A brief background of the RMP *Implementations* for western North Pacific common minke whale: stock structure, plausibility and management implications

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ABSTRACT

The first RMP *Implementation* for western North Pacific common minke whale started in 1993 and was completed in 2003. The second *Implementation* started in 2010 and, unlike the previous one, is being conducted under the new 'Requirements and Guidelines for *Implementations*' agreed by the IWC SC in 2004. Stock structure is a key piece of information for *Implementation*. Weighting of trials into 'high', 'medium' and 'no agreement' depends mainly on the plausibility rank assigned to stock structure hypotheses (into 'high', 'medium' 'low'). On the other hand the output of the *Implementations* (e.g. management advice) depends on the conservation performance of trials at its different weights. Four stock structure hypotheses (A, B, C and D) were adopted in the previous *Implementation* and the IWC SC was unable to rank the plausibility of those hypotheses. To complete the *Implementation* process it gave 'high plausibility' to the four. The implication of this was that the IWC SC was unable to agree on a single management variant to be recommended in case the Commission would decide to implement the RMP. Therefore the previous RMP *Implementation* was useless for the objective of management of common minke whale. In the current *Implementation* three stock structure hypotheses were adopted (I, II and III). Hypotheses I and II are updated versions of hypotheses A and B of the previous *Implementation* while Hypothesis III is a new one. There are substantial differences between Hypotheses I/II and III. These differences are likely to result in very different management advice. In order to provide proper management advice, it is essential to appropriately assign plausibility rank to the three hypotheses. If not, the RMP will again become a useless tool for management. To put the discussions on plausibility in context, this paper presents an outline of the past and current RMP *Implementation*s of western North Pacific common minke whale with particular emphasis on the stock structure hypotheses adopted by the IWC SC, and its management implications.

KEYWORDS: COMMON MINKE WHALES, *IMPLEMENTATION*, WESTERN NORTH PACIFIC, STOCK STRUCTURE HYPOTHESES, PLAUSIBILITY

THE 1993-2003 RMP *IMPLEMENTATION*

The first RMP *Implementation* for western North Pacific common minke whale started in 1993. Previously the IWC SC established a Working Group to start the *ISTs* for the application of the RMP for this species in the western North Pacific. The *Implementation* process took an abnormally long time to be completed due in part to the long discussions and disagreements among members on stock structure hypotheses. This abnormally long time motivated the development of specific requirements and guidelines for RMP *Implementations*, which were agreed by the IWC SC in 2004, one year after the first *Implementation* was completed. Stock structure hypotheses have very important implications for the output of the RMP *Implementation* process. Notwithstanding the process the rational to adopt some stock structure hypotheses has been weak. Some hypotheses and rational, strongly supported by some members during the *Implementation*, have been forgotten with the passage of time.

Discussion on stock structure before the 1993-2003 *Implementation*
Studies on stock structure of common minke whale around Japan started in the 1950's using a) catch distribution information, b) differences in body length and c) conception date. Based on that information the IWC identified three stocks (Sea of Japan-Yellow Sea-East China Sea (J), Okhotsk Sea West Pacific (O) and remainder stocks) and established boundaries for management of these stocks following recommendations from the Committee (IWC, 1983).

The IWC SC addressed the issue of stock structure again during the CA of this species conducted in 1991 (IWC, 1992). Regarding stock structure the analyses were based exclusively on samples and data collected during the period of commercial whaling, therefore, samples were geographically restricted to coastal areas of Japan. Analyses were focused to compare minke whales from either side of Japan. The following kinds of data and analyses were discussed during the CA:

a) Hypothesis testing based on mitochondrial DNA (mtDNA) RFLP
b) Hypothesis testing based on allozymes
c) Comparative analysis on external body proportions
d) Comparative analysis of external coloration (shoulder/flipper coloration pattern)
e) Pattern of sighting distribution
f) Pattern of catch distribution

The IWC SC agreed that the data presented confirmed the presence of at least two stocks, J stock on the western side of Japan (Sea of Japan) and O stock on the eastern side of Japan (Pacific), and that the combination of genetic, morphological and reproductive data provides strong evidences that seasonal mixing occurs in some part of the migration and feeding ranges. The SC also noted that no data exist related to the location of breeding-calving grounds. Arguing the lack of data for some parts of the migratory corridor and breeding grounds, the IWC SC agreed that the existing stock definition and boundaries did not provide an adequate basis for assessment (IWC, 1992).

