	γ_{7}	$2\gamma_{9}$			
Ad.M	J-M		2	1					4	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$						γ_{6}	γ_{7}				
	Apr		0	1					2	$2\gamma_{29}$	$4\gamma_{1}$	$2\gamma_{4}$						γ_{6}	$2\gamma_{7}$	γ_{8}	γ_{8}	γ_{34}	
	May		0	1					2	$2\gamma_{29}$	$4\gamma_{2}$	$2\gamma_{4}$						$2\gamma_{6}$	$2\gamma_{7}$	γ_{8}	$2\gamma_{8}$	$2\gamma_{34}$	
	Jun		0	1					2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{4}$						$2\gamma_{6}$	$2\gamma_{7}$	γ_{9}	$2\gamma_{9}$	$2\gamma_{34}$	
	Jul		0	1					2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$						γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	$2\gamma_{34}$	
	Aug		0	1					2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$						γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	$2\gamma_{34}$	
	Sep		2	1					4	$4\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$						γ_{6}	γ_{7}				
	O-D		4	1					2		$2\gamma_{3}$	$2\gamma_{5}$											
Ad.F	J-M		2	1					4	$4\gamma_{29}$	γ_{1}	γ_{4}						γ_{6}	γ_{7}				
	Apr		0	1					2	$2\gamma_{29}$	$2\gamma_{1}$	γ_{4}						$2\gamma_{6}$	$2\gamma_{7}$	γ_{10}	γ_{10}	γ_{34}	
	May		0	1					2	$2\gamma_{29}$	$2\gamma_{2}$	γ_{4}						$2\gamma_{6}$	$2\gamma_{7}$	γ_{11}	$2\gamma_{11}$	$2\gamma_{34}$	
	Jun		0	1					2	$2\gamma_{29}$	γ_{3}	γ_{4}						$2\gamma_{6}$	$2\gamma_{7}$	γ_{12}	$2\gamma_{12}$	$2\gamma_{34}$	
	Jul		0	1					2	$2\gamma_{29}$	γ_{3}	γ_{5}						γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	$2\gamma_{34}$	
	Aug		0	1					2	$2\gamma_{29}$	γ_{3}	γ_{5}						γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	$2\gamma_{34}$	
	Sep		2	1					4	$4\gamma_{29}$	γ_{3}	γ_{5}						γ_{6}	γ_{7}				
	O-D		4	1					2		γ_{3}	γ_{5}											

Trial 18 (Substantially more O-Stock ages 1-4 are found in sub-areas 2R, 3 & 4 year-round): Hypothesis A

J-Stock as for Baseline A (Matrix J-A)

O-Stock Trial A18 (Matrix O-AB18) Differences from the Baseline trial are highlighted in blue.

Age/ Sex	Mon	Sub - Area																					
		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M			γ_{13}	4	4	4				4	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
	Apr			γ_{14}	44	44	44				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	May			γ_{14}	44	44	44				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Jun			γ_{14}	44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Jul			γ_{15}	44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Aug			γ_{15}	44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Sep			γ_{15}	44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	O-D			γ_{15}	4	4	4				4	$2\gamma_{16}$	0	0	0	0	0		$2\gamma_{30}$	0	0	0	
Ad.M	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
	Apr			γ_{14}	2	2	2				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0		$2\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	
	May			0	0	0	0				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$2\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jun			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jul			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Aug			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Sep			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
Ad.F	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
	Apr			γ_{14}	2	2	2				1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0		γ_{30}	γ_{22}	γ_{23}	$3\gamma_{24}$	
	May			0	0	0	0				1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		γ_{30}	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Jun			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Jul			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Aug			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Sep			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	

Trial 18 (Substantially more O-Stock ages 1-4 are found in sub-areas 2R, 3 & 4 year-round): Hypothesis B

Y-Stock and J-Stock: As for Baseline B (Matrix Y-BE and J-BE)

O-Stock Trial B18 (Matrix O-AB18) as above

Trial 18 (Substantially more O-Stock ages 1-4 are found in sub-areas 2R, 3 & 4 year-round): Hypothesis E

Y-Stock, J-Stock and P-Stock: as for Baseline E (Matrix Y-BE, J-BE & P-E)

O-Stock Trial E18 (Matrix O-E18) Differences from the Baseline trial are highlighted in blue.

