Research Plan for New Scientific Whale Research Program in the western North Pacific (NEWREP-NP)

Government of Japan

EXECUTIVE SUMMARY

a. Primary, Secondary (and, if appropriate Ancillary) objectives and their importance

- NEWREP-NP has the following Primary and Secondary objectives (see details in section 2.1 and 2.2 of the research plan):

Primary Objective I: Contribution to optimizing the establishment of a sustainable catch limit for common minke whales in the coastal waters of Japan.

Secondary Objectives I (i): Investigate the spatial and temporal occurrence of J stock common minke whales around Japan, by sex, age and reproductive status; I (ii): Estimate the abundance of the J and O stocks in coastal waters of Japan; I (iii): Verify that there is no structure in the O stock common minke whale in the Pacific side of Japan; and I (iv): Improve RMP trials by incorporating age data in their conditioning.

Primary Objective II: Contribution to the RMP/IST for North Pacific sei whale[1].

Secondary Objectives II (i): Abundance estimates for North Pacific sei whale taking account additional variance; II (ii): Estimation of biological and ecological parameters in North Pacific sei whales for RMP *Implementation;* II (iii): Study of the pattern of movement of whales of the 'pelagic stock' within the feeding grounds and between feeding and breeding grounds*;* and II (iv): Specification of RMP *ISTs* for North Pacific sei whale.

Ancillary Objective I: Investigation of the influence of environmental changes on whale stocks.

Ancillary Objective II: Examination of the effects of pollutants on whales.

Ancillary Objective III: Study of distribution, movement and stock structure of large whales with particular emphasis on blue and North Pacific right whales.

- Primary, Secondary and Ancillary Objectives above are important for the improvement in the conservation and management of whale stocks for the following reasons (see details in section 2.5 of the research plan):

- Collection and analyses of relevant data and samples (abundance, stock structure, and biological parameters) will optimize the application of the RMP on the western North Pacific common minke and North Pacific sei whales.

- The JARPNII final review workshop, endorsed by the IWC SC, noted that 'if the *ISTs* for the western North Pacific common minke whales are to be revised in the future, the age data should be included in the conditioning process'. NEWREP-NP makes use of age data of common minke and sei whales to optimize their management under the RMP (both current and as this will develop in the future).

- Those data and samples will contribute to the next *Implementation Review* in the case of the western North Pacific common minke whales, and the completion of CA and the carrying out of an *Implementation* in the case of sei whale.

- Information on stock structure (biopsy) and abundance trends (sighting surveys) in large baleen whales including the North Pacific right and blue whales, will contribute to understand the pattern of recovery of those whales after past commercial whaling. These studies have been encouraged and recommended by the IWC SC.

- Research on the health of the whales is directly related to whale conservation purposes, and studies in this field have been recommended by the IWC SC.

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[1] It is appreciated that the carrying out of an *Implementation* of the RMP for sei whales in the North Pacific has yet to be agreed by the Commission. However this is typically a routine step in extending RMP *Implementations* to further resources, so for simplicity of expression this form of words will be used in this document, but that does not imply that this authorisation will still not have to be given.

- Primary, Secondary and Ancillary Objectives above are important for the conservation and management of other living marine resources or the ecosystem of which the whale stocks are an integral part for the following reasons (see details in section 2.5 of the research plan):

- Under the Ancillary Objective I on environmental changes, several kinds of information will be collected including prey species in the whale's stomach, prey species in the research area and environmental data. This will contribute to the understanding of the interaction between whales and several other components of the ecosystem, which in turn would contribute to the ecosystem approach of whale resource management.

- Primary, Secondary and Ancillary Objectives above are important for testing of hypotheses not directly related to the management of living resources for the following reasons (see details in section 2.5 of the research plan):

- Information will be provided to characterize the oceanographic structure of the research area.

- Oceanographic information will provide insight on whether or not environmental changes are occurring in the research area, particularly in the context of global warming.

- There is a great interest in the IWC SC to investigate the effects of marine debris on cetaceans and a workshop focused on this subject has taken place.

b. Evaluation of the use of lethal sampling instead of non-lethal methods (by objective) if it requires lethal sampling

- Lethal sampling is required mainly for Secondary Objectives I (i), I (iv) and II (ii) (sample/data for age determination, body length and sexual maturity); Ancillary Objective I (sample/data on prey composition/consumption and on nutritional condition indices such as blubber thickness, girth and body weight), and Ancillary Objective II (sample/data on blubber, liver, muscle and plasma) (see details in section 3.1.1 of the research plan).

- A detailed evaluation of the available information on feasibility of lethal and non-lethal techniques led the proponents to the conclusion that the sample/data listed above can be obtained only through lethal methods at this stage (see details in section 3.1.1 of the research plan).

- During the implementation of the NEWREP-NP research, the proponents will conduct feasibility studies to evaluate several new non-lethal techniques which potentially could be used to address the objectives above: DNA-Methylation for age determination, examination of hormone in blubber for determination of sexual maturity, stable isotope and fatty acids for studies on feeding ecology. Potentially all these techniques could be used based on tissues collected by biopsy sampling. Examination of some technical aspects of the biopsy sampling equipment for common minke whale is itself another of the feasibility studies on non-lethal techniques (see Figure 2 in section 3.1.1 of the research plan).

c. Species to be taken and sample size by study area and year (and targeted component of population if applicable)

- The species to be taken for Primary Objective I is the western North Pacific common minke whale of the O and J stocks (see details in section 3.1.1 of the research plan). The species to be taken for Primary Objective II is the sei whale of the North Pacific pelagic stock (see details in section 3.2.1 of the research plan). NEWREP-NP is planned for a total period of 12 years with a mid-term review after the first six years.

- The annual sample size of common minke whale in sub-area 11 (Secondary Objective I (i)) for the first 6 years is 47 animals with the sampling starting in 2017 (more detailed estimates of sample size for the objective of studying the temporal trend of the J stock mixing proportion will be made once data have been accumulated in the first six surveys); the annual sample size of common minke whale in sub-areas 7-9 (Secondary Objective I (iv)) is 123 animals with the sampling starting in 2017 (see details of the sample size estimates in common minke whale in Annex 11 of the research plan).

- The annual sample size of sei whale is 134 animals (Secondary Objective II (ii)) with the sampling starting in 2017 (see details of the sample size estimates in sei whale in Annex 16 of the research plan).

d. Summary of effect of catches on targeted stock (s)

- There is no negative effect on the stocks of common minke whale of the proposed NEWREP-NP catches in sub-areas 11 and 7-9 (see details of the analyses in section 4.1 of the research plan). (Scenarios where that might have been the case are shown to be no longer plausible.)

- There is no negative effect on the pelagic stock of sei whale of the proposed NEWREP-NP catches (see details of the analyses in section 4.2 of the research plan).

e. Summary of co-operative research provisions

- Scientists from the Institute of Cetacean Research will play the leading role in order to pursue the research activities and achieve the research objectives of NEWREP-NP, in collaboration (particularly regarding environmental change investigations) with scientists from other domestic and/or foreign organization. Annex 20 of the research plan shows a list of collaborating research institutions as well a list of institutions and research programs from which NEWREP-NP will obtain data relevant to its objectives, by research objective of NEWREP-NP.

- Participation of foreign scientists in the field, laboratory and analytical works is welcomed. To facilitate collaboration, the proponents have developed specific protocols for foreign scientists to apply for participation in field and analytical work (see details in Annex 22 of the research plan).

- Data obtained by this research program will be shared with members of the IWC SC in accordance with the IWC SC Data Availability Agreement.

- To facilitate the research collaboration and analyses, databases will be created after each survey under this program, which will specify the kind of samples and data collected during its research activities.

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LIST OF ANNEXES

Annex 22: Protocol for participation of foreign scientists in field and analytical research under the NEWREP-NP (p188)

1. INTRODUCTION

This document presents the research plan for the New Scientific Whale Research Program in the western North Pacific (NEWREP-NP), which takes into consideration the comments made by the Expert Panel Workshop held from 30 January to 3 February 2017 and by the International Whaling Commission's Scientific Committee (IWC SC) 2017 annual meeting, in conformity with paragraph 30 of the Schedule to the International Convention for the Regulation of Whaling (ICRW) and Annex P (IWC, 2013a; 2016a). This research plan forms the basis for the Government of Japan to issue a special permit, in accordance with Article VIII, paragraph 1 of the ICRW. In the process of drafting and developing this research plan, Japan also take account of the reasoning and conclusions of the Judgment of the International Court of Justice (ICJ) in the case concerning *Whaling in the Antarctic (Australia v. Japan: New Zealand intervening)* (for further details, see Annex 1).

Research needs in the western North Pacific
NEWREP-NP has two primary objectives: '*Contribution to optimizing the establishment of a sustainable catch limit for common minke whales in the coastal waters of Japan'* and, '*Contribution to the RMP/IST for North Pacific sei whale'.*

The western North Pacific common minke whale (*Balaenoptera acutorostrata*) and the sei whale (*B. borealis*), were the target species of commercial whaling by Japan, until 1975 in the case of sei whales, and until 1987 in the case of common minke whales. Both are considered target species for future commercial whaling by Japan under IWC-endorsed catch limits, in accordance with paragraph 10 (e) of the Schedule of the ICRW, calculated using the Revised Management Procedure (RMP).

The latest RMP *Implementation* for western North Pacific common minke whale, which includes the *Implementation Simulation Trials* (*ISTs*) was completed in 2013 (IWC, 2014a). Three stock structure hypotheses were considered during the 2013 *Implementation* (see sections 2.1.1.1 and 4.1). However it was not possible for the IWC SC to agree on the plausibility of these stock structure hypotheses. As a consequence, all three stock structure hypotheses were classified as 'no agreement' and were therefore treated as if they had been assigned 'Medium' plausibility in the trials. Consequently, the results of the *Implementation* produced very small catch limits for common minke whales in coastal waters of the Pacific side of Japan (sub-areas 7CS off Sanriku and 7CN off Kushiro); this is difficult to reconcile with the empirical evidence from the last years of commercial whaling in coastal areas of Japan prior to the commercial whaling moratorium. Japan's Small Type Coastal Whaling (STCW) had been catching common minke whales since 1930. For waters around Sanriku, Kushiro and north Hokkaido (sub-area 11) the average catch for the last ten years before the commercial whaling moratorium (1978-1987) was 340 animals, with no signs of decreasing Catch Per Unit Effort (CPUE) (Annex 2), so that the population of the common minke whale was considered a Sustained Management Stock under the New Management Procedure (NMP) with annual take of 340 animals (IWC, 1986; 1992). Although past CPUE data might not be completely reliable as an index of abundance (see Annex 2) the results of the 2013 RMP *Implementation* are hardly consistent with the reality observed in coastal waters of Japan before the commercial whaling moratorium. Even considering the uncertainties of the environmental changes and the possibilities of other interpretations, the wide discrepancy between the empirical evidence from the field and the results of the 2013 *Implementation* indicates that there might be problems in interpretation of the data and key assumptions used in the population assessment under the RMP *Implementation*.

Some of the perhaps problematic issues and assumptions used during the 2013 RMP *Implementation* include, among others, i) distribution and temporal migratory patterns used to define stocks/sub-areas, ii) that the J stock common minke whale is estimated to be heavily depleted and; iii) the possible existence of a coastal O stock (the so called Ow stock) as well as two J stocks (Jw and Je).

These problematic issues drive the proponents to the first Primary Research Objective of NEWREP-NP: *'Contribution to optimizing the establishment of a sustainable catch limit for common minke whales in the coastal waters of Japan'*. The idea under this Primary Objective is first to identify the causes for the wide discrepancy between the empirical evidence from the field and the results of the 2013 *Implementation* (some are mentioned above), and second to identify the data and samples required to check, verify and/or reject some of the issues and assumptions used in the 2013 RMP *Implementation*. Research activities related to the second point above are listed as several Secondary Objectives (see details in section 2).

The North Pacific sei whale has not been the subject of a previous RMP *Implementation.* As Japan considers the sei whale to be one of the target species for commercial whaling in the future, Japan intends to bridge the gap between the scientific work achieved so far at the IWC SC and that necessary for Japan to achieve its ultimate goal (i.e. recommence commercial whaling on sei whale). This gap drives to the second Primary Objective of NEWREP-NP: '*Contribution to the RMP/IST for North Pacific sei whale'*.

In particular this second Primary Objective will attempt to assess the contribution that biological data (e.g. age distribution, age at sexual maturity) of sei whales can make to the RMP *Implementation*. As the RMP is a feedback management tool, it is expected that new biological data to be used in the *Implementation* will optimize the performance of the RMP *Implementation* for sei whales in terms of catch limits and conservation statistics. In other words larger catch limits can be calculated without compromising the status of the stock(s) involved using RMP. To test such hypothesis, additional scientific information is required, which will be addressed under several Secondary Objectives (see details in section 2).

The program under this research plan therefore will attempt to optimize the application of the RMP to the western North Pacific common minke and North Pacific sei whales, by collecting and using a variety of relevant data from whales and their environment in the western North Pacific.

These two Primary Objectives come within the research categories identified by the IWC SC in its Annex P, i.e. 'improve the conservation and management of whale stocks' (IWC, 2013a; 2016a). Achieving a sustainable balance between the maintenance of the unique marine ecosystem and the utilization of its abundant resources is, as is common for all seas and oceans, an important challenge for the western North Pacific. This is also fully consistent with the objectives of the ICRW stipulated in its preamble; "to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry".

2. HYPOTHESES AND STUDY OBJECTIVES

NEWREP-NP has two Primary Objectives each derived from the elaboration of specific hypotheses to be tested. For North Pacific common minke whales some of these hypotheses are: i) that J stock is not heavily depleted and, ii) that there is only one O stock in the Pacific side of Japan. For sei whales, the hypothesis is that past and future series of biological data such as age, sexual maturity and other biological parameters could make an important contribution to the application of the RMP for the North Pacific sei whale. In other words the hypothesis is that by the use of biological data in *ISTs* larger catch limits can be calculated without compromising the status of the stock(s) involved.

2.1 Primary Objectives

2.1.1 Primary Objective I

Contribution to optimizing the establishment of sustainable catch limit for common minke whales in the coastal waters of Japan

2.1.1.1 Background on the research needs

The latest *Implementation* of western North Pacific common minke whale was completed in 2013 (IWC, 2014a). Annex 3 summarizes the main results of the *Implementation Review*.

A total of 22 sub-areas were set for the *Implementation* (Figure 1), and three stock structure hypotheses were used: Hypothesis A proposes two stocks, J and O stocks, which mix to each other spatially and temporally around Japan; Hypothesis B is similar to Hypothesis A but it proposes a different stock in the Yellow Sea (Y stock); Hypothesis C proposes five stocks: Y stock in the Yellow Sea, J stock in the Sea of Japan (Jw), J stock in the Pacific side of Japan (Je), a coastal O stock (Ow) and a pelagic O stock (Oe) in the Pacific side of Japan.

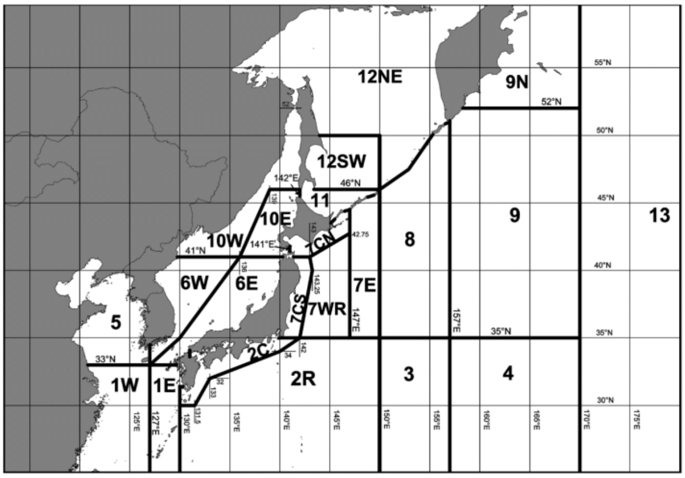


Figure 1. The 22 sub-areas used for the RMP *Implementation* for western North Pacific common minke whale (IWC, 2014b).

The plausibility of the three stock structure hypotheses was discussed at the 2012 IWC SC Annual meeting. However no agreement on plausibility was reached by the IWC SC.

The relevant information in Annex 3 is as follows:

- A total of 11 management variants were used.
- Variants 9, 10 and 11 were the most appropriate from the point of view of utilization of the resource.
- However, the average median annual commercial catches (years 1-100) for Variants 9, 10 and 11 were 17, 15 and 9 animals, respectively, for sub-areas 7CS and 7CN.
- Variant 9 was 'potentially acceptable with research'; Variant 10 was 'unacceptable'; and Variant 11 was 'potentially acceptable with research'.
- All unacceptable trials under Variants 9, 10 and 11 were related to stock structure hypothesis C, which proposed a coastal O stock in the Pacific side of Japan (Ow).
- In addition, unacceptable trials under Variant 10 were related to unacceptable performance of J stock under stock structure hypotheses A, B and C.

As noted earlier the results of the 2013 RMP *Implementation* are hardly consistent with the reality observed in coastal waters of Japan before the commercial whaling moratorium. The wide discrepancy between the empirical evidence from the field and the results of the 2013 *Implementation* suggests problems in the interpretation of the data and key assumptions used in the population assessment under the RMP *Implementation*. Some of the problematic assumptions/results and research designs identified by the proponents are the following:

i) The J stock common minke whale is heavily depleted. This assessment output led to the results that some management variants (5 and 10), for which the average catch was different from zero in sub-area 11, were not acceptable because of bad performance of the J stock under stock structure hypotheses A and B. Furthermore the performance of the Jw stock under hypothesis C was borderline or unacceptable depending on the trial.

ii) The occurrence of a coastal O stock (Ow) in the Pacific side of Japan as assumed under stock structure hypothesis C. This assumption led to the results that Variants 7, 9 and 11 were just potentially acceptable with research and Variant 10 was unacceptable. Performance for the Ow stock was unacceptable for Variants 7, 9 and 10 and borderline for Variant 11 under two trials. Performance under some trials under stock structure C was unacceptable for Variants 7, 9, 10 and 11.

iii) Large additional variance in abundance estimate. This was because sighting surveys for abundance estimates were scattered i.e. sighting survey conducted in different sub-areas were conducted in different times.

Therefore, Primary Objective I attempts to collect data that can improve the situation and that may be used to refine the results of future RMP *Implementation* on the western North Pacific common minke whales.

2.1.1.2 Detailed basis for data/sample needs

i) Further data to inform on the status of the J stock

It is necessary to collect new information on distribution and abundance of the J stock in waters around Japan and in the Okhotsk Sea in order to evaluate the plausibility of the assumption i) of 2.1.1.1. The current estimate from the *Implementation* trials of heavy depletion of this stock is difficult to reconcile with several lines of evidence which indicate the possibility of an increasing stock that is expanding its distribution. First the sustained or increasing level of by-catches for a recent period of more than 10 years in the absence of any increase in the amount of stationary gear in which this by-catch occurs (section 3). Second the occurrence of J stock in different sub-areas and periods in proportions larger than those estimated during the commercial whaling period in sub-area 7 (see details in section 3).

New information on abundance based on sighting surveys, as well as investigation of distribution and temporal trends in the mixing proportion of J stock in sub-areas around Japan, especially sub-area 11 for which available data are limited, are necessary in order to better understand the status of the J stock. Abundance can also potentially be addressed through genetic mark-recapture methods. Individual identification of J and O stock animals is possible through the combined use of genetics (microsatellite and mtDNA) and non-genetic (flipper color pattern) data.

ii) Further data to verify the existence of a single O stock

The plausibility of an Ow stock under the assumption ii) of 2.1.1.1 was evaluated through several studies on stock structure presented to the JARPNII final review workshop. All of those studies followed specific recommendations from the 2009 mid-term JARPNII review workshop (see details in Annex 4).