Discussions on stock structure during the 1993-2003 *Implementation*
The Working Group established before 1993 to start the *ISTs* felt that stock structure information was not sufficient for the trials and proposed a complicated stock scenario based on three stocks (J, O and W) and 7 sub-stocks (three in J and four in O). The Group established 13 sub-areas for the purpose of trials. Based on the report of this Working Group, the IWC SC noted the desirability of obtaining improved data on stock identity and migration pattern in western North Pacific minke whale. In response Japan started the JARPN (Japanese Whale Research Program under Special Permit in the North Pacific) with three main objectives: a) clarify whether W stock exists in pelagic areas; b) clarify the mixing rate of W stock, and c) clarify the validity of sub-stock scenario.

The program was conducted between 1994 and 1999 and a considerable amount of data on stock structure was accumulated in that period. The most valuable aspects of the JARPN were that: a) it explored regions from which data were not previously available, particularly from offshore sub-areas 8 and 9; b) samples were collected systematically on predefined track-lines, and c) the new available samples allowed the comparison among IWC's sub-areas 7, 8 and 9 using both genetic and non-genetic approaches.

The IWC SC reviewed partial data obtained by JARPN in a workshop conducted in 1996. The Working Group agreed that the new data, in conjunction with those reported previously: a) confirmed the distinction between the J and O stocks; b) the data were compatible with a hypothesis of only one stock in sub-areas 7, 8, 9, 11 and 12 (with allowances for some J stock animals in sub-areas 7, 11 and 12 seasonally), and c) the data were generally inconsistent with there being sub-stocks characterized by different levels of latitudinal migration. With regard the W stock, the Group agreed that no evidence was presented to support the hypothesis of a W stock. Some members, however, considered that the information did not exclude this possibility in particular because of concerns about the ability of the available data to detect genetic differences (IWC, 1997).

The IWC SC conducted a full review of JARPN during a workshop conducted in 2000. A total of 32 scientific papers were presented and discussed at the workshop. This time the analyses were focused to compare whales among sub-areas 7, 8 and 9, in the Pacific side of Japan:

a) Hypothesis testing based on allozymes, mtDNA control region sequences and microsatellites.
b) Comparative analysis of biological parameters.
c) Comparative analysis of conception date.
d) Comparative analysis of external measurements.
e) Pattern of sighting distribution.
f) Comparative analysis of pollutant burden.
g) Comparative analysis of parasite load.

In general these approaches were consistent with the hypothesis of two stocks, J and O stocks around Japan, but the analyses failed to detect significant differences between coastal and pelagic localities in the western North Pacific. In other words these analyses did not provide evidence for the existence of the W stock. However, some analyses suggested the occurrence of J stock animals in sub-area 7 (Pacific side of Japan) seasonally. The only indication for the occurrence of W stock came from a mtDNA analysis based on hypothesis testing, which showed some degree of mtDNA heterogeneity in samples taken in the western part of sub-area 9 in 1995. Therefore the possibility of occurrence of W stock was not completely discarded and the Workshop recommended further studies and samples, especially from offshore regions (IWC, 2001).