Age/ Sex	Mon	Sub - Area																					
		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M				4	4	4				4	γ_{16}	0	0	0	0	0			0	0	0	
	Apr				44	44	44				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0			γ_{22}	γ_{23}	γ_{24}	
	May				44	44	44				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	
	Jun				44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	
	Jul				44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	
	Aug				44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	
	Sep				44	44	44				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}			γ_{22}	γ_{23}	γ_{24}	
	O-D				4	4	4				4	$2\gamma_{16}$	0	0	0	0	0			0	0	0	
Ad.M	J-M				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	
	Apr				2	2	2				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0			γ_{22}	γ_{23}	$3\gamma_{24}$	
	May				0	0	0				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jun				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jul				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Aug				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Sep				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}			γ_{22}	γ_{23}	$3\gamma_{24}$	
	O-D				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	
Ad.F	J-M				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	
	Apr				2	2	2				1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0			γ_{22}	γ_{23}	$3\gamma_{24}$	
	May				0	0	0				1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			γ_{22}	$2\gamma_{23}$	$9\gamma_{24}$	
	Jun				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Jul				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Aug				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Sep				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	
	O-D				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	

Trial 19 (no age 1-4 whales in sub-area 9 / 9N): Hypothesis A

J-Stock as for Baseline A (Matrix J-A)

O-Stock Trial A19 (Matrix O-AB19) Differences from the Baseline trial are highlighted in blue.

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M			γ_{13}	4	4	4				4	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
	Apr			γ_{14}	2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	May			γ_{14}	2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0		$2\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Jun			γ_{14}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Jul			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Aug			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	Sep			γ_{15}	2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0		$4\gamma_{30}$	γ_{22}	γ_{23}	γ_{24}	
	O-D			γ_{15}	4	4	4				4	$2\gamma_{16}$	0	0	0	0	0		$2\gamma_{30}$	0	0	0	
Ad.M	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
	Apr			γ_{14}	2	2	2				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0		$2\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	
	May			0	0	0	0				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$2\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jun			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jul			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Aug			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$		$4\gamma_{30}$	γ_{22}	γ_{23}	$6\gamma_{24}$	
	Sep			0	0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}		$4\gamma_{30}$	γ_{22}	γ_{23}	$3\gamma_{24}$	
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
Ad.F	J-M			γ_{13}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	
	Apr			γ_{14}	2	2	2				1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0		γ_{30}	γ_{22}	γ_{23}	$3\gamma_{24}$	
	May			0	0	0	0				1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		γ_{30}	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Jun			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Jul			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Aug			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Sep			0	0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$		$2\gamma_{30}$	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	
	O-D			γ_{15}	4	4	4				1	γ_{16}	0	0	0	0	0		γ_{30}	0	0	0	

Trial 19 (no age 1-4 whales in sub-area 9 / 9N): Hypothesis B

Y-Stock and J-Stock: As for Baseline B (Matrix Y-BE and J-BE)

O-Stock Trial B19 (Matrix O-AB19) as above

Trial 19 (no age 1-4 whales in sub-area 9 / 9N): Hypothesis E

Y-Stock, J-Stock and P-Stock : as for Baseline E (Matrix Y-BE, J-BE and P-E)

O-Stock Trial E19 (Matrix O-E19) Differences from the Baseline trial are highlighted in blue.

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M				4	4	4				4	γ_{16}	0	0	0	0	0			0	0	0	
	Apr				2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0			γ_{22}	γ_{23}	γ_{24}	
	May				2	2	2				8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0			γ_{22}	γ_{23}	γ_{24}	
	Jun				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0			γ_{22}	γ_{23}	γ_{24}	
	Jul				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0			γ_{22}	γ_{23}	γ_{24}	
	Aug				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0			γ_{22}	γ_{23}	γ_{24}	
	Sep				2	2	2				4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0			γ_{22}	γ_{23}	γ_{24}	
	O-D				4	4	4				4	$2\gamma_{16}$	0	0	0	0	0			0	0	0	
Ad.M	J-M				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	
	Apr				2	2	2				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0			γ_{22}	γ_{23}	$3\gamma_{24}$	
	May				0	0	0				2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jun				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Jul				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Aug				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$			γ_{22}	γ_{23}	$6\gamma_{24}$	
	Sep				0	0	0				2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}			γ_{22}	γ_{23}	$3\gamma_{24}$	
	O-D				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	
Ad.F	J-M				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	
	Apr				2	2	2				1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0			γ_{22}	γ_{23}	$3\gamma_{24}$	
	May				0	0	0				1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			γ_{22}	$2\gamma_{23}$	$9\gamma_{24}$	
	Jun				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Jul				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Aug				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	
	Sep				0	0	0				1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$			$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	
	O-D				4	4	4				1	γ_{16}	0	0	0	0	0			0	0	0	

Trial 20 (Number 1+ whales in 2009 in sub-area 2C in any month <200): Hypothesis A

O-Stock: as for Baseline A (Matrix O-AB)

J-Stock Baseline A (Matrix J-A) Differences from the Baseline trial are highlighted in blue.