A substantial amount of new information on stock structure of common minke whale has been accumulated since the last *Implementation Review*, which was based on data collected until 2007. In particular it is noted the larger number of new samples (around 1,700), new analytical procedure (DAPC, kinship, statistical power of the heterogeneity test) and the availability of age data.

As noted above, most of the analyses in the documents presented to the 2016 JARPNII final review workshop (summarized in Annex 4) responded to recommendations made during the 2009 JARPNII mid-term review. Results of all different analyses indicate a single O stock distributed from the Japanese coast to approximately 170°E, and that the data do not support the occurrence of a coastal stock as proposed by Hypothesis C (Ow). However in the 2016 IWC SC meeting there was not unanimous support for this view. Subsequent kinship analyses seem virtually impossible to reconcile with the existence of an Ow stock, but there has not yet been time for the IWC SC to review these; nevertheless future work should clearly include a component that will lead to an increase in the size of samples available for kinship analyses to seek even stronger confirmation/verification of this result. Kinship analyses therefore will be conducted to investigate the relationship between coastal and offshore animals as recommended by the IWC SC in 2016 (IWC, 2016b), based on existing and new samples. Under the proponents' view of a single O stock scenario, we would expect parent/offspring linkages between coastal and offshore common minke whales.

iii) Use of biological data, particularly age data, in the RMP trials conditioning

The IWC SC broadly agrees on the value of age data in *ISTs* (e.g. conditioning operating models). In the case of common minke whale, ageing techniques have been improved and as a consequence age information is available for a larger number of animals. Additional age data is very important for the aim of improving RMP trials towards more reliable representations of possible true stock dynamics.

Additional age data is also important to further verify the existence of a single O stock. Although (as described above) the genetic data are continuing to strengthen the case against any O stock, it is important to also to follow other non-genetic lines of investigation, specifically by means of age data analyses similar to those conducted by Kitakado and Maeda (2016). Preliminary analyses by these authors suggested that the single stock scenario seems consistent with the age data.

In discussing the paper by Kitakado and Maeda (2016), the JARPNII final review workshop noted that 'if the *Implementation Simulation Trials* for the western North Pacific common minke whales are to be revised in the future, the age data should be included in the conditioning process' (IWC, 2016c). To achieve this aim the attainment of new age data from animals in coastal and offshore waters in the Pacific side of Japan will be required. The need to include age data as agreed by the IWC SC in adopting the JARPNII final review workshop report strengthens the justification for continued sampling. Annex 11 provides further and more detailed reasons for the justification for acquisition of further age data.

iv) Sighting data for improved abundance estimates for the O stock common minke whale

A series of abundance estimate for O stock common minke whales are available from JARPN and JARPNII. However, as pointed out in the research design under the assumption iii) of 2.1.1.1, sighting surveys designed to decrease the additional variance are required i.e. different sub-areas covered in the same time period. Systematic sighting survey under the Line Transect Method as well as genetic mark-recapture methods are proposed to address this research topic.

2.1.1.3 Secondary Objectives

The research elements identified in section 2.1.1.2 are reflected in the Secondary Objectives of Primary Objective I below:

- Secondary Objective I (i): *Investigate the spatial and temporal occurrence of J stock common minke whales around Japan, by sex, age and reproductive status*

- Secondary Objective I (ii): *Estimate the abundance of the J and O stocks in coastal waters of Japan*

- Secondary Objective I (iii): *Verify that there is no structure in the O stock common minke whale in the Pacific side of Japan*

- Secondary Objective I (iv): *Improve RMP trials by incorporating age data in their conditioning*

With regard to Secondary Objective I (iii), the proponents consider that all the recommendations from the JARPNII mid-term review workshop were addressed, and that results of the refined analyses following those recommendations were presented to the JARPNII final review workshop (IWC, 2016c). None of these refined analyses support the existence of a coastal Ow stock. Therefore the proponents consider Stock Hypothesis C to be implausible. The further genetics work proposed under this Secondary Objective (e.g. kinship analyses) is simply routine monitoring to check for no change in a current position that is already clear, and is proposed only because genetics information also becomes available, incidental to the necessary collection of future age data under the program (see below).

As detailed later in this proposal, a feasibility study on satellite tracking will be conducted on baleen whale species. In the case of the common minke whale, trials will be conducted to address the question of movement across the boundaries separating sub-areas 7CS and 7CN from offshore sub areas. Under the single O stock structure hypothesis, movement is to be expected across those boundaries. Also if tracking trials are conducted late in the feeding season, it could be possible to investigate the migration routes of common minke whales to lower latitudes areas.

With regard to Secondary Objective I (iv), the proponents wish to emphasize here the recommendation from the JARPNII final review workshop endorsed by the IWC SC: *'Thus, if the Implementation Simulation Trials for the western North Pacific minke whales are to be revised in the future, the age data should be included in the conditioning process'*, and they understand the IWC SC to have confirmed the fundamental importance of the use of age data in conditioning trials.

The main justification for lethal sampling is to obtain earplugs for age determination and biological samples for determination of reproductive status (Secondary Objectives I (i) and I (iv)), and the sampling survey for common minke whale in sub-areas 11 and 7-9 is designed with this aim in mind.

Details of survey design, area and field and analytical methods are provided in section 3 and annexes.

2.1.2 Primary Objective II

2.1.2.1 Contribution to the RMP/*IST* for North Pacific sei whale

The North Pacific sei whale has not been the subject of previous RMP *Implementation*, however the IWC SC started an *in-depth assessment* of this species in 2015. While a substantial amount of scientific information on sei whales has been accumulated in recent years through research programs such as the JARPNII in the western North Pacific and the IWC-POWER (Pacific Ocean Whale and Ecosystem Research) in the central and eastern North Pacific, these data have not been yet used in population assessment models in the context of the RMP *Implementation*.

Data required for a RMP *Implementation*

A RMP *Implementation* including the *Implementation Simulation Trials* (*ISTs*) requires several types of information for the management of whales, including:

- Time series of past catches by area
- Time series of abundance estimates (and their CVs) by area
- Hypotheses of stock structure (for trial structure, definition of target areas, variants of the Catch Limit Algorithm, CLA)
- Biological information on natural mortality, production rate, maturity and recruitment relationship, etc. (for trail structure)
- Stochastic variation of recruitment in particular, amongst other factors (for trial structure)

The RMP was designed to be robust to the uncertainty in biological information reflecting the failure of its predecessor (NMP). In this regard, the CLA requires only historical catch data and abundance estimates (with their CV) when it calculates catch limits. However, the overall RMP exercise has changed into a data-demanding process so that it cannot be implemented without a wide range of biological/ecological information during its RMP *Implementation* including the *ISTs* process in order to narrow down the scenarios to be considered. Hence, in order to conduct an RMP *Implementation*, a variety of biological/ecological data is actually required. It should be noted here that the most conservative whaling scenarios are selected as a precautionary approach, when there is uncertainty in the biological and ecological information required in the RMP *ISTs* such as stock structure and reproductive parameters (uncertainty is related to a limited amount of data, which in turn implies less precision in the parameters). In other words, further biological and ecological information will contribute to reduction of uncertainty, and therefore less conservative whaling scenarios can be used, which usually provide larger catch limits. Additional data will improve conservation as well as increase catch limit. This will be in line with one of the IWC's management objectives for commercial whaling under the RMP, which is 'making possible the highest yield from the stock' (IWC, 1990).

2.1.2.2 Estimation of biological and ecological parameters for the application of the RMP to the North Pacific sei whale

As mentioned above, the IWC SC agrees that future *ISTs* should use age-structured models (IWC, 2016c). Under Primary Objective II, not only abundance estimates and hypotheses of the stock structure but also certain biological and ecological parameters are key for the specification of trials, and therefore narrowing the reasonable range of their values and hypotheses is an important issue for calculating reasonable catch limits and thus ensuring the sound management of whaling once paragraph 10 (e) of the Schedule is amended. Using this basic idea, the IWC SC could optimize the selection amongst RMP variants.

Abundance data
Some international and national surveys have been conducted in the North Pacific for estimating whale population sizes and monitoring their population trends. Particularly, the POWER surveys under the auspices of the IWC have provided valuable information on the distribution and abundance of sei whales in the central and eastern North Pacific in summer. Also, the Japanese dedicated sighting surveys in the western North Pacific under JARPNII contributed information on abundance estimates in particular areas of the western North Pacific. A summary of the sighting datasets to be used in the North Pacific sei whale *in-depth assessment* by the IWC SC was summarized in IWC (2016d).

Biological and ecological parameters
For the North Pacific sei whales, in addition to the abundance estimates mentioned above, several types of biological data have become available since the commercial whaling era and from the JARPNII surveys. In particular, the technical procedures for determination of age and maturity status were developed over years. These advances could then give key information for inferring population dynamics of the sei whales as in the case of Antarctic minke whale, where both the abundance estimates and catch-at-age data were utilised (Punt *et al*., 2014).

Age-structured dynamics models can be applied to North Pacific sei whales and the biological parameters including those that will be estimated from data collected by NEWREP-NP will contribute to the trials structure in the RMP *ISTs.*

Stock structure
A summary of the studies and hypothesis on stock structure in the North Pacific sei whale is presented under section 4.2 below. For the *in-depth assessment* the IWC SC agreed to proceed with two alternative stock structure hypotheses:

i) A single stock in the entire North Pacific as proposed in (Kanda *et al*., 2015a)
ii) A five-stock hypothesis proposed in (Mizroch *et al*., 2015):

- Japan coastal;
- North Pacific pelagic;
- Aleutian Islands and Gulf of Alaska;
- Eastern North Pacific migratory; and
- Southern North American coastal stock (coastal California)

At the 2016 IWC SC meeting the Committee agreed that the genetic and mark-recapture data currently available are consistent with a single stock of sei whales in the pelagic region of the North Pacific (IWC, 2016b). Therefore NEWREP-NP will focus on the single North Pacific pelagic stock.

Under the NEWREP-NP priority will be given to refine the single pelagic stock hypothesis through satellite tracking experiments to further study the movement of whales within the feeding ground as well possible migratory routes from feeding areas to breeding areas in low latitudes. Genetic analyses will be also conducted.

2.1.2.3 Specification of models

Conditioning and development of trial structures are a part of the objectives of the NEWREP-NP. For conditioning and development of trial structures for the *RMP/IST*, age/sex-structured models will be used, as in previous *RMP/ISTs*. In order to help this, estimation of biological and ecological parameters such as a natural mortality and carrying capacity in the age/sex-structured model will be conducted based on statistical catch-at-age analyses (SCAA) using existing data and newly obtained data under the NEWREP-NP program.

2.1.2.4 Detailed basis for data/sample needs

As described above, the RMP is a management procedure which guarantees sustainability with safe levels of catch limits over a period of 100 years and more (IWC, 2012a). While considerable data and information are already available through past research, more refined information over a longer period is necessary for optimizing the RMP *Implementation* (see Table 1).

Therefore, the Primary Objective II aims at providing required data for application of the *ISTs* and contribute to the assessment process under the RMP *Implementation*. Furthermore, the actual catch limits which may be used for the resumption of commercial whaling will be derived from the achievement of this research objective. The specific data and samples required in this proposed program for the Primary Objective II are amplified in subsequent sections.

Table 1. Current data and future research needs for North Pacific sei whale in the context of Primary Objective II.

	Existing values and knowledge	Problems/pending issues	Aspects to potentially be clarified with past data and new data under the proposed research plan
1) Abundance	IWC-POWER JARPN/JARPNII	IWC-POWER estimates become subject to the "phase-out rule" ・ Usable for conditioning purpose ・ Usable for CLA in trials ・ No estimates agreed for use in the actual CLA as yet	・ Obtain new series of abundance estimates from surveys with IWC oversight. Repeated calculation of abundance estimates for study areas will be helpful to draw information on inter-annual variation of distribution (better estimate of additional variance and identification of factors affecting the variation).These further abundance estimates are required for application of the CLA. (Secondary Objective II (i))
2) Biological and ecological parameters	MSYR(1+) : 1～4% (revised range given by meta-analysis)	・ Need recent information on the natural mortality ・ Need to monitor any possible changes in recruitment rate	Improvement of precision of biological/ecological information ・ On natural mortality ・ Further monitoring of the changes in the recruitment rate (Secondary Objective II (ii))
3) Stock structure	Single pelagic stock assumed		Further investigation on movement within feeding grounds and between feeding grounds and breeding grounds (Secondary Objective II (iii))
4) Specification of RMP/IST	Possible use of an SCAA model	・ Need to set a plausible range of biological parameters ・ Need to specify future changes in recruitment rate	・ Conditioning of age-/sex-structured model for base case trials ・ The trials structure can also be considered with linkage between recruitment and environmental changes

2.1.2.5 Secondary Objectives

As shown in Table 1, there are several research items necessary to achieve the Primary Objective II. For this reason, this proposed plan also identifies four Secondary Objectives for sei whales as follows:

- Secondary Objective II (i): Abundance estimates for North Pacific sei whale taking account of the additional variance

- Secondary Objective II (ii): Estimation of biological and ecological parameters in North Pacific sei whales for RMP *Implementation*

- Secondary Objective II (iii): Study of the pattern of movement of whales of the 'pelagic stock' within the feeding grounds and between feeding and breeding grounds

- Secondary Objective II (iv): Specification of RMP *ISTs* for North Pacific sei whale

With regard to Secondary Objective II (iii) and as detailed later in this proposal, a feasibility study for satellite tracking will be conducted on baleen whale species. In the case of the sei whale, trials will be conducted to address the question of movement to the north of the tentative limit of the 'pelagic stock' distribution under one of the stock structure hypotheses (see item 4.2) and to the south of the tentative limit. The former will be conducted early in the feeding season and the experiment will be useful to understand the northern distribution of the stock and at the same time the plausibility of some proposed stocks under one of the stock structure hypotheses can be assessed.

The latter will be conducted late in the feeding season and the experiment will be useful to investigate migratory routes of whales to lower latitude areas.

The main justification for lethal sampling is the attainment of earplugs for age determination, and biological samples for determination of reproductive status (Secondary Objective II (ii)), and the sampling survey for sei whale in offshore areas is designed with such an aim in mind.

Details on sampling design, sampling areas and field and analytical methodologies are provided in section 3 and annexes.

2.2 Ancillary Objectives

2.2.1 Ancillary Objective I

Investigation of the influence of environmental changes on whale stocks

There have been many studies on regime shift of marine ecosystem in the western North Pacific around 1925, 1947, 1977 and 1998 (King, 2005; Overland *et al*., 2008). Possible changes in the geographical and temporal distribution of baleen whale stocks, as a response to environmental changes, will affect the interpretation of abundance estimates and trends based on systematic sighting surveys. Abundance estimates and trends are important pieces of information for management under the RMP. Ecological changes related to minke and sei whales and possible effects on management under the RMP should be further investigated through the examination of data on distribution and abundance, whale stomach contents and nutritional conditions, and environmental variables. Ecological changes are occurring in recent years as indicated by changes in prey species compositions of common minke and sei whales in JARPNII (Konishi, 2016). It should be noted that similar changes in prey species compositions of common minke whales were observed in previous regime shift (Kasamatsu and Tanaka, 1992). There is a need for continuous monitoring to understand the effect of environmental changes on whale stocks.

The proponents stress that the original aim of this Ancillary Objective is to contribute to the understanding of the implications of environmental change in terms of whale stock management, rather than detection of a major environment change itself. The proponents do recognize that, based on current scientific knowledge, it is difficult to predict whether a major environmental change (categorized as a 'regime shift') would occur within the proposed research period of NEWREP-NP.

The proponents will monitor spatial distribution, prey species compositions and body conditions of target whales and they will investigate potential influential factors (e.g. available prey), if temporal changes (which could ultimately be related to major change) in whales are observed. Such monitoring and investigation will contribute to future *in-depth assessment* (IA) of whales as in the case of Antarctic minke whales.

This Ancillary Objective will be investigated using data obtained through surveys designed for other Primary and Secondary Objectives (related to age and reproductive data).

Details on field and analytical methodologies are provided in section 3 and annexes.

2.2.2 Ancillary Objective II

Examination of the effects of pollutants on whales

In 1980, the Special Scientific Committee Working Group on Management Procedures identified that "Management measures should take into account the effect on whale stocks of environmental changes due either to natural causes or to human activities" (IWC, 1981) as one of the principles for whale management.

In response to this suggestion, the JARPNII conducted environmental studies under one of its objectives ('Monitoring environmental pollutants in cetaceans and the marine ecosystem'). It was observed that PCB levels in common minke whales (Yasunaga and Fujise, 2016a) and total mercury (Hg) levels in common minke, Bryde's and sei whales (Yasunaga and Fujise, 2016b), did not change during the research period, and were sufficiently under their thresholds in other whale species. It was suggested that the adverse effects of pollutants such as PCB and total Hg to the whale health could be low in the area. On the other hand, some areas for further research were identified: i) examination of possible adverse effects of pollutants with adjustment for confounding factors such as nutritional condition and ages; ii) species differences of sensitivity and response to pollutants; and iii) investigate of adverse effects of novel compounds.

These three research items will be addressed under this Ancillary Objective. This Ancillary Objective will be investigated using data obtained through surveys designed for other Primary and Secondary Objectives (related to age and reproductive data).

Details on field and analytical methodologies are provided in section 3 and annexes.

2.2.3 Ancillary Objective III

Study of distribution, movement and stock structure of large whales with particular emphasis on blue and North Pacific right whales

JARPN and JARPNII were useful platforms for the collection of biopsy and photo-id data from large whales, included the depleted North Pacific right whale. NEWREP-NP will be also a platform for further collection of those kinds of data, particularly on blue and right whales. On blue whales the IWC SC recommended the analysis of biopsy samples from the central and western North Pacific for comparison with genetic data from the eastern North Pacific population (IWC, 2016e). NEWREP-NP will contribute with additional biopsy and photo-id data for such purpose.

The IWC SC has welcomed the research on distribution, movement and stock structure of North Pacific right whales (IWC, 2016e). The only genetic study on stock structure was based on samples collected in the eastern North Pacific (LeDuc *et al*., 2012). The available biopsy samples from JARPNII and those to be obtained by NEWREP-NP will allow the genetic comparison between eastern and western North Pacific right whales.

As detailed later in this proposal, a feasibility study on satellite tracking will be conducted on large whale species. Trials will be conducted on large whale species, included the North Pacific right and blue whales, on an opportunistic basis.

Details on field and analytical methodologies are provided in section 3 and annexes.

2.3 Relationships amongst Primary Objectives

In both Primary Objectives the research topic is the optimization in the application of the RMP on two different species in the western North Pacific. However, the approaches to achieve such objectives differ among the species concerned. In the case of the common minke whale, RMP *Implementation* has been applied previously so the focus here is to identify the causes for the unreasonable results from the 2013 RMP *Implementation* and to identify data and samples required for a more efficient and realistic application of the RMP on this whale resource. In the case of the sei whales there is no previous RMP *Implementation* and the focus here is, by considering the experience with the common minke whale, make use of available as well new collected data and samples as input for the RMP *Implementation*. Of particular importance is the use of biological data during the conditioning, which again has the potential to optimize the use of the RMP on this whale resource by calculating a larger catch limits without increasing the depletion risk of the stock.

2.4 Requirements of lethal sampling, non-lethal methods or a combination of both for each Primary Objective (see also section 3.1.1)

2.4.1 Primary Objective I

- Secondary Objective I (i): *Investigate the spatial and temporal occurrence of J stock common minke whales around Japan, by sex, age and reproductive status*

Non-lethal (sighting data for distribution analysis); and lethal (tissues for genetic and morphological analyses, earplug and eye lens for age determination, ovaries and testis for sexual maturity determination; body measurements).

'Tissues for genetic analyses' is listed here and below under the category 'lethal'. As explained in section 3, genetic analyses are possible based on tissues obtained by biopsy samples (non-lethal) although the feasibility of biopsy sampling varies among whale species (see details in section 3). Since age data are definitively required (see section 3), and can be obtained only by lethal methods, genetic data become co-incidentally available from such samples. Therefore, the question of whether biopsy sampling in practical does not require further consideration.