During the *Implementation* two workshops were conducted, in 2002 (IWC, 2003) and 2003 (IWC, 2004a). During the 2002 workshop some new or updated analyses were presented:

    a)   Clustering analysis of mtDNA control region sequence data (Boundary Rank Technique) (BR)
    b)   Analysis of geographical distribution by sexual class
    c)   Hypothesis testing based on mtDNA control region sequences
    d)   Hypothesis testing based on microsatellites

Considering the results of different kinds of analyses, the workshop defined four baseline stock structure hypotheses for consideration in the trials, which were accepted subsequently by the IWC SC (Figure 1):

a) Scenario A: two main stocks (J and O) allowing the sporadic occurrence of a third stock (W) in part of sub-area 9 (based on the results of genetics and non-genetics approaches presented to the JARPN review, particularly mtDNA results, by Japanese scientists).

b) Scenario B: two stocks (J and O) (based on the results of the genetic and non-genetic approaches presented to the JARPN review).

c) Scenario C: four stocks (J, Ow, Oe, W) with three to the eastern side of Japan with hard boundaries at 147°E and 157°E (results of the application of the technique Boundary Rank to mtDNA data by US scientists).

d) Scenario D: three stocks (J, O and W) with mixing gradient between O and W between 147°E and 162°E (based on the interpretation of the results of BR and assisted by some oceanographic data by US and Australian scientists).

These four hypotheses were adopted despite considerable disagreement among IWC SC members on the plausibility of Hypotheses C and D. Hypotheses A and B were based mainly on hypothesis testing of genetic (mtDNA and microsatellite) and non-genetic data, following suggestions from the IWC SC since1994. Hypothesis C and in part Hypothesis D were based on the results of the application of the BR to mtDNA data. The core of Hypothesis C suggested two O stocks (Ow and Oe) divided by a hard boundary at 147°E.

The BR technique has not been published and it has not been used in current IWC SC assessment of whale stocks. It has not been used in the formulation of the current three stock structure hypotheses of common minke whale (see below). Even the US proponents of Hypothesis III, which were in favor of the BR technique in the previous *Implementation*, have opted this time for the hypothesis testing approach.

Plausibility rank of stock structure hypotheses in the 1993-2003 *Implementation*
During the 2002 IWC SC meeting Japanese scientists presented the results of an AIC (Akaike's Information Criterion)-based evaluation of the plausibility of baseline stock scenarios defined by the 2002 workshop. These were based exclusively on mtDNA data. To our knowledge this was the only attempt to develop a procedure to evaluate plausibility objectively.

Results of the AIC gave a low plausibility to stock structure C and D. However there was no agreement at the IWC SC on the validity of using AIC for evaluating plausibility therefore the IWC SC agreed to retain the four basic stock structure scenarios.

Several papers dealing with evaluation of plausibility of the different stock scenarios were prepared by Japanese scientists for the 2003 IWC SC meeting. However, the IWC SC refused to discuss these papers and to be able to complete the already long *Implementation* decided to give these four different stock structure scenarios the same `high` plausibility (IWC, 2004b) meaning that the IWC SC failed to assign plausibility to different hypotheses in an objective and scientific way. The result of this was that when the *Implementation* was completed the management implications were flawed.

Management implications
A total of six RMP variants were defined at the 1993-2003 *Implementation*. Regardless of which stock structure hypotheses are considered plausible only Variant 1 (Small Areas equal sub-areas. For this option, the Small Areas for which catch limits would be set are 7W, 7E, 8W, 8E, 9W, 9E, 11, 12SW and 12NE) and Variant 5 (7+8+11+12 and 9 are combination areas and catches are Catch-cascaded to the sub-areas with each combination area i.e. Small Areas are the same as for Variant 1), were acceptable based on the risk-related statistics. Of these, Variant 5 was preferable based on the catch-related statistics.

All variants were acceptable under stock structure A and B. Variant 6 (7+8+11+12 and 9 are Small Areas; catches from the 7+8+11+12 Small Area are taken from sub-areas 7W and 11 using Catch-cascading across those two sub-areas) was the preferable based on the catch-related statistics.

Variant 6 (V6) of Scenario A4-J1 (stock scenario A, MSYR: 4% and J catch series 1) gave a median catch/year (commercial+incidental) of 132 O stock animals and 21 W stock animals. Under V6 O stock animals can be taken from sub-areas 7W and 11. The catch for Variant 5 of Scenario C4-J1 was 32 Ow stock animals, 25 Oe animals and 94 W stock animals e.g. most of the allowed catch quota was in offshore waters and not accessible to the small coastal whaling (IWC, 2004b).