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	May	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	Jun	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Jul	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Aug	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Sep	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	O-D	2	2	$2\gamma_{35}$				2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$			
Ad.M	J-M	2	2	γ_{35}				2	4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr	0	0	γ_{35}				2	2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$						γ_6	$2\gamma_7$	γ_8	γ_8		
	May	0	0	γ_{35}				2	2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$		
	Jun	0	0	γ_{35}				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$		
	Jul	0	0	γ_{35}				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Aug	0	0	γ_{35}				2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Sep	2	2	γ_{35}				2	4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7				
	O-D	4	4	γ_{35}				2	2		$2\gamma_3$	$2\gamma_5$											
Ad.F	J-M	2	2	γ_{35}				2	4	$4\gamma_{29}$	γ_1	γ_4						γ_6	γ_7				
	Apr	0	0	γ_{35}				2	2	$2\gamma_{29}$	$2\gamma_1$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}		
	May	0	0	γ_{35}				2	2	$2\gamma_{29}$	$2\gamma_2$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$		
	Jun	0	0	γ_{35}				2	2	$2\gamma_{29}$	γ_3	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$		
	Jul	0	0	γ_{35}				2	2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Aug	0	0	γ_{35}				2	2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Sep	2	2	γ_{35}				2	4	$4\gamma_{29}$	γ_3	γ_5						γ_6	γ_7				
	O-D	4	4	γ_{35}				2	2		γ_3	γ_5											

Trial 20 (Number 1+ whales in 2009 in sub-area 2C in any month <200): Hypotheses B & E

Y-Stock, P-Stock and O-Stock: as for Baseline B & E (Matrix Y-BE, P-E, O-AB & O-E)

J-Stock Baseline B (Matrix J-BE) Differences from the Baseline trial are highlighted in blue.

Age/	Mon	Sub - Area																					
Sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	May		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$						γ_6	γ_7	$2\gamma_8$	$2\gamma_8$		
	Jun		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Jul		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Aug		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	Sep		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$	$2\gamma_9$		
	O-D		2	$2\gamma_{35}$					2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$						γ_6	γ_7	$2\gamma_9$			
Ad.M	J-M		2	γ_{35}					4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$						γ_6	γ_7				
	Apr		0	γ_{35}					2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$						γ_6	$2\gamma_7$	γ_8	γ_8		
	May		0	γ_{35}					2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$		
	Jun		0	γ_{35}					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$						$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$		
	Jul		0	γ_{35}					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Aug		0	γ_{35}					2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7	γ_9	$2\gamma_9$		
	Sep		2	γ_{35}					4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$						γ_6	γ_7				
	O-D		4	γ_{35}					2		$2\gamma_3$	$2\gamma_5$											
Ad.F	J-M		2	γ_{35}					4	$4\gamma_{29}$	γ_1	γ_4						γ_6	γ_7				
	Apr		0	γ_{35}					2	$2\gamma_{29}$	$2\gamma_1$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}		
	May		0	γ_{35}					2	$2\gamma_{29}$	$2\gamma_2$	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$		
	Jun		0	γ_{35}					2	$2\gamma_{29}$	γ_3	γ_4						$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$		
	Jul		0	γ_{35}					2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Aug		0	γ_{35}					2	$2\gamma_{29}$	γ_3	γ_5						γ_6	γ_7	γ_{12}	$2\gamma_{12}$		
	Sep		2	γ_{35}					4	$4\gamma_{29}$	γ_3	γ_5						γ_6	γ_7				
	O-D		4	γ_{35}					2		γ_3	γ_5											

Trial 23 (No ‘C’ animals in sub-area 12NE): Hypothesis E

Y-Stock, J-Stock, P-Stock and O-Stock: As for Baseline E (Matrix Y-BC, J-BE, P-E & O-E)

C-Stock Trial E23 (Matrix C-E23) orange shows the difference from Trial 2

Age/ Sex	Mon	Sub - Area																					
		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M															0	0						1
	Apr															0	0						1
	May															0	0						1
	Jun															0	0						1
	Jul															0	0						1
	Aug															0	0						1
	Sep															0	0						1
	O-D															0	0						1
Ad.M	J-M															0	0						1
	Apr															γ_{33}	0						2
	May															γ_{33}	γ_{31}					🟧	1
	Jun															γ_{33}	γ_{31}					🟧	0
	Jul															γ_{33}	γ_{31}					🟧	0
	Aug															γ_{33}	γ_{31}					🟧	0
	Sep															γ_{33}	γ_{31}					🟧	0
	O-D															0	0						1
Ad.F	J-M															0	0						1
	Apr															$2\gamma_{33}$	0						2
	May															γ_{33}	$3\gamma_{31}$					🟧	1
	Jun															γ_{33}	$3\gamma_{31}$					🟧	0
	Jul															γ_{33}	$3\gamma_{31}$					🟧	0
	Aug															γ_{33}	$3\gamma_{31}$					🟧	0
	Sep															γ_{33}	$3\gamma_{31}$					🟧	0
	O-D															0	0						1

Adjunct 3

Calculation of stock mixing proportions, including correction for 'missing alleles':

Unpooled results for sub-area 6W

C.L. de Moor

This adjunct is based on de Moor (2014) and de Moor (2011), which detail the calculation of the stock mixing proportions by month and sex for use in conditioning the 2013 *Implementation Simulation Trials* of western North Pacific common minke whales (Allison *et al*, 2014).