- Secondary Objective I (ii): *Estimate the abundance of the J and O stocks in coastal waters of Japan*

Non-lethal (sighting data for abundance estimates); and lethal (tissues from fetus and mother for genetic analyses on 'mark-recapture').

- Secondary Objective I (iii): *Verify that there is no structure in the O stock common minke whale in the Pacific side of Japan*

Non-lethal (satellite tracking for studies on movement and distribution of whales); and lethal (tissues for genetic analyses on kinship).

- Secondary Objective I (iv): *Improve RMP trials by incorporating age data in their conditioning*

Non-lethal (sighting data for abundance estimates); and lethal (earplug and eye lens for age determination; ovaries and testis for sexual maturity determination; body measurements).

See details of field and analytical methods related to the four Secondary Objectives under section 3 and annexes.

2.4.2 Primary Objective II

- Secondary Objective II (i): *Abundance estimates for North Pacific sei whales taking account additional variance*

Non-lethal (sighting data for abundance estimates; environmental data as covariates in spatial modeling).

- Secondary Objective II (ii): *Estimation of biological and ecological parameters in North Pacific sei whales for RMP Implementation*

Non-lethal (sighting data for abundance estimates); and lethal (earplug and eye lens for age determination; ovaries and testis for sexual maturity determination; body measurements).

- Secondary Objective II (iii): *Study of the pattern of movement of whales of the 'pelagic stock' within the feeding grounds and between feeding and breeding grounds*

Non-lethal (satellite tracking for studies on movement and distribution); and lethal (tissues for genetic analyses).

- Secondary Objective II (iv): *Specification of RMP ISTs for North Pacific sei whales*

Non-lethal and lethal information of the three items above is required.

See details of field and analytical methods related to the five Secondary Objectives under section 3 and annexes.

2.5 Value of each Primary and Ancillary Objective

- Improvement in the conservation and management of whale stocks
    - Collection and analyses of relevant data and samples (abundance, stock structure, biological parameters) will optimize the application of the RMP on the western North Pacific common minke and North Pacific sei whales.
    - The JARPNII final review workshop, endorsed by the IWC SC, noted that 'if the *ISTs* for the western North Pacific common minke whales are to be revised in the future, the age data should be include in the conditioning process' (IWC, 2016c).

- Those data and samples will contribute to the next *Implementation Review* in the case of the western North Pacific common minke whales, and the completion of CA and the carrying out of *Implementation* in the case of sei whale.
- Information on stock structure (biopsy) and abundance trends (sighting surveys) in large baleen whales including the North Pacific right and blue whales, will contribute to understand the pattern of recovery of those whales after past commercial whaling. These works have been welcomed and recommended by the IWC SC (IWC, 2016c).
- Research on the health of whales is directly related to whale conservation purposes, and studies in this field have been recommended by the IWC SC (IWC, 1995).

- Improvement in the conservation and management of other living marine resources or the ecosystem of which the whale stocks are an integral part

  - Under the Ancillary Objective I on environmental change, several kinds of information will be collected including prey species in the whale stomach, prey species in the research area and environmental data. This will contribute to the understanding of the interaction between whales and several other components of the ecosystem, which in turn would contribute to the ecosystem approach of whale resource management.

- Testing of hypotheses not directly related to the management of living resources

  - Information will be provided to characterize the oceanographic structure of the research area.
  - Oceanographic information will provide insight on whether or not environmental changes are occurring in the research area, particularly in the context of global warming.
  - There is a great interest in the IWC SC to investigate the effects of marine debris on cetaceans and a workshop focused on this subject has taken place (e.g. IWC, 2014c).

2.6 JARPN/JARPNII scientific outputs and relationship with NEWREP-NP

JARPN was started in 1994 and was completed in 1999. The IWC SC conducted a review workshop of JARPN in 2000 (IWC, 2001). The JARPNII started in 2000 and 2001 as a two-year feasibility survey. The full program started in 2002 and the first six-year period was completed in 2007. The second six-year period was completed in 2013. Data and results from the JARPNII were reviewed in two workshops, a mid-term review workshop based on the samples and data collected in the first period (IWC, 2010) and a final review based on samples and data collected by JARPN and JARPNII until 2013 (some data were available until 2014) (IWC, 2016c). Results of the three last surveys of JARPNII (2014-2016) that became available after the final review will be reviewed during the review workshop for NEWREP-NP in January/February 2017.

The main scientific outputs of JARPN/JARPNII are summarized in Annex 5, by research objective of JARPNII. The JARPNII final review workshop welcomed the scientific contribution of JARPN/JARPNII. At the same time it identified areas where further work was required, and provided useful suggestions and recommendations to refine the analyses.

Some of the main outputs of JARPN/JARPNII, including the catch at age data to refine RMP/*ISTs*, will be used for the future RMP *Implementation*, together with the new data to be collected by NEWREP-NP, thereby the future RMP *Implementation* will be benefited from long-term high quality data.

It should be clarified here that NEWREP-NP is not an extension of JARPN/JARPNII as NEWREP-NP has different research objectives and a different focus on the issue of environmental change. However the proponents will continue refining their JARPNII results following the recommendations from the JARPNII final review workshop and the SC (see Table 24 in IWC, 2016f), and results will be presented to the annual meeting of the IWC SC. It should also be noted that the NEWREP-NP has been developed using relevant data and results of scientific work by scientists from all over the world, including but not limited to JARPN and JARPNII.

The main focus of NEWREP-NP is on the optimization of the application of the RMP on common minke and sei whales. The proponents considered that the priority to include Bryde’s whale is low at least at this stage because the RMP *Implementation* the IWC SC conducted on this species in the North Pacific has produced results compatible with other information, unlike the case of the common minke whale (see IWC, 2008). As distinct from the situation for JARPNII where its main scope reflected long-term research need, the proponents see a shorter-term need to narrow the scope of the research especially focusing on common minke whale and sei whale. As regards the ecosystem the proponent's primary short-term goal is to contribute to the understanding of the implication of the environmental changes in terms of whale stock management, and thereby also assist in the development of ecosystem models by other researchers and research institutions.

3. METHODS TO ADDRESS OBJECTIVES

3.1 Primary Objective I

3.1.1 Field methods

- Species, number, time frame, area

For Primary Objective I, the western North Pacific common minke whale will be the target species and the study areas will be i) the Sea of Japan side of Japan; ii) north of Hokkaido (sub-area 11) and Pacific side of Japan (sub-areas 7-9). The Sea of Japan will be the main target area for dedicated sighting surveys for abundance estimate purposes. North of Hokkaido (sub-area 11) and Pacific side of Japan (sub-area 7-9) will be the main target area for lethal sampling. Sub-area 11 will be one of the target areas for the research on distribution and temporal trend in mixing proportion of J stock animals. Sub-areas 7, 8 and 9 will be the main target area for verifying the single structure of the O stock and for improving the RMP through the use of age data. The research area will be surveyed between April and October, which is the migratory season of common minke whale around Japan.

The annual sample size for common minke whales in sub-area 11 for the first 6 years is 47 animals, which was estimated based on Secondary Objective I (i) (see analytical details in section 3.1.3). The annual sample size for common minke whales in sub-areas 7-9 in the Pacific side of Japan is 123 animals, which was estimated based on Secondary Objective I (iv) (see analytical details in section 3.1.3).

The research period under NEWREP-NP is planned to be 12 years with a midterm review after the first six years in order to evaluate progress in achieving research objectives, and revise the research program if necessary. As this Primary Objective is associated with the application of the RMP, the six-year period is in line with the annotations to the RMP, which states that 'An *Implementation Review* for a species and *Region* should normally be scheduled no later than six years since the completion of the previous *Implementation* (*Review*)' (IWC, 2012a). The detailed timeline of research activities in NEWREP-NP is presented in section 3.1.4.

- Sampling protocol for lethal aspects of the proposal

Annex 6 shows the whale sampling design for Primary Objective I (common minke whale). Basically four small catcher boats will be involved in the survey (see Annex 21), and they will depart the port in the morning and return the port every night. A land-based operation system will be incorporated for whale sampling in the coastal areas. In order to increase the geographical coverage in sub-areas 7CS, 7CN and 11, whales will be sampled in different ports regardless of whether or not those ports have a land station to conduct the biological surveys. The whales sampled will be transported by tracks from the port to the nearest land station for biological survey. *Nisshin Maru* may be used as a research oceanic station when necessary.

Land stations with a research head office will be established in Kushiro (sub-area 7CN), Ayukawa (sub-area 7CSW) and Abashiri (sub-area 11). Ayukawa and Kushiro land stations will be switched depending on the migration of the common minke whale: e.g. Ayukawa from spring to summer and Kushiro from summer to autumn. Abashiri will be surveyed in different seasons so that data on seasonal changes in distribution and mixing rate of the J stock can be obtained.

The sampling procedure will be designed taking into account operational capacity, ability, and arrangements of the small boats, and will be different from the random sampling procedures adopted by the offshore component lead by *Nisshin Maru*. All whales sampled will be transported to a land station and biologically examined by a team of scientists.

Details of the sampling procedure are given in Annex 6. In particular Tables 1 and 2 of this annex shows the number of samples of common minke whale by month, year and sub-area collected by JARPN/JARPNII in the period 1994-2016, and the expected samples by NEWREP-NP in the period 2017-2022 (including offshore sub-areas), respectively.

Sampling in sub-areas 7WR, 7E, 8 and 9 will be carried out by the sampling and sighting vessels attached to the research base *Nisshin Maru*, which will be also engaged in sampling of sei whales under Primary Objective II.

Sampling protocol for minke and sei whales in sub-areas 7WR, 7E, 8 and 9 is described in Annex 12.

- Assessment of why non-lethal methods, methods associated with any ongoing commercial whaling, or analyses of past data have been considered to be insufficient

Biological data, including age data and sexual maturity, will contribute the conditioning in the RMP *Implementation*, which includes the *ISTs.* In this regard, obtaining the latest biological data is important for the RMP *Implementation* as more refined information over a longer period is necessary for optimizing the RMP *Implementation.* Secondary Objectives most relevant to this point are the following:

> Secondary Objective I (i): *Investigate the spatial and temporal occurrence of J stock common minke whales around Japan, by sex, age and reproductive status*
>
> Secondary Objective I (iv): *Improve RMP trials by incorporating age data in their conditioning*

The data to be obtained by lethal sampling of common minke whales under these objectives are the age (by reading earplugs and racemization method), sexual maturity (by examining ovaries and testis samples), body length (by measurements of body on board of the vessels) and tissues for genetic analyses (regarding to genetics see also section 2.4.1).

<u>Age data</u>
Age data are key information for the work under these two objectives. There is currently no satisfactory non-lethal method to obtain age data. In the context of developing a new whale research plan for the Antarctic waters, the proponents critically reviewed whether the age is indeed unobtainable by methods other than lethal sampling. After giving serious consideration to the information summarized below, the conclusion was reached that age data at the annual scale can be obtained only through lethal sampling methods (see details in GOJ, 2015). This conclusion would apply to other baleen whales including those in the western North Pacific, and not only to Antarctic minke whales.

DNA methylation approach (DNA-M) was recently developed and applied to humpback whales for the aim of age determination in this species (Polanowski *et al*., 2014). In discussing and evaluating the DNA-M technique the NEWREP-A review workshop noted that 'the technique does not provide the chronological age of the individual but rather a physiological age that can be used as a proxy for chronological age' and that 'physiological and metabolic differences between species, means that the method will need to be calibrated for each species'. Furthermore the workshop noted that 'because the conditions in which individual grow may also affect their physiological age and metabolism, it is possible that the calibration slopes and variances of the DNA-M technique may not be interchangeable between populations found in different areas or even between different periods within the same population, i.e. the technique may require calibration by species, population and period'. Finally the workshop stated that 'given the novelty of the technique and the fact that it has only been applied to a single population of a single species of cetacean, there is as yet no experience on this regard' (IWC, 2015c).

In addition, several research initiatives were proposed during the 2016 IWC SC meting to evaluate further the utility of the DNA-M technique, among others that, in addition to skin, connective tissue and the lipid filled fat cells (usually obtained by biopsy sampling) should be investigated. This, in light of the results of Horvath (2013) that the correlation between chronological age and methylation profiles varies a great deal among different tissues (IWC, 2016f).

Recent investigations have indicated that the precision of DNA-M-based recruitment estimates from SCAA are much worse that those obtained from earplug-based readings, with DNA-M-based results hardly better than those in the absence of any age data at all (Kitakado, 2016). Hence at this juncture, indications are that the non-lethal DNA-M approach cannot provide ageing information as precise as earplug-based age readings and that the former method, unlike the latter, cannot therefore meaningfully improve results from analyses related to assessment and management recommendations.

This has led the proponents to the conclusion that the DNA-based methods would not provide usefully informative results at this stage, and that lethal sampling is required for the work under these two objectives of NEWREP-NP.

Furthermore, Yasunaga *et al*. (2017b) reports on the difficulty of obtaining biopsy samples from common minke whales as a result of the biopsy sampling experiments conducted between 2014 and 2016 under the JARPN II.

The proponents have started a feasibility study on DNA-M in the Antarctic minke whale as part of the NEWREP-A program (plan presented to the IWC SC in 2015) to see whether the information content of the results might be improved, and they will carry out similar studies on the common minke and sei whales in the North Pacific as part of the NEWREP-NP program based on the results of the studies on Antarctic minke whale and additional recommendations from the NEWREP-NP review workshop (see Figure 2). Progress of the feasibility study on Antarctic minke whale will be presented to the 2017 IWC SC meeting while a final report is planned for the 2018 IWC SC meeting. A final assessment of the feasibility of non-lethal techniques will be carried out during the mid-term review after the first six years, including an evaluation of possible modification of sample size of the lethal component of the program, on a whole-program basis. The results of the feasibility study on age determination based on DNA-M will be relevant here.

Sexual maturity

Determination of sexual maturity, which requires lethal sampling, is also important for the work under these two objectives because age at sexual maturity affects the reproductivity of the stock that is a key parameter for stock dynamics. The proponents reviewed the literature to investigate whether or not sexual maturity of common minke whales can be determined with the use of non-lethal techniques. An attempt was made to assess the reproductive status of North Atlantic right whales using fecal hormone metabolites (Rolland *et al*., 2005). The authors concluded that 'the analysis of fecal hormone metabolite levels in combination with life history data from photographically identified whales shows that the technique can be used to determine gender, determine pregnancy and lactation, and to assess age at sexual maturity in right whales'. It should be noted that although adult resting female right whales had higher levels of fecal oestrogens and progestins than juvenile females, the differences were not significant. Apart from this, there are two main reasons of why this technique cannot be used to determine reproductive status in the western North Pacific common minke whale. The first is that the conclusions of the study on right whale were based on a combination of chemical analyses of feces and biological information of photo-identified whales. It is known that photo-identification is not an appropriate technique for common minke whale because of its large abundance. Also, unlike the right and humpback whales, there is no typical external morphological character useful for individual identification in the common minke whale. The second reason is that the probability of locating fecal samples from common minke in the field is very low (see Yasunaga *et al*., 2017a).

There are another two studies that determined the pregnancy status of cetaceans based on measurement of progesterone concentration in blubber by radioimmuno-assay (blubber can be obtained by biopsy sampling). The first study concluded that blubber progesterone concentrations might be used to determine pregnancy status in free-ranging North Atlantic common minke whales (Mansour *et al*., 2002). The second study concluded that the blubber progesterone concentrations can distinguish pregnant from non-pregnant mature and immature ones in three species of dolphins. However the technique cannot differentiate pregnancy stage (Kellar *et al*., 2006). The technique appears to provide consistent results through several cetacean species examined, however it can provide information on pregnancy only. It cannot distinguish among non-pregnant mature female, immature females, mature males and immature males.

This has led the proponents to a conclusion that the determination of sexual maturity requires lethal sampling for the work under these two objectives of NEWREP-NP. However to further analyze the feasibility of non-lethal technique to determine sexual maturity in whales, the proponents will conduct feasibility studies on hormones in blubber and plasma, similar to the studies being conducted on Antarctic minke whale (see Figure 2), following the experience of the studies under the Icelandic whale research program under special permit (IWC, 2014d). Progress of the feasibility study on Antarctic minke whale will be presented to the 2017 IWC SC meeting while a final report is planned for the 2018 IWC SC meeting. A final assessment of the feasibility of non-lethal techniques will be carried out during the mid-term review after the first six years.

Body length

Body length is important because it has a potential to be used as an indicator of age. Accurate measurement of the whale body length can be taken only through lethal sampling. After the review of relevant literature (Best, 1984; Dawson *et al*., 1995; Jaquet, 2006) it is concluded that the precision of measurements obtained from shipboard techniques are insufficiently accurate.

Tissues for genetic analysis

Genetic analyses are possible based on tissues obtained by biopsy sampling. Tissue samples have a potential to give indicators of biological data lethally obtained as tissue samples provide basis for other potential non-lethal methods to determine age such as DNA methylation approach (DNA-M). It should be noted, however, the utility of such indicators needs to be examined in relation to research objectives. The feasibility of biopsy sampling varies among whale species. Yasunaga *et al*. (2017a) summarized the results of the biopsy sampling experiments conducted between 2014 and 2016 under the JARPNII. There was more success in obtaining biopsy samples in the case of Bryde's and sei whales than in the case of common minke whales.

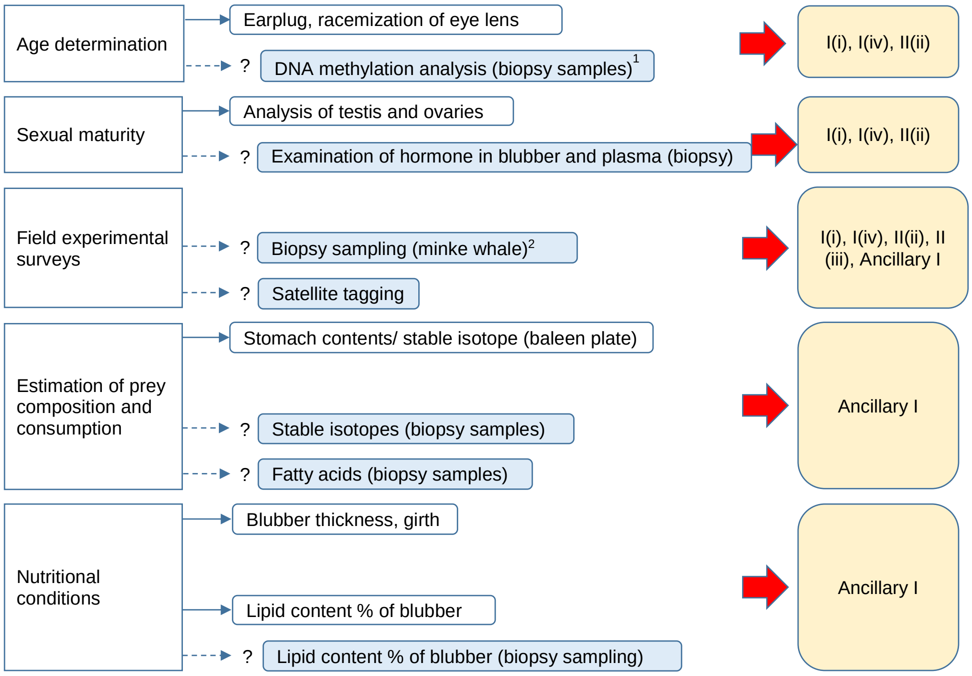
Mogoe *et al*. (2016) proposed a four-step criterion for evaluating the utility of a new non-lethal technique on whales, and the success of obtaining biopsy samples from a whale species is just one of those steps (see details in Mogoe *et al*., 2016).

In any case the genetic analyses under the Secondary Objective I (i) would be conducted jointly with analyses of biological data such as age and sexual maturity, which require lethal sampling, so the question of whether biopsy sampling in practical does not require further consideration (see also section 2.4.1).

Under NEWREP-NP additional feasibility studies on technical aspects of biopsy sampling in common minke whales will be conducted (Figure 2), and results will be presented to future IWC SC meetings.