The views of the IWC SC members were divided in recommending a management variant in 2003: most members recommended that variant 5 was the preferred management option if the RMP is implemented. Other members recommended that variant 6 should be the preferred management option if the RMP is implemented. Such disagreements on management advice could have been avoided if the relevant questions on stock structure had been resolved satisfactorily and plausibility rank assigned in an appropriate scientific way.

THE CURRENT RMP *IMPLEMENTATION*

In 2009 instead of conducting the typical *Implementation Review* (after five years since completion the first *Implementation*) the IWC SC agreed to conduct a *pre-implementation assessment*, which was completed at the 2010 IWC SC meeting. Therefore at this meeting the IWC SC agreed to start the *Implementation* process for this stock. This time the IWC SC is conducting the *Implementation* under the new 'Requirements and Guidelines for *Implementations*' agreed by the IWC SC in 2004. Under these guidelines an *Implementation* should be conducted in a two-year period, during which two intersessional workshops and two annual meetings are carried out. The First Intersessional Workshop was completed in December 2010. One of the main tasks of the First Annual Meeting in June 2011 is the assignment of plausibility rank to different stock structure hypotheses. As noted above the IWC SC is still lacking an appropriate procedure for this important task.

Stock structure hypotheses
Three stock structure hypotheses (Hypotheses I, II and III) were proposed and specified for the *Implementation* (see Figure 2 for the new sub-areas).

Hypothesis I (Figure 3a)
Single J stock distributed in the Yellow Sea, Sea of Japan and in the Pacific side of Japan. Single O stock occurs in sub-areas 7, 8 and 9, which migrate in summer mainly to the Okhotsk Sea (sub-areas 12SW and 12NE). Both J and O stocks overlap temporally in the Pacific coast (sub-areas 7CS and 7CN) and the southern part of the Okhotsk Sea (sub-areas 11 and 12SW).

Hypothesis II (Figure 3b)
Same as Hypothesis I but a different stock (Y stock) resides in the Yellow Sea and overlaps temporarily with the J stock in the south part of sub-area 6W.

Hypothesis III (Figure 3c)
There are 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. The JE distributes in the Pacific side of Japan around the year and mix with the OW in sub-areas 7CS and 7CN between April and September. The JW distributes in sub-areas 6W, 6E and 10W and mix with the OW and OE in sub-areas 11 and 12SW. The OW distributes in sub-area 7W around the year and mix with the OE there and with the JW and OE in sub-area 12SW. Only the OE migrates into sub-area 12NE.

Stock structure hypotheses I and II are updated versions of the previous Hypotheses A and B, with some elements of these hypotheses (e.g. Y and C stocks) mimicking some of the aspects of two of the sensitivity tests considered during the 2003 *Implementation* (IWC, 2004b). A difference between Hypotheses I/II and previous Hypotheses A/B is the more extensive distribution of J stock animals in the Pacific side of Japan and the spatial and temporal mixing of J and O stock animals in sub-areas 7CS and 7CN is now more documented under Hypotheses I and II.

Hypotheses I and II derived from several analyses, genetics and non-genetics, recommended by the IWC SC since 1994.

Stock structure hypothesis III is new. It derives mainly from hypothesis testing analyses of mtDNA and microsatellites data of O and J stock animals pooled.

Therefore we have the situation that the 'high plausibility' hypotheses C and D of the 1993-2003 *Implementation* are not supported by the new samples and analyses. Furthermore hypothesis testing is the approach used by the proponents of Hypothesis III, and the BR method used to propose Hypothesis C in the previous *Implementation* is no longer used in the current *Implementation*. An updated analyses based on BR provided no support for Hypothesis C (Gaggiotti and Durand, 2010)

The key issues to resolve and implications for management
As noted above stock structure is critical information for *Implementation*. Weighting of trials into 'high', 'medium' and 'no agreement' depends mainly on the plausibility rank assigned to stock structure hypotheses (into 'high', 'medium' 'low'). On the other the hand the output of the *Implementations* (e.g. management advice) depends on the conservation performance of trials at its different weights.