In testing the mixing in sub-area 6W, samples representative of 'pure' Y-stock and J-stock animals were taken as follows:

Stock	Location / months to define pure sample	Haplotypes Sample Size	Loci Sample Size
Y-stock	5 (all months)	58	58 58 58 58 58 58 56 58 58 58 54
J-stock	6E (all months)	392	392 392 392 392 392 392 392 392 392 392 392 (392 391 392 392 392)

Mixing proportions in sub-area 6W were calculated from 415 samples from bycatch data only.

Hyp B and E: Proportion of J mixing with Y		Sample Size	Proportion Haplotypes	SE	Sample Size (x11)	Proportion Loci	SE
Jan-Mar	Males	83	0.555	0.142	83 with 81 in 11th	0.745	0.050
Apr		37	0.449	0.253	37 with 36 in 1st	0.963	0.083
May		41	0.749	0.243	41 with 40 in 8th	0.926	0.062
Jun		43	0.534	0.245	43	0.787	0.080
Jul		21	0.830	0.38	21	0.788	0.089
Aug		16	1.000	0.004	16 with 15 in 11th	0.726	0.137
Sep		20	0.533	0.335	20 with 18 in 11th	0.475	0.107
Oct-Dec		97	0.629	0.140	97 with 96 in 7th and 94 in 11th	0.859	0.049
Jan-Mar	Females	13	0.730	0.314	13 with 12 in 6th	0.284	0.128
Apr		3	0.002	0.139	3	0.751	0.301
May		7	0.000	0.006	7	0.529	0.148
Jun		10	0.364	0.309	10	0.583	0.167
Jul		1	1.000	0.009	1	0.999	0.000
Aug		4	1.000	0.024	4	0.457	0.323
Sep		6	0.415	0.636	6 with 5 in 9th	0.773	0.143
Oct-Dec		13	0.409	0.455	13 with 12 in 11th	0.806	0.130
Summary: all data		415	0.625	0.069	415 with 414 in 1st, 6-9th and 406 in 11th	0.776	0.109
Pooled Data							
Jan-Mar	M F	96	0.584	0.131	96 with 95 in 6th, 94 in 11th	0.672	0.047
Apr-Jun	M F	141	0.496	0.126	141 with 140 in 1st , 8th	0.812	0.04
Jul-Aug	M F	42	1.000	0.004	42 with 41 in 11th	0.749	0.077
Sep-Dec	M F	136	0.593	0.123	136 with 135 in 7th, 9th, 130 in 11th	0.761	0.04

Notation:

In most cases samples are obtained from 16 loci. In sub-area 6W samples from the first 11 loci only were available to be used in the calculation of the mixing proportion, denoted by (x11) in the above table. In some cases there was a missing value in a sample at a particular loci. Thus, for example if the total sample size were 50, for one of the loci (the 10th) the sample size is 49. This is noted by saying e.g. '50 with 49 at 10th'.

REFERENCES

Allison, C., de Moor, C.L. and Punt, A.E. 2014. Report of the Scientific Committee. Annex D1. Report of the Working Group on the *Implementation Review* for Western North Pacific Common Minke Whales. Appendix 2. North Pacific minke whale *Implementation Simulation Trial* specifications. *J. Cetacean Res. Manage. (Suppl.)* 15:133-80.

de Moor, C.L. 2011. Calculation of stock mixing proportions, including correction for 'missing alleles': unpooled results. Paper SC/D11/NPM4rev presented to the First Intersessional Workshop for the *Implementation Review* of western North Pacific common minke whales, 12-16 December 2011, Tokyo, Japan (unpublished). [Paper available from the Office of this Journal].

de Moor, C.L. 2014. Report of the Scientific Committee. Annex D1. Report of the Working Group on the *Implementation Review* for Western North Pacific Common Minke Whales. Appendix 2. North Pacific minke whale *Implementation Simulation Trial* specifications. Adjunct 3. Calculation of stock mixing proportions, including correction for 'missing alleles': unpooled results. *J. Cetacean Res. Manage. (Suppl.)* 15:167-80.