Utility of historical data and samples

There are some data on sexual maturity and body length of common minke whale from the past commercial whaling. Although there are also biological and genetic data on common minke whale from previous JARPN and JARPNII, the analyses of those data alone are not sufficient for the two objectives above because the future stock dynamics, which is a key in RMP, can be best projected by incorporating latest biological data such as catch at age in conditioning and development of trial structures for RMP *Implementation*. The new biological samples to be collected by NEWREP-NP will be examined together with the available historical data to investigate temporal trends in the parameters involved. Ongoing changes occurring in common minke whale need to be detected through collection of relevant data on a yearly basis in order that the two objectives are achieved. This inevitably needs new samples under this program.



[1]Currently a feasibility study of DNA methylation is being conducted on Antarctic minke whale. Depending on the results (expected by 2018), new feasibility studies could start for western North Pacific common minke and North Pacific sei whales, if so they will take into consideration the additional recommendations from the NEWREP-NP review workshop.
[2]Statistical analyses based on data collected in 2014-16 suggested that biopsy sampling of common minke whale is not feasible in practice (Yasunaga *et al*., 2017a; b). However some additional studies on technical aspects of the biopsy sampling equipment will be conducted under NEWREP-NP, under the advice of foreign experts.

Figure 2. Use and evaluation of new non-lethal techniques (field and analytical) on common minke and sei whales in NEWREP-NP, and relation to primary and ancillary objectives (white: lethal methods; blue: non-lethal methods that will be evaluated in this research). Experiments on new non-lethal techniques are designed by taking technical recommendations from the NEWREP-NP review workshop into consideration.

- Sampling protocol for established non-lethal techniques

<u>Sighting survey method</u>
Sighting surveys are to be conducted by the Line Transect Method and the survey protocols will follow the Requirements and Guidelines for Conducting Surveys and Analyzing Data within the Revised Management Scheme (IWC, 2012b) so that they will be conducted under the oversight of the IWC SC. Sighting protocols are the same as those used in IWC-POWER surveys. Considering the recommendations from the NEWREP-A review workshop on sighting surveys (IWC, 2016h), the proponents will consider the following: i) survey design and methods will be reviewed taking into account previous sighting surveys and spatial model developments; ii) they will work closely with the IWC SC before finalizing surveys approaches; and iii) they will also ensure that future survey plans submitted to the IWC SC fully follow the guidelines for such surveys, including the incorporation of planned track-lines. The specific sighting plans for each year will be presented to the annual meetings of the IWC SC to ensure that future survey plans fully follow the IWC SC guidelines. Details of the analytical procedures focused on common minke whales are provided in section 3.1.3.

Issues on sighting survey's design, data collection protocols and priorities, data analyses and coordination will be included in research plans to be submitted to the annual meeting of the IWC SC for approval before the start of the survey. Also the following additional issues will be addressed in the research plan: evaluation of past survey's analytical difficulties, appropriate temporal stratification, appropriate direction of travel, use of independent observer (IO) mode, use of passive independent observer, development of protocols/priorities for biopsy-related activities, evaluation of additional variance analysis and spatial model methods and 'regime shift'-related aspects.

<u>Photo-identification and biopsy sampling</u>
Photo-ID and biopsy experiments will continue to be conducted for blue, fin, humpback, North Pacific right and killer whales. These methods will provide useful data for stock structure, mixing and movements. Particular

emphasis will be given to blue and right whales (see Ancillary Objective III). The IWC SC has welcomed photo-ID photographs and biopsy samples from those species in the North Pacific (IWC, 2015a; 2016e). Details of the field procedures are given in section 3.7.

There will be coordination with IWC POWER with respect to sighting surveys, biopsy sampling and photo-ID for large whales to ensure consistent data collection and processing, as appropriate. Information on the large whale species will be included in the cruise reports to be submitted to the IWC SC to encourage collaboration with scientists involved with research on these species.

Oceanographic observations

Oceanographic conditions in this research program will be investigated using data collected by ocean circulation models such as FRA-ROMS (Okazaki *et al*., 2016) (see details below).

3.1.2 Laboratory methods

Annexes 7-10 shows the laboratory and analytical procedures for each Secondary Objective. Below is a brief summary of the laboratory work for the most relevant research items. Secondary Objectives are referred to in parenthesis.

- Age determination (I (i) (iv))

Age determination will be conducted by two different methods counting growth layer groups (GLGs) accumulated in the earplugs and racemization ratio of aspartic acid in eye lens. The former will be the primary ageing method. The left and right earplugs with glove-finger will be collected carefully onboard the research vessel and fixed in 10% formalin solution until age determination. Because young whales have soft and easily-broken earplugs, they will be collected using the method of gelatinized extractions, following Maeda *et al*. (2013). In the laboratory, the flat along the central axis of the earplug will be cut using a sharp blade, ground on a wet stone to expose the neonatal line and growth layers. Growth layers will be counted using a stereoscopy microscope. Details of the laboratory procedure are given in Annex 7 and they will follow standard procedure (Best, 1982; Lockyer, 1984b).

Analysis of ratio of D- and L-aspartic acids (Asp D/L) will follow the method for whales described by Nerini (1983) and modified by Yasunaga *et al*. (2014) for Antarctic minke whale. In the field, eye lens samples will be stored in polyethylene bags at -80°C until analysis at the laboratory. The core sample will be carefully taken from the lens to avoid contamination and then it will be homogenized. Details of the laboratory procedure are given in Annexes 7 and 10.

- Determination of sexual maturity (I (i) (iv))

Methods for determination of sexual maturity will follow Lockyer (1984a). Sexual maturity in females will be preliminary determined at the research base vessel by the presence or absence of corpora lutea/albicantia in the ovaries. Ovaries will be preserved at -20°C and counting the number of corpora lutea/albicantia in both ovaries will be done at the laboratory after cutting the surface of the ovary using a scalpel. Sexual maturity in males will be determined preliminarily on the research base vessel, based on testis weight criterion. Testis weight (heavier side) of more than 290g will be determined as sexually mature (Bando, unpublished data). At the laboratory, HE stained testis sections will be prepared and observed using standard microscope. Males with seminiferous tubules over 100μm diameter will be determined as sexually mature (Kato, 1986; Kato, *et al*., 1991). Details of laboratory procedures are provided in Annexes 7 and 10.

- Genetics (I (i) (iii))

Standard laboratory protocols will be used for mtDNA control region sequencing and microsatellite DNA profiles. Laboratory work and data analyses will follow the IWC SC's guidelines for DNA data quality (IWC, 2009) as much as possible. Sampling and laboratory procedures of the genetics laboratory of the Institute of Cetacean Research were summarized by Kanda *et al*. (2014), and the IWC SC agreed that the paper had responded appropriately to some relevant recommendations on DNA data quality from the JARPAII review workshop (IWC, 2015a;b). In 2016 additional information was provided by the proponents on estimates of microsatellite genotyping error rates and again, the IWC SC agreed that the work presented had addressed a recommendation on DNA data quality from the JARPNII final review workshop (IWC, 2016c).

Total genomic DNA will be extracted from tissues preserved in 99% ethanol. For mtDNA, approximately 500bp of the control region will be amplified by the PCR. All samples will be sequenced for both strands with the same primers used for the PCR amplification. For microsatellite DNA a set of at least 15 primers (depending of the whale species) will be used. Details of the laboratory procedures are provided in Annex 7.

3.1.3 Analytical methods

Annexes 7-10 show the laboratory and analytical procedures for each Secondary Objective. Below is a brief summary of the analytical procedures for the most relevant research items. Secondary Objectives are referred to in parenthesis.

- Sample size estimation

Common minke whale in sub-areas 7-9

Annex 11 and Adjuncts 1-3 provide the rationale and the analyses for the selection of sample size for the North Pacific common minke whale. The analyses considered some of the recommendations from the NEWREP-NP review workshop, and were discussed further during the 2017 IWC SC annual meeting.

Lethal sampling is required to obtain age information. This allows for improved conditioning of RMP trials by providing estimates of population trajectories and their changing trends that are more closely representative of the population's behavior than can be obtained using abundance estimates alone. The extent of improvement increases with increasing sample size, which provides part of the basis to make the sample size choice, though clearly this decision also requires consideration of other factors including the possible effect of the catches on the stock as well as of aspects of practicality.

Annex 11 Adjunct 3 provides results labelled in terms of annual numbers *n* of 0 (i.e. no whales aged, only abundance estimates available), 40, 80 and 120. These numbers *n* do, however, refer to an 'effective' sample size which justifies analysis under the assumption of no over-dispersion in the ageing data. The actual sample sizes have to take that over-dispersion into account, which increase them to 0, 53, 107 and 160 respectively.

The computations focus on changes in recruitment rates (births per adult female) – possibly the result of environmental factors such as oceanographic regime shift and climate change - and how well these and the associated changes in population trends can be detected in relation to the amount of ageing information available. As mentioned earlier, the western North Pacific has been experiencing decadal-scale regime shifts of marine ecosystem that would likely affect population dynamics of whale populations. It is thus very important for resource managers that possible changes in population trends be detected in a timely manner. The broad pattern of the results is clear: in the absence of ageing information, survey indices of abundance alone are unable to detect these changes; however, given ageing information, they are detected to at least some extent, and also fairly soon after they have occurred. This remains true for a number of cases of different MSYR values, whether the changes are up or down, and when the changes occur.

Detectability of some change to the true population trajectory, and the associated extent, is clearly best for the largest annual sample size examined of 120 whales. However, an annual sample size of 80 whales was also found to be capable of detecting important changes to the true population trajectory and the associated changes, albeit to a lesser degree than an annual sample size of 120 whales. An annual sample size of 40 whales was found to be incapable of adequately detecting crucial changes in the recruitment rates. An annual sample size of 80 whales (or the actual sample size of 107 after taking into account of over-dispersion) was also found to be a feasible sample size in terms of the capacity of the research vessels. Taking account of these factors, it was concluded that the sample size of 107 O stock common minke whales per annum is the optimal sample size for this research plan. 60% of the sample size will be taken in coastal sub-areas (7CS and 7CN) and 40% in offshore sub-areas (7WR, 7E, 8 and 9) (Annex 11). Therefore 64 animals will be sampled in coastal sub-areas and 43 in offshore sub-areas. Because around 20% of the animals in sub-areas 7CS and 7CN are from the J stock (Annex 7) the sample size of O stock in coastal sub-areas needs to be adjusted to 80 animals. Then the total sample size in the Pacific side of Japan hence becomes 123 animals.

Common minke whale in sub-area 11 (I (i))

Annex 11 Adjunct 4 provides the rational and analyses for the selection of sample size North of Hokkaido (sub-area 11). As shown in Annex 7, unlike the case of sub-areas 7CS and 7CN, there are only limited and dated data on mixing proportions of the J stock in sub-area 11. Therefore the priority sub-area for addressing Secondary Objective I (i) will be sub-area 11.

It is known that segregation by sex, age and reproductive status occurs during migration of common minke whales along the Japanese coast (Hatanaka and Miyashita, 1997). For that reason, information on genetics alone is not sufficient and simultaneous collection of both genetics and biological information including age data is essential in order to evaluate the spatial and temporal migration pattern of common minke whales, and to estimate patterns of stock mixing by age and sexual maturity classes. This will ultimately provide important information for conditioning of future RMP/*ISTs* trials

It should be noted here that there are not enough data in sub-area 11 for making an exact estimate of sample size for the objective of studying the yearly trend in the proportion of the J stock in this sub-area. Therefore the estimate of sample size in Annex 11 Adjunct 4 is preliminary. Basically the proponents conducted an examination of the required sample size to estimate the mixing proportion itself, rather than the yearly trend thereof, of the J stock in this sub-area with sufficient precision (e.g. SE (p) less than 0.1), which, combined with the biological data collected simultaneously, will be important for achieving the objective here. The resulting annual sample size was 47 animals.

This estimate applies only for the first six years of NEWREP-NP. More detailed estimates of samples size for the objective of studying the temporal trend of the J stock mixing proportion will be made once data have been accumulated in the first six surveys. At that time, also an evaluation on the level of improvement in the RMP conditioning of incorporating new information on J stock proportion in sub-area 11 may be considered.

- Assignment of common minke whale individuals to stock (I (i))

The newly obtained samples will be assigned to either O or J-stocks, applying microsatellite data to a Bayesian clustering analysis in the program STRUCTURE version 2.0 (Pritchard *et al*., 2000). The program implements a model-based clustering method for inferring stock structure (K, the number of stocks in the model) using multilocus genotype data with and without information on sampling locations, which allows for the analyses of the samples without choosing sample units. The posterior probability for $K = 2$ is estimated from ten independent runs without information on sampling locations. All runs are performed with 100,000 Markov chain Monte Carlo repetitions and 10,000 burn-in length using the admixture model which assumes individuals may have mixed ancestry, with correlated allele frequencies which assumes frequencies in the different stocks are likely to be similar due to migration or shared ancestry. Individual assignment is conducted using estimated individual proportion of membership probability (>90%).

The phylogenetic analysis based on the Neighbor-Joining method (Saitou and Nei, 1987) will be performed using mitochondrial sequences, in the program PHYLIP (Felsenstein, 1993) to complement the individual assignment by the STRUCTURE analysis. Assignment will be further complemented by the examination of morphological characters separating O and J stocks (see details in Annex 7).

- Abundance estimates (I (ii))

Abundance of whales will be estimated by two approaches: design-based estimator and model-based estimator. For preliminary analysis under the former approach, mark-recapture distance sampling (Borchers *et al*., 1988, 2006; Laake, 1999), which is one of the packages in the DISTANCE program (Thomas *et al*., 2010), will be applied to estimate abundance considering preliminary g(0) estimates. Regarding the latter approach, Density Surface Modeling (DSM) (Miller *et al*., 2013) will be used, which is one of the packages in the DISTANCE program (Thomas *et al*., 2010) but other options will be tried as well. For example the approach presented by Murase *et al*. (2016a) will be used as a template of this type of analysis bearing in mind the comments from the JARPNII final review workshop. Sea Surface Temperature (SST), Sea Surface Height anomaly (SSHa) and sea surface chlorophyll-a concentration (Chl-a) recorded by satellites, and digital seafloor depth data will be used as environmental covariates in the models. Data from ocean circulation models such as FRA-ROMS will also be used as covariates.

Details of each approach for abundance estimation of common minke whales are shown in Annex 8.

- SCAA (I (iv))

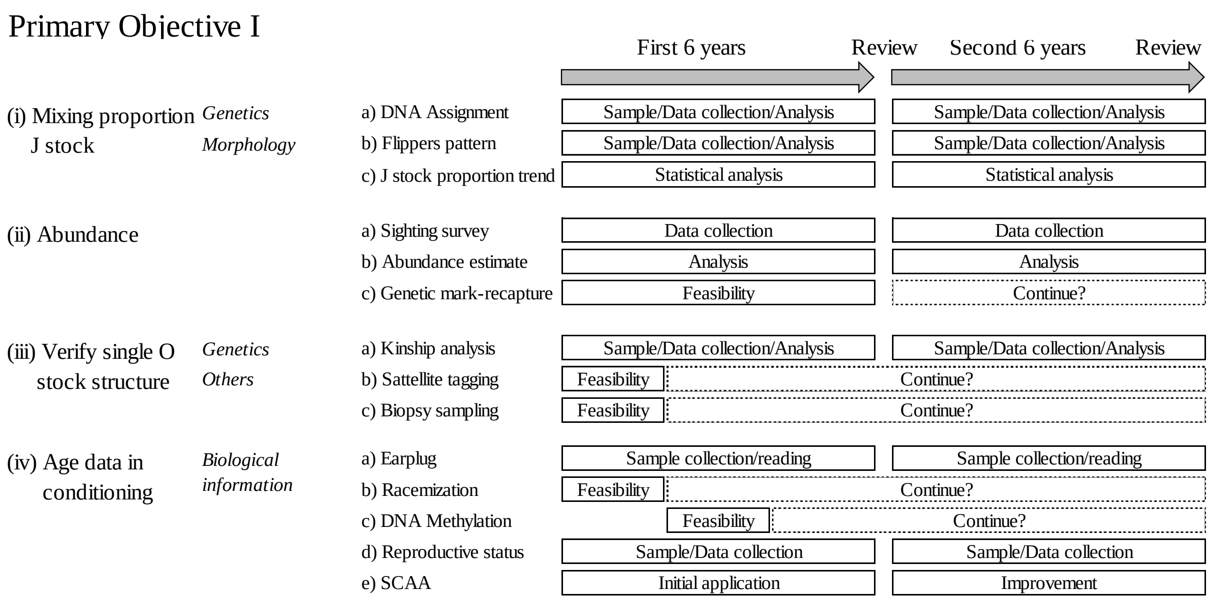
The recent availability of age data from North Pacific common minke whale (Maeda *et al.*, 2016) provides a basis to improve the accuracy of the RMP *ISTs* of IWC (2014a) for these common minke whales through taking these data into account when conditioning these trials. In this research the new age data will be used by the Statistical-Catch-At-Age (SCAA) assessment approach. The SCAA was applied to Antarctic minke whales (Punt *et al.*, 2014), and this model was recognized by the IWC SC as the 'best currently available model for examining stock dynamics for Antarctic minke whales' (IWC, 2014e). Details of the model are presented in Annexes 10 and 11.

- Kinship analysis (I (iii))

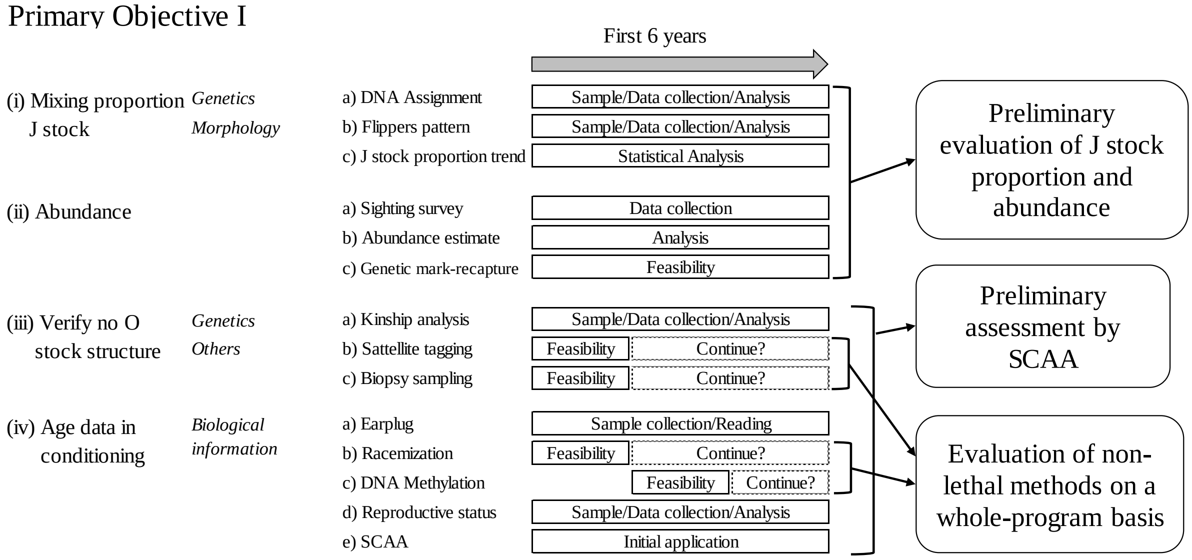
Tiedemann *et al*. (2014) reported a method for finding relatives among North Atlantic common minke whales based on microsatellite data. The method was welcomed by the IWC SC (IWC, 2015b). The method was recommended by the IWC SC to investigate relatives among North Pacific common minke whales (IWC, 2016b). The method by Tiedemann *et al*. (2014) will be used to examine previous samples from JARPN/JARPNII and bycatches, together with new samples collected by NEWREP-NP. Details of the method are provided in Annex 9.