A major source of disagreement within the Committee during the 2010 Annual Meeting related to whether common minke whales in sub-areas 7 and 2 represented a mixture of O- and J-stock animals (Hypotheses I/II) or a single stock with 'intermediate characteristics' (e.g. OW under Hypothesis III). The Committee consequently agreed that resolving this issue, using genetic and non-genetic data, was a high priority for discussion at the First Intersessional Workshop and beyond (IWC, 2011).

One of the differences between the analytical approach used by the proponents of Hypotheses I/II and those of Hypotheses III is related to the way they treated samples identified as J and O stocks animals. Proponents of Hypotheses I/II followed the instructions from the IWC SC to conduct the analyses separately for J and O stock animals. This was possible due to the microsatellite genotyping study presented originally by Kanda *et al.* (2009). These analyses were subsequently refined in response to IWC SC suggestions (Kanda *et al.*, 2010). On the other hand the proponents of Hypothesis III based their analyses on total samples and no effort was made to separate J and O stock animals in their analyses. Grouping of the total samples in different spatial and temporal strata resulted in several 'significant' p values that the authors interpreted as sign of multiple O and J stocks (independent stocks with intermediate characteristics). Results of the analyses conducted in this way might have several interpretations, which are difficult to verify with new data and analyses.

By taking into account the output of the 1993-2003 *Implementation*, it is likely that management advice would differ substantially between Hypotheses I/II and Hypothesis III scenarios. Similar to the case of former Hypothesis C, management advice under current Hypothesis III would imply that the core allowed catch be taken in offshore waters.

Therefore it is very important that before the IWC SC advances to the next step (the step after the plausibility ranking in the process of *Implementation*), the key questions on stock structure differentiating Hypotheses I/II from III should be resolved adequately.

SUMMARY

- The IWC SC conducted the first *Implementation* on western North Pacific common minke whales between 1993 and 2003.
- Four stock structure hypotheses were adopted in the first *Implementation*: Hypotheses A, B, C and D. Hypothesis C proposed the occurrence of a small coastal O stock (Ow) and it was based on the results of the Boundary Rank technique applied to mtDNA data. Hypotheses A and B were based on the results of genetic and non-genetic analyses that followed recommendations from the IWC SC since 1994.
- No procedure is available for the IWC SC to assign plausibility to stock structure hypotheses in an objective and scientific way.
- Consequently in 2003 the IWC SC was unable to assign plausibility to the four hypotheses in a scientific manner. In order to complete the already long *Implementation* it assigned 'high plausibility' to all four hypotheses.
- Because the difficulty to assign plausibility ranks in an objective manner, the views of the IWC SC members were divided in recommending a management variant in 2003: most members recommended that variant 5 was the preferred management option if the RMP is implemented. Other members recommended that variant 6 should be the preferred management option if the RMP is implemented. Variant 5 was not acceptable from the perspective of coastal whaling.
- A new *Implementation* is being conducted currently under the new 'Requirements and Guidelines for *Implementations*' agreed by the IWC SC in 2004. However the IWC SC is still lacking a procedure to assign plausibility to stock structure hypotheses in an objective and scientific way.
- Three stock structure hypotheses (Hypotheses I, II and III) were adopted and specified for the current *Implementation*. Hypotheses I and II are improved versions of previous Hypotheses A and B. Hypothesis III is a new hypothesis.
- Previous 'high plausibility' Hypotheses C and D have been abandoned and the analytical procedure on which Hypothesis C was based (BR), is no longer used in the current *Implementation*. All analyses related to the three hypotheses are based on hypothesis testing.
- The key question on stock structure is whether common minke whales in sub-areas 7 and 2 represented a mixture of O- and J-stock animals (Hypotheses I/II) or a single stock with 'intermediate characteristics' (e.g. OW under Hypothesis III).
- By taking into account the output of the 1993-2003 *Implementation* it is likely that management advice would differ substantially between Hypotheses I/II and Hypothesis III scenarios. Therefore it is very important that before the IWC SC continues with the current *Implementation* the key questions differentiating Hypotheses I/II from III should be resolved adequately.