3.1.4 Time frame with intermediate targets

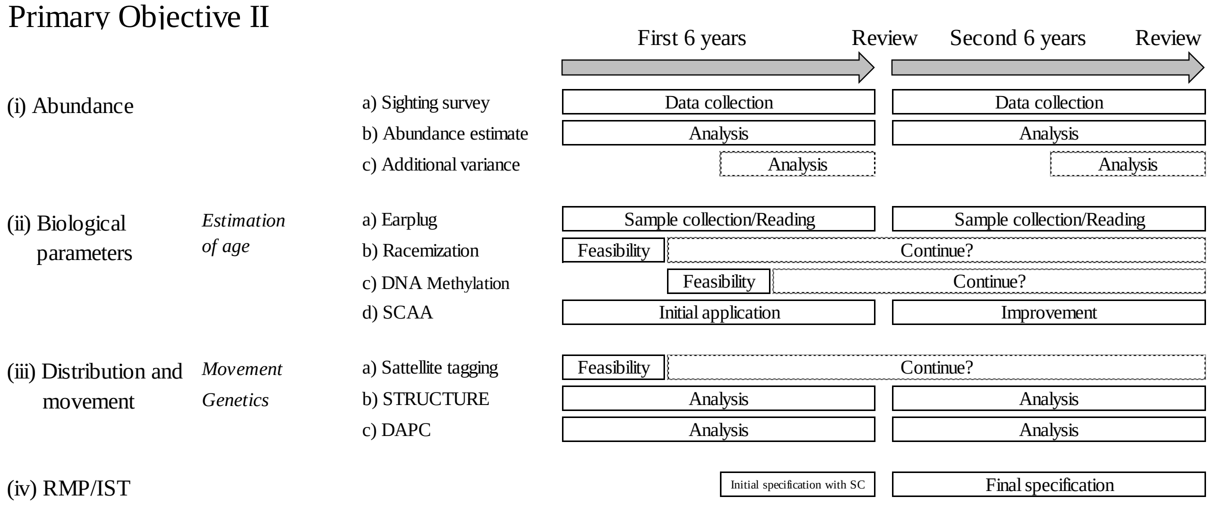
Figure 3 shows the kind of research activities and associated timelines under the NEWREP-NP's Primary Objectives I and II, and Ancillary Objectives I-III. For each primary and ancillary objective, the upper part of the figures shows the timeline for the research activities in the entire 12-years research period. The lower part of the figures shows the timelines for the first six-year period, specifying the outputs and evaluation to be obtained after the first six-year period. Details are explained under section 5.1.



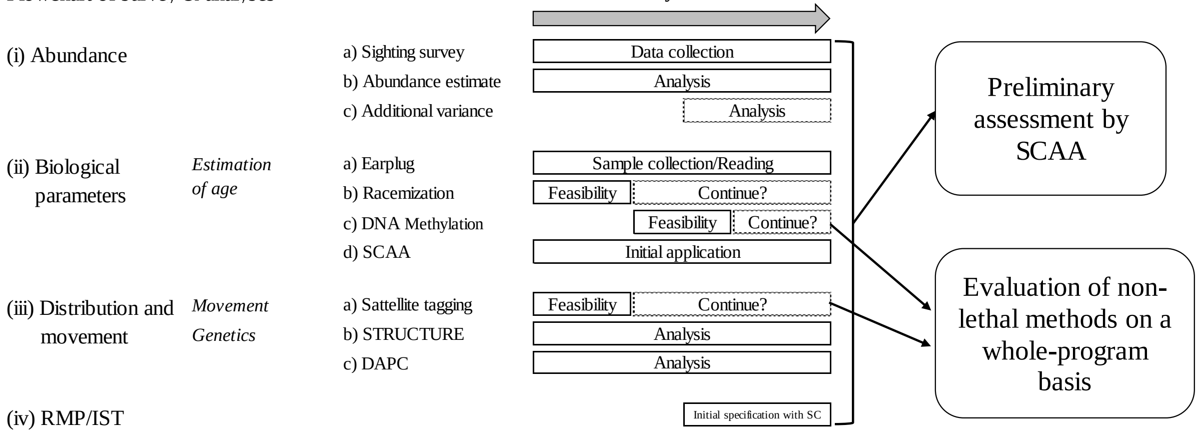
Primary Objective I



Primary Objective II



Primary Objective II
Flowchart of survey & analyses



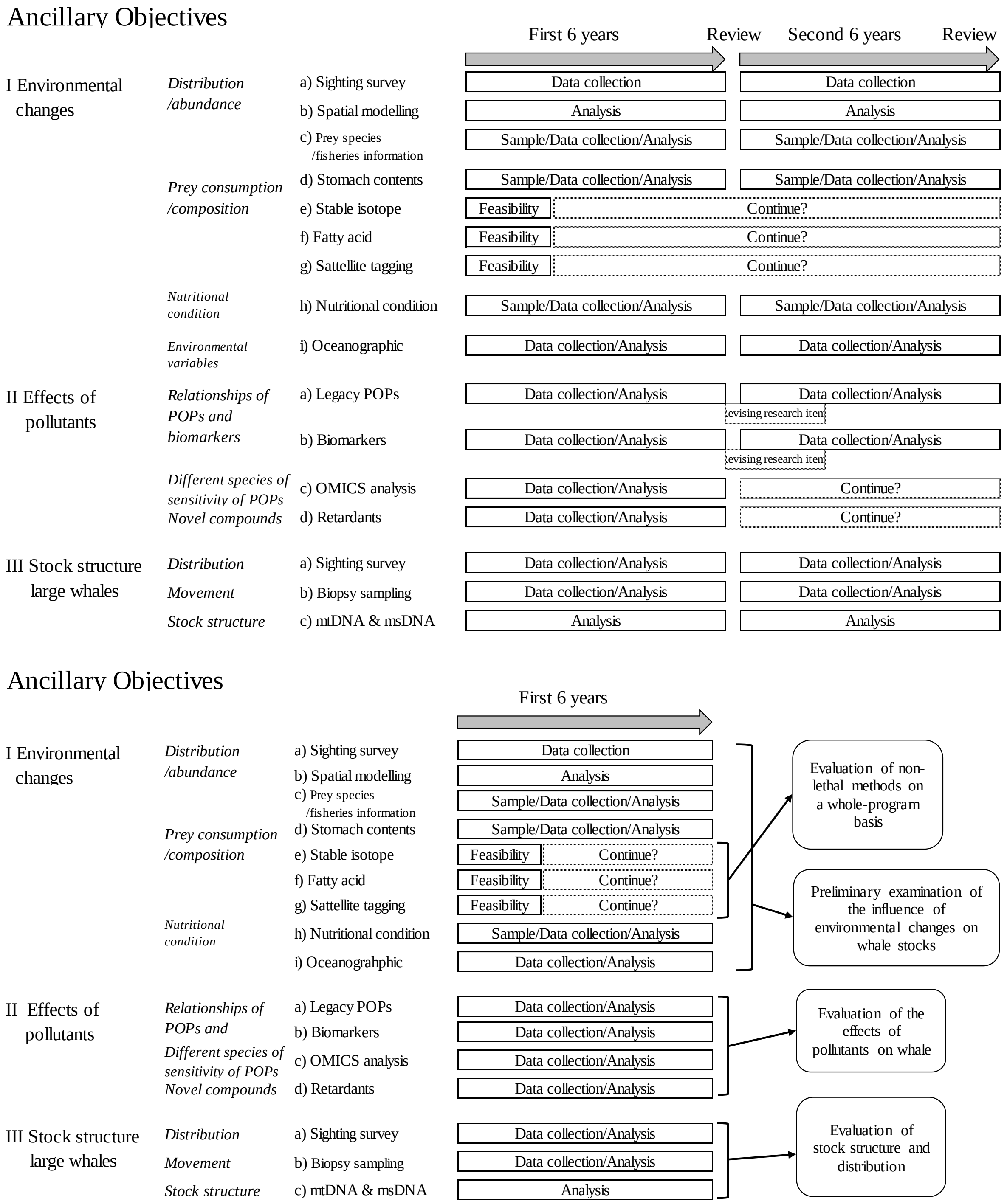


Figure 3. Research items associated to Primary and Ancillary Objectives and timeframe for six and 12-year period.

3.1.5 Explanation that this objective can be achieved by the method proposed

Secondary Objective I (i): *Investigate the spatial and temporal occurrence of J stock common minke whales around Japan, by sex, age and reproductive status*

Individual assignment to the J and O stocks common minke whales based on a set of microsatellite loci and the Bayesian program STRUCTURE has worked well in previous studies for separating O and J stock individuals (e.g. Pastene *et al*., 2016) as recognized by the IWC SC (IWC, 2010). Following recommendations from the IWC SC (IWC, 2016b), an extra number of loci will be used in the microsatellite analysis to decrease the number of 'unassigned' animals. To complement the microsatellite analyses, other genetics (mtDNA sequencing) and non-genetic methods (e.g. morphology) will be used to assign individuals to stocks.

It is known that segregation by sex, age and reproductive status occurs during migration of common minke whale along the Japanese coast (Hatanaka and Miyashita, 1997). For that reason, simultaneous collection of both genetics and biological information including age data is essential in order to evaluate the spatial and temporal migration pattern of common minke whales, and to estimate the pattern of stock mixing by age and sexual maturity classes. Accepted techniques for determination of age (Maeda *et al*., 2013) and determination of reproductive status (Lockyer, 1984a) will be used. Both genetic and biological information gained from the samples will be used in conditioning of RMP/*ISTs* trials.

Secondary Objective I (ii): *Estimate the abundance of the J and O stocks in coastal waters of Japan*

Systematic sighting surveys under the Line Transect Method is an accepted technique for abundance estimates of whales, and the IWC SC Requirements and Guidelines for Conducting Surveys and Analyzing Data within the Revised Management Scheme (RMS) (IWC, 2012b) will be followed. The Sea of Japan is believed to contain only J stock common minke whales so interpretation of sighting survey data is straightforward. Sub-areas 7 and 11 contains a mix of J and O stocks so in this case, the interpretation of sighting data should take into consideration the available information on mixing proportion in those sub-areas. It should be noted that such mixing data will be gathered under the Secondary Objective I (i) above.

Secondary Objective I (iii): *Verify that there is no structure in the O stock common minke whale in the Pacific side of Japan*

The IWC SC in 2016 considered that kinship analyses similar to those carried out by Tiedemann *et al*. (2014) would be useful to investigate further the two O stock hypothesis (IWC, 2016b). Such analyses will be conducted under NEWREP-NP based on past and new samples.

Secondary Objective I (iv): *Improve RMP trials by incorporating age data in their conditioning*

The catch-at-age analyses presented to the JARPNII review workshop (Kitakado and Maeda, 2016) were considered useful by the workshop, which recommended that 'if the *ISTs* for the western North Pacific common minke whales are to be revised in the future, the age data should be included in the conditioning process' (IWC, 2016c). The proposed SCAA model is recognized as the 'best currently available model for examining stock dynamics for Antarctic minke whale' (IWC, 2014e). See also discussion in Annex 11.

3.1.6 Data to be obtained

Table 2 below shows the data and samples to be collected by NEWREP-NP, by Primary and Ancillary research objectives.

Table 2. Data and samples to be collected under NEWREP-NP, by research objective.

	Data		Sample
Abundance estimate			
1,2,3	Weather data		
1,2,3	Effort data		
1,2,3	Sighting record of whales		
1,2,3	Angle and distance experiments		
Common minke whale/sei whale			
1,2,3,4	Catching date and location	1,2,3,4	Testis
1	Photographic record of external character	1,2,3,4	Ovary
1,2,3,4	Sex and body length	1,2,4	Earplug
1,2,3	Satellite tracking	1,2,4	Ocular lens
3,4	Body weight	1,2,3,4	Baleen plates
3,4	Blubber thickness and nutrition condition	1,2,4	Tissue samples for genetic study (including fetus)
3,4	Stomach content: freshness and weight	1,2,3,4	Tissue and organ samples for chemical study
1,2,3,4	Testis weight	4	Tissue and plasma samples for physiological study
1,2	Fetal number, sex, length and weight	3,4	Prey species in stomach
4	Marine debris (in stomach)		
Other large whales			
5	Photo-ID	3,5	Skin sample (biopsy)

[1]: Data or samples to be used for Primary Objective I
[2]: Data or samples to be used for Primary Objective II
[3]: Data or samples to be used for Ancillary Objective I
[4]: Data or samples to be used for Ancillary Objective II
[5]: Data or samples to be used for Ancillary Objective III

3.1.7 Description of use of data from other projects or programs (Objectives in parenthesis)

- Morphological data of common minke whale (Tokyo University of Marine Science and Technology, Japan) (I (i))
- Earplug-based age data (National Research Institute of Far Seas Fisheries, Japan) (I (i); I (iv))

3.2 <u>Primary Objective II</u>

3.2.1 Field methods

- Species, number, time frame, area

For this Primary Objective the North Pacific sei whale will be the target species. While lethal sampling of sei whale will be conducted mainly in the western North Pacific, the study area for non-lethal research such as sighting survey will be the pelagic region of the North Pacific delimited approximately by the Japanese DNA survey (30°N-50°N; 145°E-140°W), which is occupied by a single stock of sei whale. This research area will be surveyed between April and October.

The annual sample size for lethal research of sei whale is 134 animals, which was estimated based on Secondary Objective II (ii) (see analytical details in section 3.2.3).

The research period under NEWREP-NP is planned to be 12 years with a midterm review after the first six years in order to evaluate progress in achieving research objectives, and revise the research program if necessary. As this Primary Objective is associated with the application of the RMP, the six-year period is in line with the annotations to the RMP, which states that 'An *Implementation Review* for a species and *Region* should normally be scheduled no later than six years since the completion of the previous *Implementation* (*Review*)' (IWC, 2012a). The detailed timeline of research activities in NEWREP-NP is presented in section 3.1.4.

- Sampling protocol for lethal aspects of the proposal

Annex 12 shows the details of the whale sampling design for sei whales. A research base vessel (*Nisshin Maru*) and two sampling and sighting vessels (*Yushin Maru No. 1* and *3*) will participate in the survey (see Annex 21 for details of the vessels). The track lines and the allocation of vessels will be set in a similar manner as in previous JARPNII surveys. A zig-zag-shaped track line will be set in the research area. The track line consists of one main and two parallel courses, established seven n. miles from the main course. In order to secure the sampling of the estimated number of samples, an Adaptive Type Survey (ATS) (e.g. Pollard *et al*., 2002) and a Special Survey

(SS) (Bando *et al*., 2016) may be conducted, when the whale density are expected to be high. ATS will be designed by adding tracks lines over the predetermined track lines. On the other hand, the SS will establish new track lines independently from the original track lines. The track lines of ATS and SS consist of one main and two parallel courses that will be established several n. miles apart from main course.

The sampling sighting vessels will survey the research area at a speed of 10.5 knots from one hour after sunrise to one hour before sunset, with three top men assigned to the barrel. All sei whales sighted as primary and secondary sightings, excluding cow and calf pairs, will be targeted for sampling. When a sighting consists of more than one animal, the first targeted animal will be selected using tables of random sampling numbers (TRS).

Each whale sampled will be transported to the research base and examined biologically by a team of scientists.

See Annex 12 for details of the sei whale sampling procedures. In particular Tables 1 and 2 of this annex shows the number of samples of sei whales by month, year and sub-area collected by JARPNII in the period 2002-2016 and the expected samples by NEWREP-NP in the period 2017-2022, respectively.

- Assessment of why non-lethal methods, methods associated with any ongoing commercial whaling, or analyses of past data have been considered to be insufficient

As in the case of the common minke whale under Primary Objective I, the research items requiring lethal sampling are age and sexual maturity determination associated with Secondary Objective II (ii).. Therefore the assessment of why non-lethal methods or analyses of past data have been considered to be insufficient is the same as in the case of the common minke whale above. As in the case of the common minke whale, several feasibility studies on new non-lethal techniques will be conducted for sei whale (Figure 2).

- Sampling protocol for established non-lethal techniques

Sighting surveys for abundance estimates, photo-id and biopsy of large whale species for studies on stock structure, distribution and movement, and oceanographic surveys will be also conducted under the Primary Objective II. Procedures are the same as in the case of the common minke whale described above.

3.2.2 Laboratory methods

Annexes 13-15 shows the laboratory and analytical procedures for Secondary Objectives II (i), (ii) and (iii), respectively. Below is a brief summary of the laboratory work for the most relevant research items. Secondary Objectives are referred to in parentheses.

- <u>Age and sexual maturity determination (II (ii))</u>

Laboratory procedures are the same as in the case of common minke whale (see Annex 14 for the application in the case of sei whale).

- <u>Satellite tracking and genetics (II (iii))</u>

Field and laboratory procedures are the same as in the case of common minke whale (see Annex 15 for the application in the case of the sei whale).

3.2.3 Analytical methods

Annexes 13-15 shows the laboratory and analytical procedures for Secondary Objectives II (i), (ii) and (iii), respectively. Below is a brief summary of the analytical procedures for the most relevant research items. Secondary Objectives are referred to in parentheses.

- Sample size estimation

Annex 16 provides the rationale and analyses for the selection of the sample size for sei whales. The analyses considered some of the recommendations from the NEWREP-NP review workshop as appropriate, and were also discussed at the 2017 IWC SC annual meeting.

Lethal samples are required to obtain age information. This allows for improved conditioning of RMP trials by providing estimates of population trajectories and their changing trends that are more closely representative of the population's behaviour than can be obtained using abundance estimates alone. The approach followed to estimate the sample size is based on the age-and sex-structured model applied to the single pelagic stock of sei whales for conditioning and generating future data in simulations. The target is to estimate the natural mortality rate, *M*, by using SCAA methodology.

In the population dynamics model the natural mortality is assumed to be age-independent at *M*=0.04 and 0.05 (/year), and the MSYR (1+) is set at 1 and 2.5%. These values are used not only for conditioning but also for generating future data in the simulation context to assess the estimation performance for the natural mortality rate.

Robust results across four scenarios considered are that for an annual sample size of 100 animals or above, bias reduces to close to zero, and RMSE stabilizes at about 0.005 (see details in Annex 16). The variance of the distribution of *M* estimates narrows considerably as the sample size is increased from 40 to 100. This value makes no allowance for possible over-dispersion in the age data. Consequently the assumption was made that this is the same as for common minke whale, corresponding to a need to increase the sample size by a multiplicative factor of 1.34 (Appendix D of Adjunct 3 of Annex 11).

Consequently the annual sample size for sei whale is 134.

- Abundance estimates (II (i))

As in the case of the common minke whale abundance estimates will be based on both design-based estimator and model-based estimator. Assuming that g(0)=1, design based abundance estimator (Thomas *et al*., 2010), which are the standard methodology of line transect surveys, will be applied. Covariates related to detectability of the whales are used to estimate detection function (e.g. Hakamada and Matsuoka, 2015; 2016). Estimation procedure will be conducted using DISTANCE program (Thomas *et al*., 2010). Model selection of the detection functions will be made using AIC. The estimated abundance for each year and each sub-area can be used as input for models to estimate additional variance. The approach in Kitakado *et al* (2012) will be used to estimate yearly variation in abundance levels due to inter-annual change in distribution of the sei whale population and abundance trend of the sei whales. By considering the inter-annual variance, underestimating the variance of the abundance estimate can be avoided. This work would respond to the recommendation made at the JARPNII review workshop (IWC, 2016c).

Regarding model-based estimator the DSM (Miller *et al*., 2013) will be used, which is one of the packages in the DISTANCE grogram (Thomas *et al*., 2010). But other options will be tried (e.g. smoother, modeling framework, variance estimation method etc.) to improve abundance estimates. For example, the approach presented by Murase *et al*. (2016a) will be used as a template of this type of analysis bearing in mind the comments from the JARPNII final review workshop (IWC, 2016c). SST, SSHa and Chl-a recorded by satellites, and a digital seafloor depth data were used as environmental covariates in the models. Data from ocean circulation models such as FRA-ROMS will also be used as covariates. It is also planned to compare abundance from model-based estimates with those from the design-based estimates. This work would respond to the recommendation made at the JARPNII review workshop (IWC, 2016c).

See details in Annex 13.

- SCAA (II (ii))

The analysis is similar to that described for common minke whale under Primary Objective I above (see Annex 14 for the application of SCAA to sei whale).

3.2.4 Time frame with intermediate targets

Figure 3 shows the time frame for the specific research under Primary Objective I and II, for both six-year and twelve-year periods. See section 5.1 for details.

3.2.5 Explanation that this objective can be achieved by the method proposed

Secondary Objective II (i): *Abundance estimates for North Pacific sei whales taking account of additional variance*

Systematic sighting surveys under the Line Transect Method is an accepted technique for abundance estimates of whales, and the IWC SC Requirements and guidelines for conducting surveys and analyzing data within the Revised Management Scheme (RMS) (IWC, 2012b) will be followed. The IWC SC has agreed that the pelagic region of the North Pacific contains a single stock (IWC, 2016b) so that the interpretation of sighting data in the context of abundance estimate should be straightforward.

Secondary Objective II (ii): *Estimation of biological and ecological parameters in North Pacific sei whales for RMP* Implementation

The proposed Statistical Catch-At-Age (SCAA) model is recognized as the 'best currently available model for examining stock dynamics for Antarctic minke whale' (IWC, 2015c). It can be used for sei whales in the North Pacific as well.

Secondary Objective II (iii): *Study of the pattern of movement of whales of the 'pelagic stock' within the feeding grounds and between feeding and breeding grounds*

The IWC SC agreed that a single stock occupies the pelagic region of the North Pacific. The proponents aim to address this objective using the satellite tracking approach. As whales will be sampled to obtain age information, genetic samples will be also examined to update some analyses following recommendations from the IWC SC. See Murase *et al*., (2016b) for an application of satellite tracking approach to North Pacific Bryde's whale.

Secondary Objective II (iv): *Specification of RMP ISTs for North Pacific sei whales*

This objective will be achieved once the three objectives above are achieved.

3.2.6 Data to be obtained

Table 2 shows the data to be obtained by NEWREP-NP relevant to both Primary Objectives.

3.2.7 Description of use of data from other projects or programs (Objectives in parenthesis)

- Sighting data (IWC-POWER program) (II (i))
- Earplug-based age data (National Research Institute of Far Seas Fisheries, Japan) (II (ii))
- Biopsy samples (IWC-POWER program) (II (iii))

3.3 Summary of the overall justification for final study area, sampling design and sample size

For the Primary Objective I the study area comprised by sub-area 11 is important for addressing the Secondary Objective I (i). Clearly there is a need to acquire new information on the distribution of the J stock and genetic and biological data allowing the estimates of J stock proportion trend in the future in this sub-area. Such information is potentially relevant for the RMP conditioning. This sub-area is also important for Secondary Objectives I (ii) and Ancillary Objective I. The sample size of 47 animals is considered preliminary and additional estimates of sample size will be carried out when data have been accumulated in this sub-area. Sampling design is considered appropriate as a strictly random design is not required to fulfill the research objectives. The use of several small catcher boats and ports, and the use of transport vessels and oceanic research base vessel, will increase the geographical coverage and ensure that the sample size is obtained.

The study area comprised by sub-areas 7-9 is important particularly for addressing Secondary Objectives I (iv). This area is an area for future coastal commercial operations and therefore the optimization of the RMP through the use of age data become very important. The number of samples (123) is considered moderate and is well supported by the quantitative analyses. The sampling design was established to obtain annual samples in both coastal and offshore areas.

The study area comprised by the pelagic region of the North Pacific is important for addressing all Secondary Objectives under Primary Objective II. This region is occupied by a single stock of sei whale and therefore the interpretation of abundance, biological parameters and stock structure should be straightforward. Sample size (134) is moderate and well supported by the statistical analyses. In this case random sampling will be carried out along a zig-zag-shaped track line, which is considered appropriate mainly for addressing Secondary Objective II (ii).

3.4 Possible modification of lethal sample size

The proponents will conduct non-lethal researches such as biopsy sampling and satellite tagging in order to examine their feasibility during the first six years of NEWREP-NP. The reconsideration of lethal sample size would be made at the time of the mid-term review based on the results of those non-lethal researches, if they are turned out feasible. While it is premature at this stage to elaborate a concrete and specific protocol of such reconsideration of lethal sample size, below are some of basic concepts that seem relevant at the mid-term review, when necessary.

- The criteria developed by Mogoe *et al* (2016) will be applied to evaluate the feasibility of the employed non-lethal techniques and verify whether the non-lethal method(s) could compliment lethal method so that lethal sample size could be reduced.
- Age data are the key information to judge whether a particular non-lethal techniques (for example, biopsy sampling for conducting DNA methylation analysis) can replace/reduce the sample sizes of lethal technique
- Sufficient analyses have been conducted regarding Q1 and Q2 of the Mogoe's criteria (efficiency of biopsy sampling). Further investigation on Q3 (quality of data) and Q4 (cost) may be conducted, if necessary.

3.5 Ancillary Objective I

The methodology associated with this objective is shown in Annex 17.

This Ancillary Objective requires information on stomach contents, blubber thickness, girth and body weight, oceanographic conditions, fisheries information. A feasibility study to investigate the lipid content % of blubber (blubber can be obtained by biopsy), will be carried out (Figure 2).

3.6 Ancillary Objective II

The methodology associated with the three research items identified under this ancillary objective is shown in Annex 18. Marine debris in the stomach of the whale samples, particularly plastic debris, will be investigated in the context of research item (iii).

This Ancillary Objective requires internal tissue (liver) samples, plasma, and age from earplug and racemization methods.

3.7 Ancillary Objective III

Studies on stock structure, distribution and movement of large baleen whales, with particular emphasis on blue and right whales, will be conducted through biopsy sampling and photo-identification. Annex 19 describes the biopsy sampling and photo-identification procedures. Laboratory and analytical procedure for the genetic work is similar to those used for minke and sei whales (see Annex 7).

4. ASSESSMENT OF POTENTIAL EFFECT OF CATCHES

4.1 Primary Objective I (common minke whale)

- Information on stock structure

Discussions on stock structure of western North Pacific common minke whale have taken place at the IWC SC since 1993, with the latest comprehensive discussions occurring during the RMP *Implementation Review* in 2013 (IWC, 2014a).

Three stock structure hypotheses were used in the *Implementation Review* (IWC, 2013b) (see Introduction for details of these hypotheses). The plausibility of the three stock structure hypotheses was discussed at the 2012 IWC SC Annual Meeting. A group of five geneticists summarized their interpretation of the relative support for and against the five hypothesized stocks involved in the different hypotheses (JE, JW, OE, OW and Y) (IWC, 2013b). Despite this effort by geneticists it was not possible for the IWC SC to agree on the plausibility of the three stock structure hypotheses. This was in part because the IWC SC has not been able to design a clear method to evaluate plausibility of stock structure hypotheses. As a consequence, the three stock structure hypotheses were ‘no agreement’ and the three hypotheses were therefore treated as if they had been assigned ‘Medium’ plausibility in the trials (IWC, 2013b).

The relevant questions for the aim of an evaluation on the effects on the stocks of the NEWREP-NP catches is whether or not there is additional structure within the J and O stocks around Japan. Regarding the J stock, the five geneticists concluded that the genetic evidences for a Je stock in the Pacific side of Japan was low and the evidence against were moderate or high. Regarding the O stock, they concluded that the evidence for an Ow stock in coastal areas in the Pacific side of Japan were moderate while the evidences against were low or moderate. As noted above, the IWC SC could not reach an agreement on plausibility of different hypotheses.

As explained in section 2.1, several new analyses on stock structure were presented to the JARPNII final review workshop (conducted after the 2013 *Implementation Review*), which were specifically focused to examine the plausibility of additional structure in the O stock. The summary of those studies is provided in Annex 4.

Most of the analyses presented to the JARPNII final review workshop responded to recommendations made during the 2009 JARPNII mid-term review. Results of all recent analyses indicate a single O stock distributed from the Japanese coast to approximately 170°E, and that the data do not support the occurrence of a coastal stock as proposed by hypothesis C (Ow).

Therefore the analyses conducted to evaluate the effect on the common minke whale stocks of future NEWREP-NP catches are based primarily on stock structure hypothesis A, which proposes two stocks around Japan, J and O, which mix to each other temporally and spatially, but hypothesis C is also considered

- The estimated abundance of the species/stocks, including methods used and an assessment of uncertainty, with a note as to whether the estimates have previously been considered by the SC

The relevant information to be considered includes primary effort, primary sighting position, survey blocks, sub-areas, and area definitions for surveys, and was provided in Appendices 3 and 4 of IWC (2014a). Abundance estimates based on this information was listed up in (IWC, 2014a), and was based on g(0)=1. Additional abundance estimates based on JARPNII surveys were added to the list (IWC, 2016g Annex D p12).

Okamura *et al*. (2009) estimated abundance considering g(0) estimate and they estimate g(0) for each platform and their combinations. The results were presented to the IWC SC in 2009. In the discussion, it was noted that although there had been no IO data collection in surveys in previous years, in the absence of direct estimates of g(0) , the estimates of g(0) presented in Okamura *et al*. (2009) could be used for the top barrel and the upper bridge for these earlier surveys.

Corrected abundance estimates based on g(0) estimated by Okamura *et al*. (2009) are used for an evaluation of the effects of the catches on the stock (s).

- Provision of the results of a simulation study on the effects of the permit takes on the stock that takes uncertainty into account

The analyses considered some of the recommendations from the NEWREP-NP review workshop, and were also discussed at the 2017 IWC SC annual meeting.

Three stock structure hypotheses were used in that *Implementation Review* (IWC, 2013b) (see the Introduction section of the proposal for more details of these hypotheses). In essence:

Hypothesis A	J and O stocks
Hypothesis B	Y, J and O stocks
Hypothesis C	Y, Jw, Je, Ow and Oe stocks

The baseline trials for those hypotheses developed in that *Implementation Review* have been used here to assess the effect of catches, except that:

a) Hypothesis B has not been considered, as the hypothesized Y stock to the west of Korea is not impacted by the catches under consideration.

b) Those trials (*ISTs*) considered the lowest plausible MSYR value to be MSYR(mat) = 1%. The Scientific Committee has subsequently agreed that this minimum be increased to MSYR(1+) = 1% [IWC, 2014b], so that the deterministic versions of the trials in question have been reconditioned with MSYR(1+) values of 1%, 2%, 3% and 4% (only the value of MSYR was changed in these reconditionings).

The constant future annual research catches considered when projecting under the proposed annual take of 170 minke whales is divided amongst sub areas as set out in Table 3, which corresponds to the temporal and spatial allocation proposed.

Table 3: Distribution of future J and O whale research catches amongst sub areas. Catches take place in the months of April-October

Sub area	7CS	7CN	7WR	7E	8	9	11
Annual catch	40	40	5	5	10	23	47

Projections under these catches for MSYR(1+) values of 1% and 2% are shown in Figure 4 for Hypothesis A for the J and O stocks, and in Figure 5 for Hypothesis C for the Jw, Je, Ow and Oe stocks. Note that these projections assume that current levels of bycatch continue unchanged. To ease understanding, projections are also shown for the case of these bycatches only, with no research catch[2].

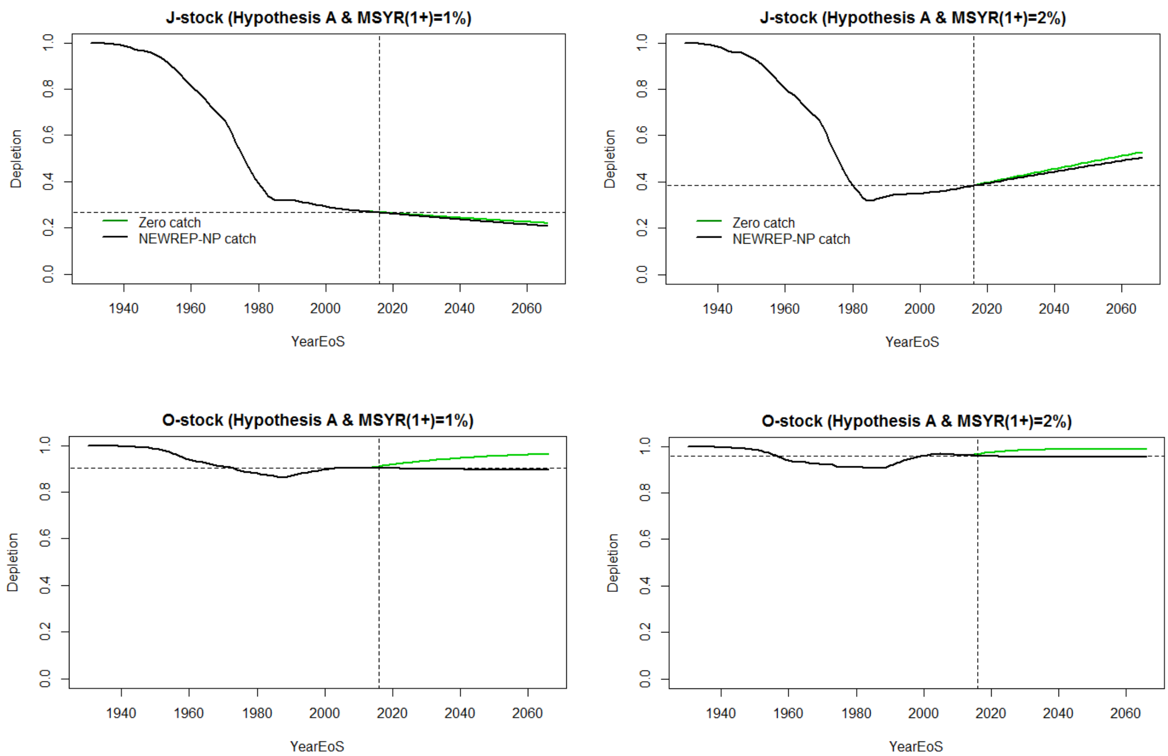


Figure 4. Projections under the proposed catches for MSYR(1+) values of 1% and 2% for Hypothesis A for the J and O stocks. Depletion refers to the mature female component. Note that the zero catch results refer to the situation of no commercial or research catch, but bycatch continuing as in the immediate past.

[2] The projections here have used the IWC code which allows only for a fixed catch each year following the last year of the assessment, i.e. projections here start in 2013. Thus the proposed scientific catches have been taken to apply starting in 2013, rather than in 2017. Strictly the actual catches made over 2013-2016 should be input, but the resultant differences to the projections will be very small and of no consequence to the key conclusions.

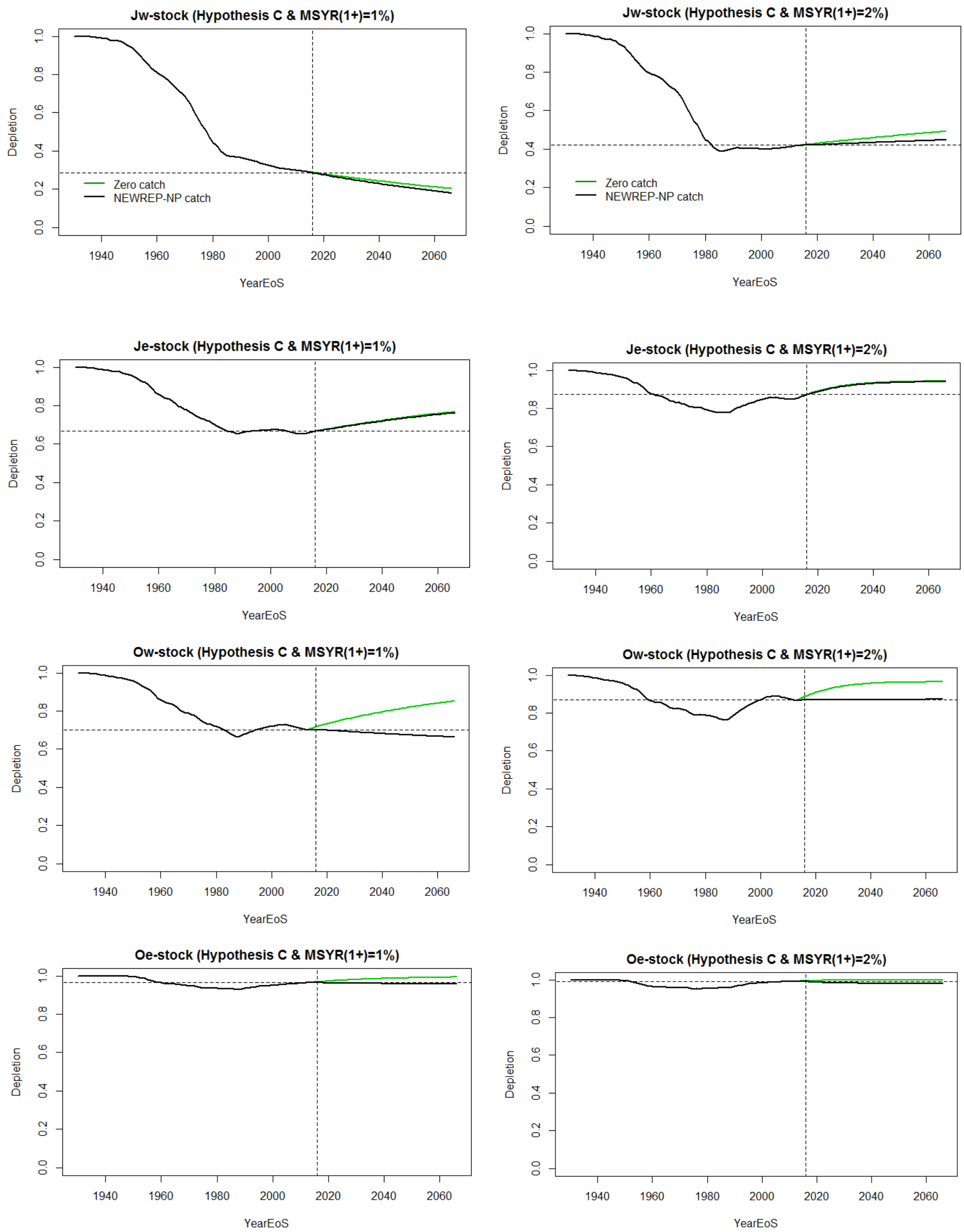


Figure 5. Projections under the proposed catches for MSYR(1+) values of 1% and 2% for Hypothesis C for the Jw, Je, Ow and Oe stocks. Depletion refers to the mature female component.
Note that the zero catch results refer to the situation of no commercial or research catch, but bycatch continuing as in the immediate past.

For MSYR(1+) = 2%, all stocks show increases and/or are well above 54% of their pre-exploitation levels under the research catches proposed, so there are no population conservation concerns.

For MSYR(1+) = 1%, under Hypothesis A the J stock is currently less than 54% of its pre-exploitation level and is projected to continue to decline, while under Hypothesis C the same applies for the Jw stock (though this is a consequence of the bycatches only, as no research take from sub areas where this stock is present is planned), and the Ow stock, currently at 70.2% of its pre-exploitation level, decreases slowly to reach 66.3% by 2066. However, while these instances might be considered by some to be population conservation concerns, the proponents consider that issue to be of no real concern, as recent information/analyses have shown the associated stock structure/MSYR combinations to be clearly implausible, for the reasons set out below.

In summary, the results provided therefore show that the research catches proposed will not adversely impact the stocks, so that no population conservation concern arises.