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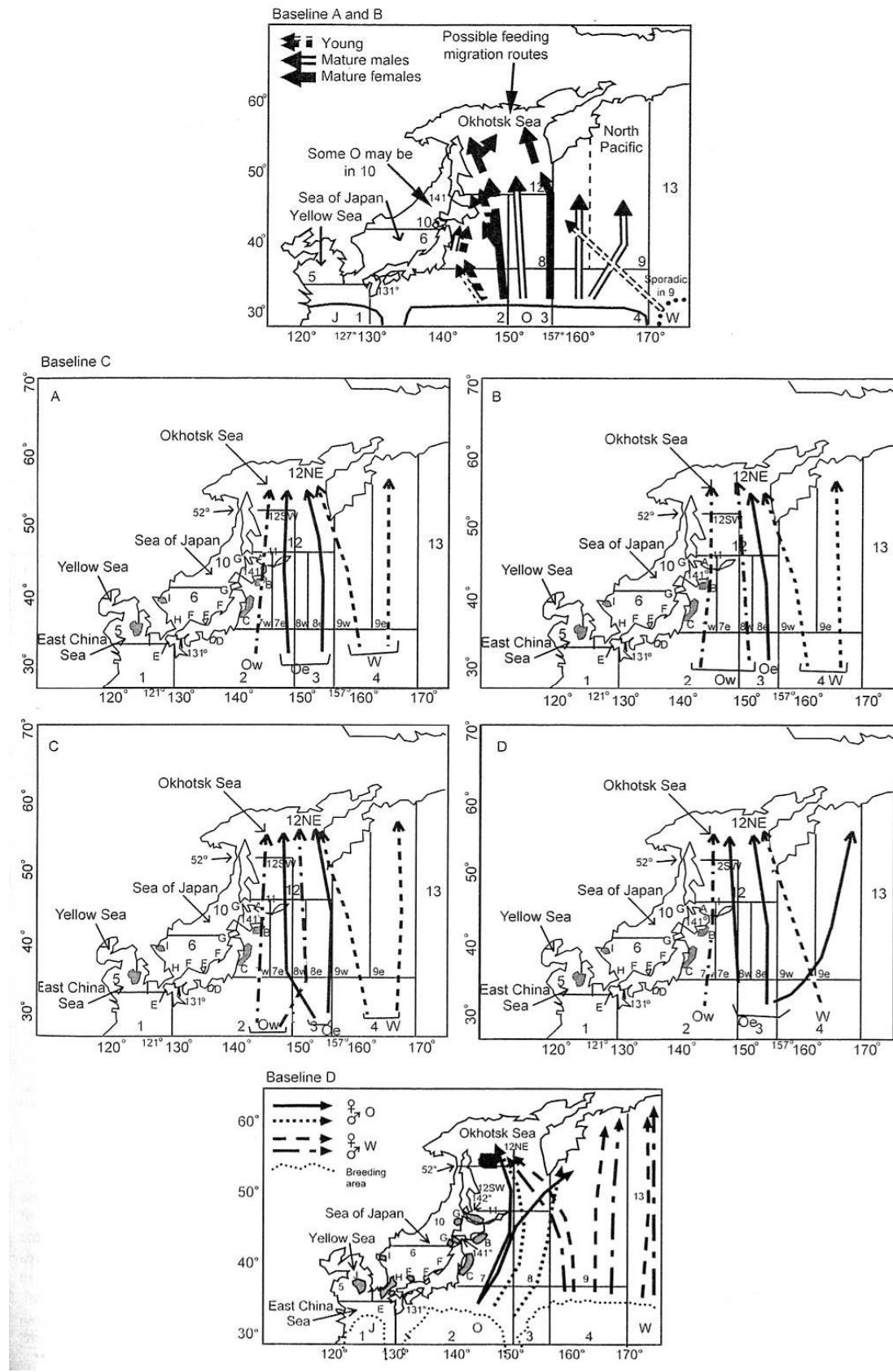
Figure 1. Hypotheses on stock structure of North Pacific common minke whale used during the 1993-2003 RMP *Implementation* (IWC, 2004). See text for details.
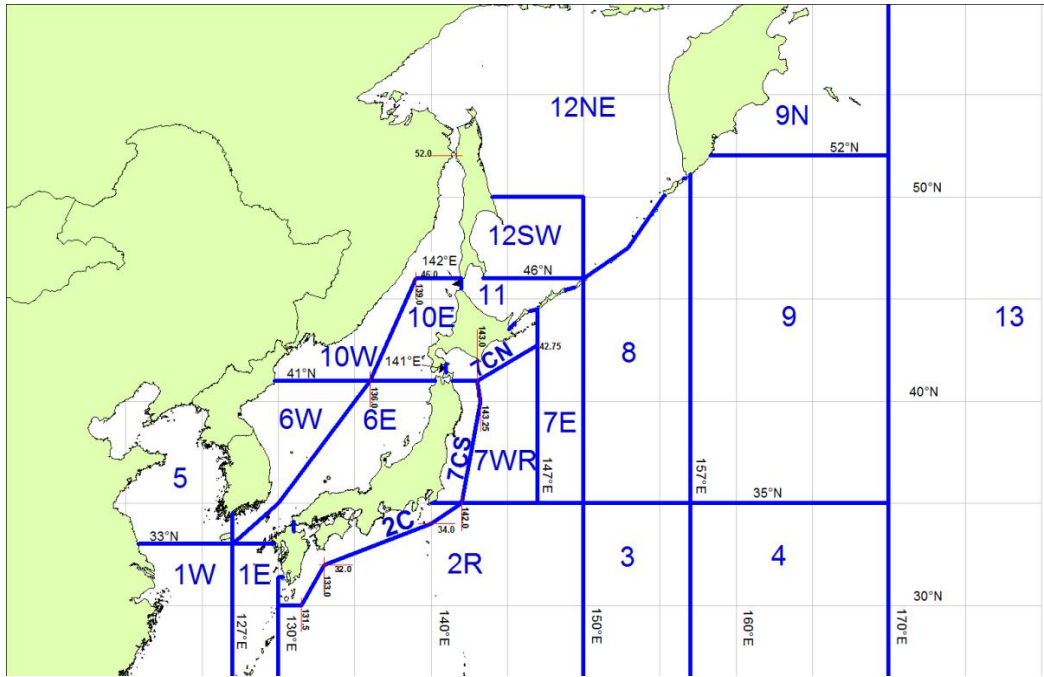
Figure 2. New sub-areas defined in the current RMP *Implementation* of western North Pacific common minke whales.
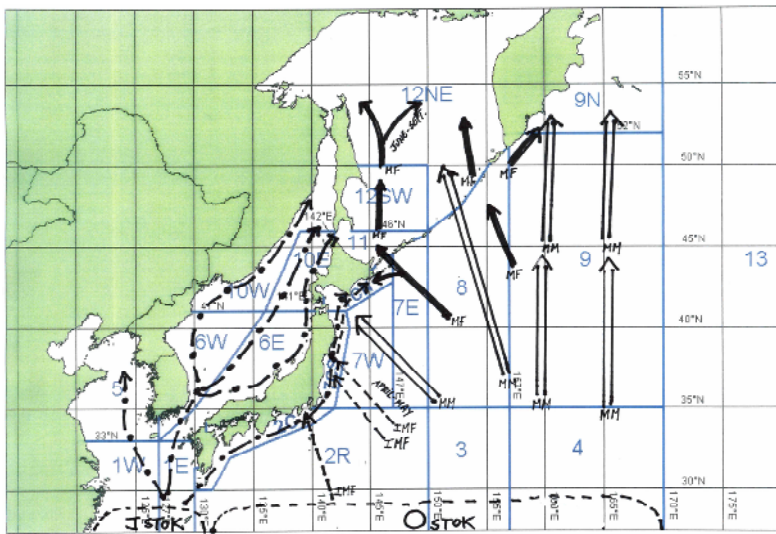