The assumption of an MSYR(1+) value for 1% for the J stock in Hypothesis A

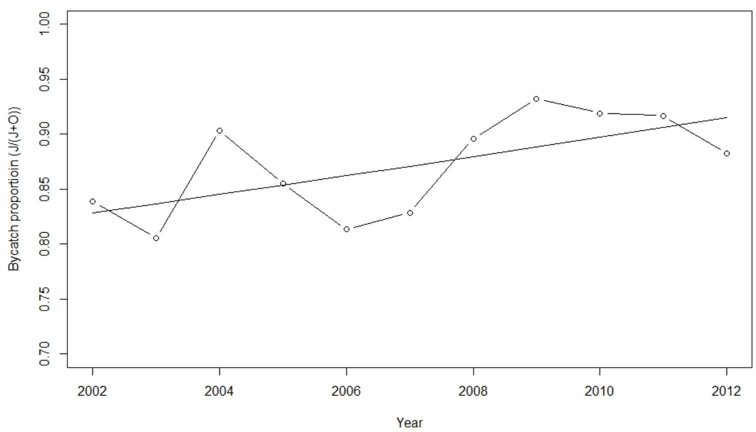
The conditioning of the North Pacific common minke whale *IST*s includes a component in the objective function which secures trends in whale abundance that are consistent with by-catch per unit effort in fixed set nets, including those off Japan (see equation F.6 in IWC 2014a).

However this conditioning does not take account of further information that is available on the J:O split of these bycatches which indicates an increasing proportion of J whales, contrary to what might be expected if the J stock was heavily depleted and continuing to decline under the current bycatches as indicated for MSYR(1+) = 1% in Figure 4 above. Figure 6 compares this historical observed trend with the annual values for the proportion of J whales in the J+O total for different values of MSYR(1+) as predicted, and is suggestive that this further J:O bycatch ratio information may be able to discriminate amongst different MSYR(1+) values. Note that the explanation for the recent increase in the J stock proportion in the overall population as MSYR increases is that the O stock is hardly depleted so that its numbers hardly change, whereas the J stock has been more substantially reduced in the past, and has recently been changing at a fairly large rate that increases with MSYR.

Figure 7 compares the estimate of annual trend provided by log-linear regression of the J proportion of the bycatch (with the associated 95% CI) with the point estimates of the trends from the Hypothesis A model abundances for different MSYR(1+) values. This suggests an MSYR(1+) value of 2.8% with a lower 95% confidence limit of 1.6%.

Deterministically such a log-linear relationship is the more justified for the J:O bycatch ratio compared to the J proportion, but precision decreases because of the greater variance in ratio data. Such an analysis does, however, suggest a larger value for the lower 95% confidence limit for MSYR(1+) of 2.8%.

These bycatch data are thus strongly suggestive of a MSYR(1+) value of 2% or more, for which the results discussed above indicate no conservation concern for the J stock under the research catches proposed.



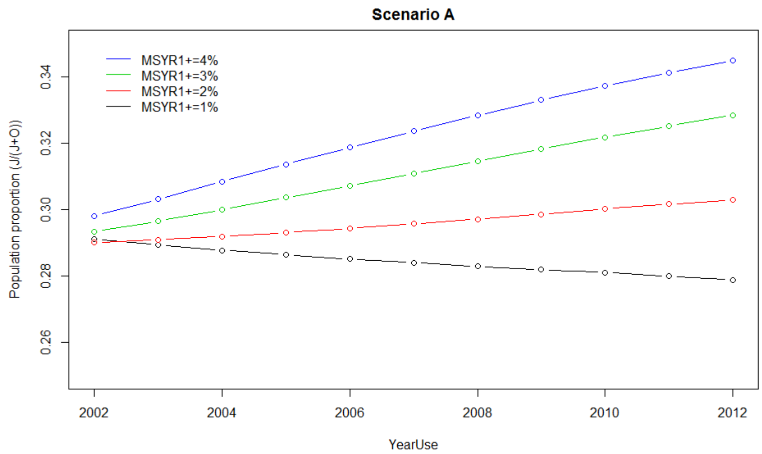


Figure 6. Comparison of historical observed trend in the proportion of bycatch of J whales in the J+O total with the trend in the proportion of J whales in the J+O total for different values of MSYR(1+) as predicted under Hypothesis A.

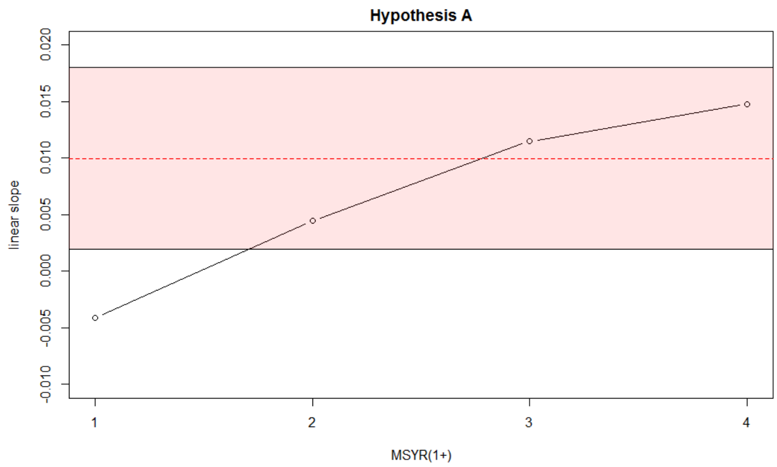


Figure 7. Comparison of the estimate of annual trend provided by log-linear regression of the observed bycatch (with the associated 95% CI) with the point estimates of the trends from the Hypothesis A model abundances for different MSYR(1+) values.

A more formal investigation is possible through noting that the bycatch model used for the *ISTs* (IWC 2014c) indicates that the expected value of the J stock bycatch proportion in each (pertinent) sub area for each year is equal to the corresponding proportion (appropriately averaged over months) of the number of whales in that sub area each year, specifically:

$$E[C_{B,t,m}^{k,s}] = A^k P_{t,m}^{k,s} E_t \ , \tag{1}$$

where $E[C_{B,t,m}^{k,s}]$ and $P_{t,m}^{k,s}$ are the expected bycatch and the number of whales in year *t* and month *m* for subarea *k* and stock *s* (J or O), respectively (these two quantities depends on the value of $MSYR_{1+}$); A^k is a sub-area effect; and E_t is an effort in year *t*.

Assuming catches are Poisson distributed, so that these J stock proportions are binomially distributed, leads to the following negative log likelihood as a function of the value of MSYR(1+):

$$NLL(MSYR_{1+}) \propto -\sum_{t,k}\left[C_{B,t}^{k,J} \log \phi_t^{k,J} + C_{B,t}^{k,O} \log \phi_t^{k,O})\right], \tag{2}$$

where

$$\phi_t^{k,s} = \frac{\sum_m E[C_{B,t,m}^{k,s}]}{\sum_s \sum_m E[C_{B,t,m}^{k,s}]} = \frac{\sum_m A^k P_{t,m}^{k,s} E_t}{\sum_s \sum_m A^k P_{t,m}^{k,s} E} = \frac{\sum_m P_{t,m}^{k,s}}{\sum_s \sum_m P_{t,m}^{k,s}} = \frac{P_t^{k,s}}{\sum_s P_t^{k,s}} \qquad (s = \text{J/O}) \qquad (3)$$

and

$$P_t^{k,s} = \sum_m P_{t,m}^{k,s} \quad (s = \text{J/O}) .$$

Since $P_{t,m}^{k,s}$ depends on the value of MSYR(1+), the loglikelihood is a function of that value as specifically shown in (2).

The associated computations indicate strong support for an MSYR(1+) value of 4% or more. However there are systematic deviations from model predicted proportions for some sub areas, which are such as preclude these results from being used to provide reliable confidence bounds. This indicates a need to refine the current bycatch model in the next *Implementation Review* for these minke whales. In the meantime, however, this result does provide qualitative support for the conclusion above based on a simpler approach regarding the value of MSYR(1+).

While in general terms there might be reservations about the assumption of CPUE being proportional to abundance, these concerns are greatly reduced here because the effort in question relates to set nets in fixed locations over time, and the analysis assumes only that the ratio of the stocks present in the bycatches is given by the ratio of the populations of those stocks present in the sub area concerned.

The assumption of separate Ow/Oe and Jw/Je stocks for Hypothesis C
Tables 4 and 5 (duplicated from Taguchi *et al*., 2017) show the number of close-kin pairs observed by sub area pairings for O and J whales. They also show which sub area pairings should and should not evidence pairings in terms of the Hypothesis C mixing matrices for the assumed Ow/Oe and Jw/Je stocks.

Table 4. The number of Parent-Offspring pairs of O stock whales within and between sub-areas (copied from Taguchi *et al*., 2017). The blue color indicates those sub-area pairings that are not consistent with the Hypothesis C mixing matrices for the assumed Ow/Oe stocks; the orange color indicates those sub-areas that are not inconsistent with this hypothesis.

O stock

	1E	2C	6E	7CN	7CS	7WR	7E	8	9	11
1E				1						
2C				1						
6E										
7CN				1	7	1		3	7	1
7CS					5	1		1	6	
7WR										
7E									2	
8									2	
9									1	
11										

Table 5. The number of Parent-Offspring pairs of J stock whales within and between sub-areas (copied from Taguchi *et al*., 2017). The blue color indicates those sub-area pairings that are not consistent with the Hypothesis C mixing matrices for the assumed Jw/Je stocks; the orange color indicates those sub-areas that are not inconsistent with this hypothesis.

J stock

	2	6	7CN	7CS
2				
6		4		2
7CN			1	
7CS				2

Table 4 indicates 18 examples of close-kin pairs that are inconsistent with the Hypothesis C split of O whales into Ow and Oe stocks. This constitutes compelling evidence that this split is NOT supported by the data.

Table 5 indicates 2 examples of close-kin pairs that are inconsistent with the Hypothesis C split of J whales into Jw and Je stocks. This is not quite as strong evidence as in the Ow-Oe case above, given the lesser number of close-kin pairs observed which are inconsistent with the Hypothesis C assumptions. Nevertheless this result, taken together with the view of geneticists that the genetic evidence for a Jw-Je differentiation is in any case very weak (IWC 2013b), is sufficient to conclude that this differentiation within J whales in Hypothesis C is not plausible.

In summary, taking account of the close-kin evidence now available, Hypothesis C may no longer be considered plausible.

4.2 Primary Objective II (sei whale)

- Information on stock structure

The most comprehensive studies conducted so far with regard to the stock structure of the North Pacific sei whales were those presented at the mid-term JARPNII Review workshop in 2009 (Kanda *et al.* 2009) as well as those presented at more recent IWC SC meetings (Kanda *et al.* 2013). These studies used microsatellite DNA loci and mtDNA markers to examine sei whales samples collected from almost the entire range of North Pacific.

Kanda *et al.* (2009) analyzed genetic variation at 17 microsatellite DNA loci and 487bp of mitochondrial DNA (mtDNA) control region sequences in the JARPNII samples (n=489) from 2002 to 2007 in the area between 143°E and 170°E as well as in the commercial whaling samples (n=301) from 1972 and 1973 conducted in the area between 165°E and 139°W. The results indicated no evidence of significant genetic differences within as well as between the JARPNII and commercial whaling samples. Both females and males showed the same pattern of the stock structure. Sequencing and phylogenetic analysis of the mtDNA control region also showed no evidence of the genetic heterogeneity in the JARPNII samples as well as no spatially or temporally unique phylogenetic clusters.

Kanda *et al.* (2013) examined genetic variations at 14 microsatellite DNA loci in the North Pacific sei whale using biopsy samples obtained from the IWC-POWER surveys that covered the 173°E - 172°W area of the central North Pacific in 2010 (n=13), 170°W - 150°W area of the central North Pacific in 2011 (n=29), and 150°W - 135°W area of the eastern North Pacific in 2012 (n=35), and these obtained data were analyzed with those in Kanda *et al.* (2009). This study allowed the authors to examine temporal (40 years apart between the POWER and commercial whaling data) and spatial (143°E to 135°W area divided into western, central and eastern) genetic differences of the North Pacific sei whales. Similar to Kanda *et al.* (2009), the results showed no evidence of the temporal genetic differences between the recent POWER and past commercial whaling samples collected from the same area and no evidence of the spatial genetic differences among the western, central and eastern samples.

One drawback to these two studies was that there was no direct comparison among samples collected at the same time of the year from the different areas over the North Pacific. Considering that sei whales conduct seasonal migration from their breeding ground to feeding ground every year, development of stock structure hypothesis should test the genetic differentiation in the samples collected in the same year that eliminate temporal negative biases. If no genetic difference is found, this would hardly suggest a strong possibility of multiple stocks in the area. Kanda *et al*. (2015a) looked at genetic variation at the microsatellite DNA loci to analyze the JARPNII and POWER samples collected from the same time of years in 2010, 2011 and 2012, respectively. Again the study failed to demonstrate evidence of multiple stocks of sei whales in the North Pacific.

The *in-depth assessment* of North Pacific sei whale started at the 2015 IWC SC meeting. The IWC SC agreed to proceed with two initial alternative stock structure hypotheses: i) a single stock in the entire North Pacific as proposed by Kanda *et al*. (2015a;b), based on several pieces of evidence including genetics; and ii) a five-stock hypothesis proposed in Mizroch *et al*. (2015), based mainly on the interpretation of mark-recapture data: Japan coastal; North Pacific pelagic; Aleutian Islands and Gulf of Alaska; eastern North Pacific migratory; and Southern North American coastal stock (coastal California) (IWC, 2015a). The IWC SC agreed that discriminating between these two hypotheses is difficult in the absence of genetic data from the potentially extirpated stocks, and thus both hypotheses are plausible (IWC, 2015a). The IWC SC agreed that the oceanic regions of the North Pacific are composed of a single stock (IWC, 2015a).

At the 2016 IWC SC meeting the Committee agreed that the genetic and mark-recapture data currently available are consistent with a single stock in the pelagic region of the North Pacific (IWC, 2016b). Therefore the analyses conducted to evaluate the effect on the sei whale stocks of future NEWREP-NP catches are based on the hypothesis of a single stock in the pelagic regions of the North Pacific to which the catches to be made will be restricted.

- The estimated abundance of the species/stocks, including methods used and an assessment of uncertainty, with a note as to whether the estimates have previously been considered by the SC

Hakamada and Matsuoka (2015) estimated abundance estimate based on IWC-POWER data from the 2010-2012 surveys using the design based estimator and detection function with covariates following the previous IWC SC recommendations. Considering the discussion at the IWC SC in 2015, Akaike-weighted average of the estimate of 29,632 (CV=0.242) was endorsed for use in the in-depth assessment of the sei whales (IWC, 2016d).

Hakamada and Matsuoka (2016) estimated abundance of 5,086 (CV=0.378) in sub-areas 7, 8 and 9 in late season based on the 2008 JARPNII sighting data using the design based estimator and detection functions considering some covariates of detectability. The estimates were presented at the final JARPNII review workshop and the review workshop recommended that exploration of methods to account for sampling differences between areas and years to obtain measures of short and long-term variation and trends and estimates the extent of additional variance due to changes over time in spatial distribution (IWC 2016c). The additional variance has not been estimated yet and this would cause some underestimation of variances of abundance estimates.

Since the areas covered by these two surveys do not overlap, the abundance estimates from each have been added. Hence computations have been conducted for a population estimate of 34,718 in 2010 and its lower 5%-ile of 24,530.

- Provision of the results of a simulation study on the effects of the permit takes on the stock that takes into account uncertainty

The analyses considered some of the recommendations from the NEWREP-NP review workshop, which were discussed at the 2017 IWC SC annual meeting.

Figures 8 and 9 shows projections of the cases considered for the NP sei whales. The calculation was conducted based on conditioned age-/sex-structured models (see Annexes 14 and 16). Regardless of parameters assumed, there is no serious difference in the median trajectory between the two catch scenarios (0 and 134 per year) over the 12 year research period, and therefore it is evident that the impact of an annual catch of 134 whales is negligible.

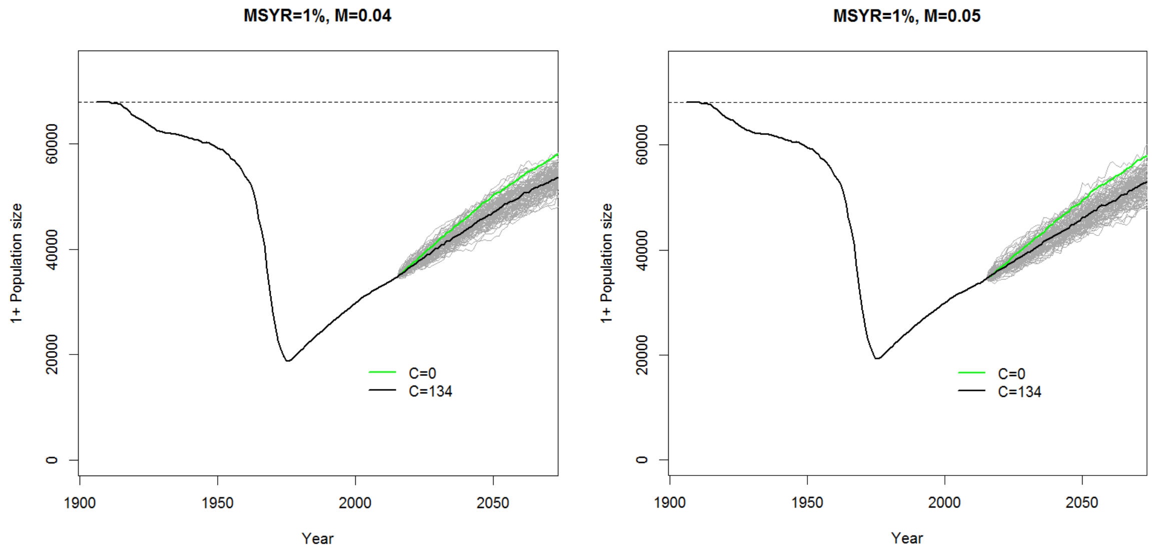


Figure 8. Population trajectory for the sei whales for 50 years under MSYR(1+)=1%. The black line shows the median trajectory with the proposed catch of 100 replicates (gray lines). The green line is the median for no catch. The horizontal dashed line shows the carrying capacity for the 1+ population.

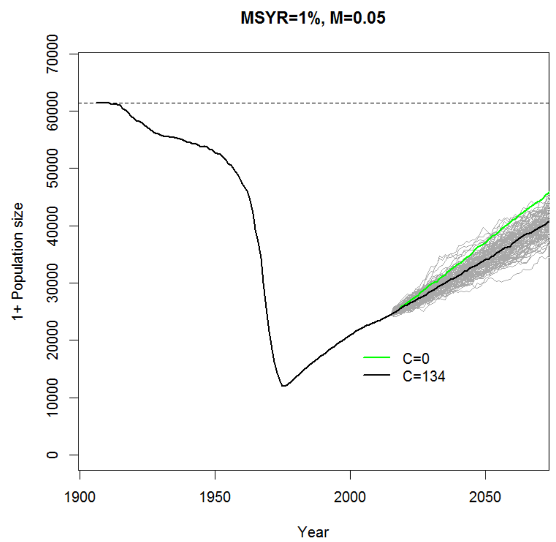


Figure 9. Precautionary evaluation of population trajectory for the sei whales by hitting the lower 5%-tile of abundance estimate in 2010.

5. LOGISTICS AND PROJECT MANAGEMENT

5.1 Description of intermediate targets to allow for adequate review of progress relative to objectives

Figure 3 shows the kind of research activities and associated timelines under the NEWREP-NP's Primary Objectives I and II. As a general rule, progress in the works of NEWREP-NP under each Secondary and Ancillary Objective will be presented to annual meetings of the IWC SC. This applies to both the collection of samples and analysis of data using routine techniques (related to the research objectives of the program) as well the works on feasibility studies related to new non-lethal techniques.

The proponents will provide additional information on sample and data archiving, and construct relational database. As explained below they will construct a list of sample/data after each field survey, by research topic or objective. By the mid-term review they will construct relational databases for specific research topics related to objectives.

In general the work to assess the feasibility of new non-lethal techniques will be conducted during the first two years (2017-18). The exception is the assessment of DNA-M for North Pacific baleen whales, which will be made once the feasibility study on Antarctic minke whale is completed (after 2018). A final assessment of the feasibility of non-lethal techniques will be carried out during the mid-term review after the first six years, including an evaluation of possible modification of sample size of the lethal component of the program, on a whole-program basis. The results of the feasibility study on age determination based on DNA-M will be relevant here.