Figure 3a. Schematic representation of Hypothesis I of the current RMP *Implementation* (modified from Hatanaka and Miyashita, 1997).
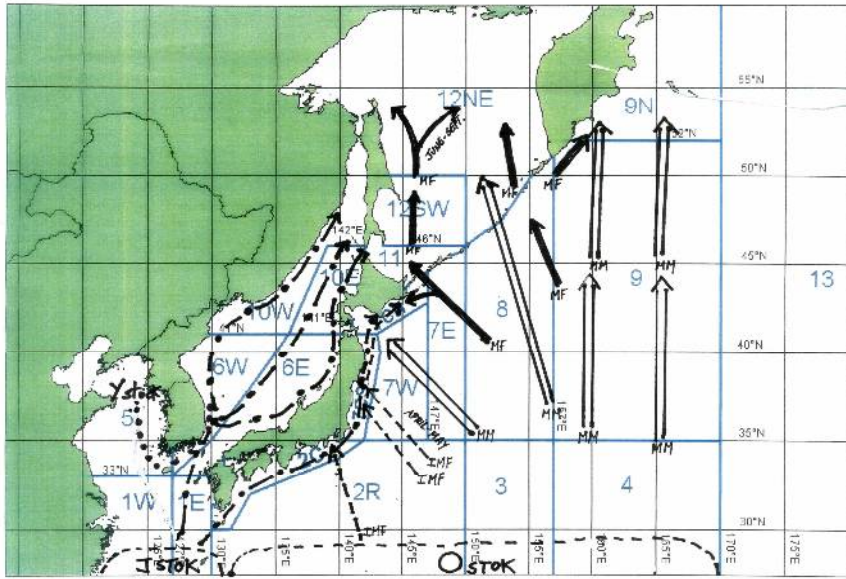MM=mature males, MF=mature females, IMF=immature males and females.

Figure 3b. Schematic representation of Hypothesis II of the current RMP *Implementation* (modified from Hatanaka and Miyashita, 1997).

MM=mature males, MF=mature females, IMF=immature males and females. Y stock residing in the Yellow Sea and mixing with the J stock in the southern part of sub-area 6W in summer.
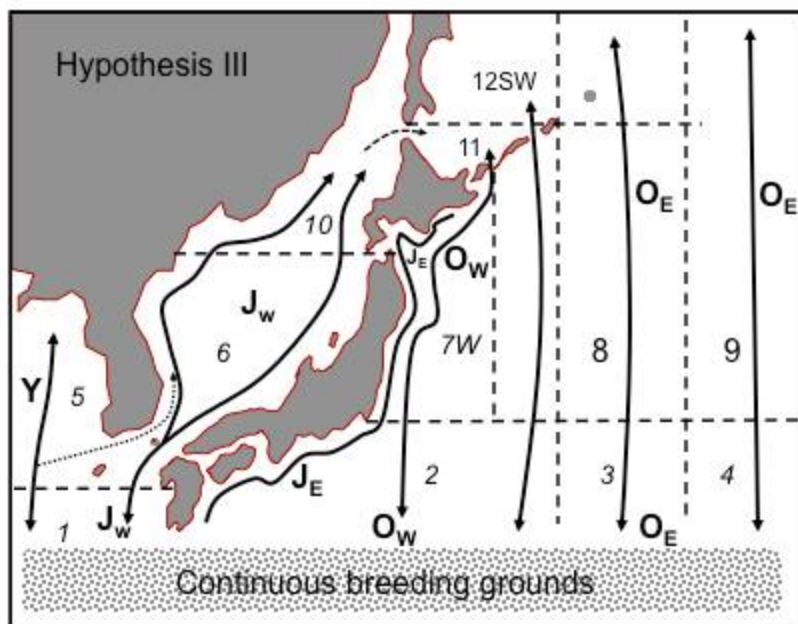

Figure 3c. Schematic representation of Hypothesis III of the current RMP *Implementation* (taken from SC/63/RMP8)