The collection of routine data will be conducted during the first six years, and analyses will be carried out in some cases integrating the new data with those obtained in JARPN and JARPNII. Results for each Secondary Objective will be presented and evaluated during the mid-term review, and the scientific review will assist the direction of the analyses in the second period of the NEWREP-NP. Some of the research items requires the attainment of data during the very first years and analyses will start subsequently (e.g. additional variance).

Details of the analyses to be conducted under each objective are provide in the annexes.

5.2 Description of overall project management including personnel and logistic resources

As for the whole program management, the Fisheries Agency of Japan (FAJ) will assume responsibility, including provision of the necessary funding. Regarding personnel resources to be engaged in the program, scientists from the ICR will play the leading role in order to pursue the research activities and achieve the research objectives of NEWREP-NP in collaboration with scientists from other domestic and/or foreign organizations (see Annex 20).

The proponents recognize the need for the recruitment of sufficient highly trained and qualified analyst/modellers to improve study design, data analysis and review. The proponents will continue to look for suitable analyst/modellers during the research period.

Below is a brief summary of ICR's laboratories and personnel engaged in the implementation of the NEWREP-NP (objectives are indicated in parenthesis):

Reproductive data and biological parameters (I (i), I (iv), II (ii)): Whale Biology Laboratory of ICR, Tokyo. Two experienced scientists.

Whale abundance estimates (I (ii), II (i)): two experienced scientists and one doctoral student.

Feeding ecology of whales (Ancillary Objective I): Feeding Ecology Laboratory of ICR, Tokyo. Three experienced scientists.

Genetics (I (i), I (iii), II (iii)): Genetic Laboratory of ICR. Three experienced scientists and two technicians.

Pollutant monitoring and whale health (Ancillary Objective II): Environmental Chemical Laboratory of ICR, Tokyo. One experienced scientist and one just-graduated scientist.

A number of researchers from ICR will be dedicated exclusively to field activities under the NEWREP-NP (4), supported by a number of part-time university students (2-3).

Research collaboration
Some of the data will be obtained by external laboratories and some of the analyses will be carried out in collaboration with external scientists (see details in Annex 20). A number of research topics under NEWREP-NP will be treated in undergraduate and post-graduate university theses.

Research vessels
A number of research vessels will be available to ICR for carrying out the field work (lethal and non-lethal components of the NEWREP-NP). Pictures and details of the vessels are available in Annex 21.

Report to the IWC SC
The proponents intends to provide relevant information concerning program management to the IWC SC every year in an annual progress report for the SC's comments and suggestions to facilitate steady progress of the program in an open and transparent manner. This information will include progress achieved for each Secondary Objective as noted in section 2.1 above, the involvement of external scientists/organizations and their roles, as well as updates on financial and logistic resources. This annual update and comment process through the IWC SC

is expected to improve the management of the program throughout its duration.

5.3 Backup plan for contingencies

As research activities could be disrupted by natural factors such as an unusual distribution of whales and bad weather, this proposed research plan establishes a contingency backup plan in order to respond to the contingency and secure the scientific value of data to be collected by this research for the purpose of achieving the stated scientific objectives.

The backup plan would address three aspects; (i) adjustments of research protocols at the scene of disruption, (ii) adjustment of research plans including research period, sample size, and research areas after the year of disruption, and (iii) consideration of analysis methods to compensate the effects of disruptions. Possible issues arising from a disrupted research plan could include reduced sample size, unsurveyed research areas, sampling bias and missed research periods. They might cause reduced accuracies, reduced randomness, and increased biases.

(i) Adjustments of research protocols at the scene and in the year of disruption

With regard to the variation in whale distribution, from the results of the dedicated sighting surveys under previous sighting surveys, it was revealed that distribution of baleen whales in the survey area is narrower in the north and south due to the influence of the distribution of prey species which was affected by the water temperature. It is difficult to predict those distributions in advance because they change every year and season with the temporal changes in oceanographic structures.

At the planning stage, the tracklines for the whale sampling surveys are designed to cover wide range of survey area. However, when actual surveys are conducted, some tracklines could be cancelled and/or new tracklines would be designated in order to respond to the actual distribution of the whales that might be predicted by the oceanographic structures at that time.

In addition, some parts of the survey area could be affected by the path of typhoons and other bad weather. Fog is often dominant in the northern cold waters. Therefore, tracklines would be sometimes forced to be amended to avoid these bad areas affected by such temporal weather conditions.

It should be noted that reaction to those disruptions, such as the suspension of field research due to bad weather, inevitably requires a case-by-case decision making. For example, in the North Pacific Ocean, typhoons frequently pass through the survey area, but how to adjust field surveys depends on, inter alia, the predicted route and magnitude of respective typhoon.

In case of a disruption, the head of the research (e.g. the cruise leader) will decide whether the research activities should be continued or relocated to other research areas. These adjustments including resumption of the research in other areas and periods than originally planned will be fully recorded and made available for the analysis required in establishing adjusted research plans and in conducting scientific considerations for compensating the effects of the disruption.

(ii) Adjustment of research plans including research period, sample size, and research areas after the year of disruption

When the number of samples does not reach a target sample size, the reduced number could be carried over to the latter years of the research plan and/or the whole research period could be extended when scientific justification based on the careful analyses of the data collected is established in consultation with the IWC SC. When this happens, effects on the sampled stock(s) will be reassessed.

Missed research periods and unsurveyed areas might also require adjustment proposed research plans. Scientific justification for the need of adjustment research plans regarding period and areas will be provided along with pertinent data and its analysis to the IWC SC. Such an adjustment research plan will be established immediately after the completion of the research of the year of disruption.

A summary information on the progress of the research, on an annual basis, in terms of samples obtained and areas and periods covered will be made public. This summary provides transparency in the implementation of the proposed research and background for adjustment research plans if they become necessary.

(iii) Consideration of analysis methods to compensate the effects of disruptions

Effects of disruptions will be analyzed in terms of reliability of scientific data obtained. This would allow the consideration of analysis methods to compensate the effects of disruptions. One of the potential problems likely caused by the disruptions is spatially and temporally imbalanced sampling outcome. Like in the case of discussion in the abundance estimation, lack of design-unbiasedness may be overcome by introducing the model-based estimation approaches, where finding better spatial and environmental covariates is a crucial part for its success.

It is also important for the analysis that the adjustments described above in (i) and (ii) are well-planned and executed. However, as the effects of the disruptions could vary substantially, a case-by-case approach might be unavoidable. A high level of transparency will be necessary for the analytical methods employed to address the effects of the disruptions.

6. CO-OPERATIVE RESEARCH

6.1 Assessment of the degree to which the programme will coordinate its activities with related research projects

This proposed research program is primarily intended to contribute to the improvement of conservation and management of whale resources in the western North Pacific in accordance with the ICRW as shown in its research objectives. It follows that its scientific output will be produced first and primarily for the review and discussion in the IWC SC. At the same time, in line with an observation by the ICJ, there will be increased efforts to publish its scientific achievements in peer-reviewed journals outside the IWC.

Participation of foreign scientists in the field surveys will be welcomed, so long as they meet the following qualifications established by the Government of Japan: i) costs for participation, travel expenses to and from the home ports, subsistence on board the research vessels and any other ancillary cost, will be covered by the participant; ii) indemnification and insurance for any casualty or personal injury while on board the research vessels, will be covered by the participant; iii) participation of those who are found to have intentionally sabotaged the implementation of the research in the field shall be terminated.

Research collaboration will be sought with relevant scientists and research institutions (national and international), in consideration of the objectives of the proposed research. In the case of Primary Objectives I and II, and its Secondary Objectives, collaboration will be made, among others, with scientists of the IWC SC, which have been heavily involved with RMP research in the past, and with scientists from national research institutions such as the Tokyo University of Marine Science and Technology, National Research Institute of Far Seas Fisheries, National Research Institute of Fisheries Science among others. The ICR will coordinate the research activities with other institutions. Annex 20 provides a list of collaborating research institutions, and of research institutions/projects from where relevant data will be obtained, by NEWREP-NP objectives.

As in the case of JARPN and JARPNII, data obtained by this new proposed research program will be shared with members of the IWC SC in accordance with the IWC SC Data Availability Agreement (DAA) (IWC, 2004). Data and samples from the research will be available for other accredited scientists and research organizations in accordance with the protocol for access to samples/data from the ICR (http://www.icrwhale.org/pdf/appendix2.pdf) (see also Annex 22).

To facilitate the collaboration and analyses, databases will be created after each survey under this program conducted by the ICR, which will specify the kind of samples and data collected during its research activities. Databases which include data from laboratory work will be created in time for the mid-term review of the research program in line with the Annex P (IWC, 2013a). According to the Annex P the proponent of the research program should submit a preliminary data description document that explains the data two months before the Annual IWC SC meeting prior to the specialist workshop that will review the proposed program. It also specifies that the final data description document and the data themselves will be made available in electronic format one month after the close of the Annual IWC SC Meeting. The mid-term review is expected after the completion of the first six-year period of the proposed research plan.

In addition, efforts will be made to respond the NEWREP-A Review Panel’s specific recommendations regarding research collaboration, which are also relevant here: (1) *ad hoc* collaborations on specific issues; (2) the development of a formal protocol for outside scientists to express interest; and (3) the development of a strategy to promote incorporation of external Japanese and/or foreign scientists into the research (IWC, 2016h). Regarding the recommendation (1), NEWREP-NP will continue contacting potential partners, and co-operative research will be identified and arranged for specific items in due course, preferably before research activities on such items start. As for the recommendation (2), NEWREP-NP will develop and post such a protocol on the website of the ICR (both in Japanese and English) well in advance of the first research cruise under NEWREP-NP (the same as was the case for NEWREP-A) (and see section 6.2). With respect to recommendation (3), NEWREP-NP will: i) continue contacting specific potential collaborators directly; and ii) invite co-operative research widely through the internet (e.g. ICR's website) and at related meetings (including those of the IWC SC) indicating specific research items for collaboration. An 'annual progress report' to the IWC SC, will also help to promote research collaboration with external scientists/organizations by including descriptions of the involvement of external scientists/organizations and specification of their roles in the research (the same as in the case of NEWREP-A).

6.2 A note on the provisions for co-operative research (field studies; analytical studies)

Protocols for collaboration in field and analytical studies are shown in Annex 22, and are also available at the ICR Home Page (both in English and Japanese).

7. CONCLUSIONS

Primary, Secondary and Ancillary research objectives are clearly defined in this research plan for NEWREP-NP. These objectives address topics important for conservation and management of sei and common minke whales in the western North Pacific. The research under NEWREP-NP involves the use of both lethal and non-lethal techniques. At this stage, lethal techniques are the only available techniques to obtain information on the age, reproductive status, prey composition and consumption, and indices of nutritional conditions of the animals, which are important information for addressing the objectives of NEWREP-NP. Some potential new non-lethal techniques will be evaluated in NEWREP-NP through feasibility studies. Sample sizes are based on sound statistical analyses, the levels are moderated and the statistical evaluation by the proponents indicates no negative effect of the NEWREP-NP catches on the stock (s). This research proposal for NEWREP-NP established a time period for the research, and timelines for addressing each Primary, Secondary and Ancillary objectives. Finally this research plan for NEWREP-NP establishes provisions and protocols to facilitate research collaboration.

In summary all the items in the guidelines of Annex P were considered in the development of this research plan for NEWREP-NP.

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Annex 1

NEWREP-NP and consideration of the reasoning and conclusions in the Judgment of the International Court of Justice (ICJ) on 31 March 2014

1 The procedure for drafting and development of NEWREP-NP and consideration of the reasoning and conclusions in the Judgment of the ICJ

Annex P provides the detailed procedure under which the review of the special permit program at the Scientific Committee pursuant to Paragraph 30 of the Schedule is to be conducted and the items for review which should be included in the proposal for new permit. NEWREP-NP is developed to address these items for review provided in Annex P.

At the same time, Japan developed this plan for NEWREP-NP with full consideration of the guidance on the issuance of future special permits, provided by the ICJ Judgment on 31 March 2014 in the case *Whaling in the Antarctic (Australia* v. *Japan: New Zealand intervening)* (for the Judgment, dissenting opinions, separate opinions and declarations, see http://www.icj-cij.org/docket/files/148/18136.pdf). Although the subject-matter of the said case did not concern Japan's scientific whale research program in the western North Pacific, the Judgment in its reasoning part, stated that "[i]t is to be expected that Japan will take account of the reasoning and conclusions contained in this Judgment as it evaluates the possibility of granting any future permits under Article VIII, paragraph 1, of the Convention" (paragraph 246). The Court also stated that it will look to the authorizing State to explain the objective basis of its determination to grant special permits (paragraph 68). Hence, in this research plan, Japan explains the objective basis for its determination to grant special permits.

The details of Japan's analysis of the salient parts of what was stated in the Judgment were provided in the "Research Plan for New Scientific Whale Research Program in the Antarctic Ocean (NEWREP-A)"[3] which was reviewed by the Scientific Committee in 2015 and hence will not be repeated in this proposed plan.

Japan has in particular taken seriously the Court's finding that the decision to grant special permits under Article VIII, paragraph 1, of the ICRW, "cannot depend simply on that State's perception" (paragraph 61). Japan always welcomes comments from outside that are based upon scientific consideration to which it will give due regard even after the research plan is finalized. The process for development of the original proposal of the research plan is outlined in Appendix.

The question "whether the programme under which these activities occur involves scientific research" (the first limb of the standard of review set forth by the Court, paragraph 67) is examined in more detail in relevant parts in Sections 2, 3, 5 and 6 of this proposed plan respectively.

The following part explains "whether, in the use of lethal methods, the programme's design and implementation are reasonable in relation to achieving its stated objectives" (the second limb of the standard of review, paragraph 67), through the examination of each of the seven elements identified by the Court.

2 Reasonableness of the program's design and implementation in relation to achieving its stated objectives

<u>Element 1: "decisions regarding the use of lethal methods"</u>

- Japan continues to uphold its scientific policy with regard to whales that it does not use lethal means more than it considers necessary to achieve the research objectives. In this respect, the proponents are of the view that the feasibility and practicability of non-lethal methods need to be evaluated in a systematic manner. In assessing the feasibility and practicability of any non-lethal method, the proponents will consider the following four questions: (1) whether a tissue and other samples can be obtained by a non-lethal method; (2) whether enough samples for statistical analysis can be obtained by the non-lethal method; (3) whether the sample obtained by the non-lethal method can produce scientific information compared to that produced by a lethal sampling method; and (4) whether the cost for obtaining the sample/producing scientific information is reasonable. Questions 1 and 2 above are technical, Question 3 is analytical, and Question 4 is a logistical evaluation. It should be noted that, in order to conclude that a particular non-lethal method is feasible and practicable to the extent that it can practically replace a lethal sampling method, all of the four tests need to be satisfied. In developing this research plan, the

[3] Available at http://www.jfa.maff.go.jp/j/whale/pdf/151127newrep-a.pdf.

feasibility of non-lethal methods as an alternative to or a means of reducing the planned scale of lethal sampling was carefully reviewed (see Section 3).

- With regard to Primary Objective I (common minke whale), it has been concluded in this plan that there are no non-lethal methods available for obtaining age-data, sexual maturity, and body length, all of which are required for achieving Objective I (i) and Objective I (iv) (see Section 3.1.1). These mean that the answer to the question (3) above "whether the sample obtained by the non-lethal method can produce scientific information compared to that produced by a lethal sampling method" is "No". Furthermore, Yasunaga *et al*. (2017) reports the difficulty of obtaining biopsy samples from common minke whales. In other words, the answer to the question (2) "whether enough samples for statistical analysis can be obtained by the non-lethal method" "No". Since it means that not all four criteria mentioned above can be satisfied at once, the proponents concluded that no non-lethal method is feasible and practicable in terms of achieving Primary Objective I.
- Likewise, with regard to Primary Objective II (sei whale), it has been concluded in this plan that there are no non-lethal methods available for obtaining age-data, sexual maturity, and body length, all of which are required for achieving Objective II (ii) (see Section 3.2.1). These mean that the answer to the question (3) above "whether the sample obtained by the non-lethal method can produce scientific information compared to that produced by a lethal sampling method" is "No". Since it means that not all four criteria mentioned above can be satisfied at once, the proponents concluded that no non-lethal method is feasible and practicable in terms of achieving Primary Objective II.
- Furthermore, the proponents will also conduct further study on the feasibility and practicability of a variety of non-lethal methods including satellite tagging, biopsy sampling and their associated analytical methodologies (see Figure 2 in section 3.1.1). A final assessment of the feasibility of non-lethal techniques will be carried out during the mid-term review after the first six years, including an evaluation of possible modification of sample size of the lethal component of the program, on a whole-program basis. Specifically, this proposed plan includes the following feasibility study of the non-lethal methods:

  - Investigating the feasibility of age-determining methods other than earplug reading (*i.e.* DNA methylation analysis);

  - Conducting satellite tagging on common minke whales and sei whales to elucidate movement within the feeding grounds and the location of their breeding grounds, in preparation for the collection of genetic samples from the breeding grounds;

<u>Elements 2 and 3: "the scale of the programme's use of lethal sampling" and "the methodology used to select sample sizes"</u>

- Element 2, namely, "the scale of the programme's use of lethal sampling" and Element 3, namely, "the methodology used to select sample sizes" are both related to the selection of sample sizes.
- As noted above, there are several data that are indispensable for this research plan to achieve its stated objectives, such as age data and sexual maturity that require lethal sampling.
- With regard to common minke whales, Secondary Objectives I (i) and I (iv) are the most relevant as the scientific grounds for the sample size calculation are the requirement for age data, which can be obtained with the necessary accuracy only through lethal sampling methods, as key information (see Section 3.1.3)
  - Sample size of common minke whale in sub-area 11 (Secondary Objective I (i)): it is known that segregation by sex, age and reproductive status occur during migration of common minke whale along the Japanese coast (Hatanaka and Miyashita, 1997). For that reason, information on genetics alone is not sufficient and simultaneous collection of both genetics and biological information including age data is essential in order to evaluate the spatial and temporal migration pattern of common minke whales, and to estimate pattern of stocks mixing by age and sexual classes in sub-area 11. It was calculated that 47 animals are required to estimate the mixing proportion of the J stock in this sub-area with sufficient precision (e.g. SE (p) less than 0.1, see Annex 11 for details), which, combined with the biological data collected simultaneously, will be essential for achieving the objective here, and both genetic and biological information gained from these animals will be used in the conditioning of RMP*ISTs*. It should be noted that this estimate only applies for the first six years of NEWREP-NP. More detailed estimates of samples size for the objective of studying the temporal trend of the J stock mixing proportion will be made once data have been accumulated in the first six surveys.
  - Sample size of common minke whale in sub-areas 7-9 (Secondary Objective I (iv)): lethal samples are required to obtain age information. This allows for improved conditioning of RMP trials by providing estimates of population trajectories and their changing trends that are more

closely representative of the population's behavior than can be obtained using abundance estimates alone. The extent of improvement increases with increasing sample size, which provides part of the basis to make the sample size choice. On the other hand, there should be other considerations such as the need to restrain the lethal sample size to not more than necessary to achieve the proposed research objective, the sufficient quantity of data to be able to detect important changes to recruitment rates under different scenarios, the possible effect of the catches on the stock, and the feasibility of research implementation. Taking account of these factors, the proponents concluded that the sample size of 123 per annum is the optimal size for this research plan.

- With regard to sei whales, Secondary Objectives II (ii) is the most relevant as the scientific grounds for the sample size calculation are the requirement for age data, which can be obtained only through lethal sampling methods; these data constitute the key information for this objective (see Section 3.2.3).
    - Age data allows for improved conditioning of RMP trials by providing estimates of population trajectories and their changing trends that are more closely representative of the population's behavior than can be obtained using abundance estimates alone. The target is to estimate the natural mortality rate by using SCAA methodology. In the population dynamics model the natural mortality is assumed to be age-independent at M=0.04 and 0.05 (/year), and the MSYR (1+) is set at 1 and 2.5%. These values are used not only for conditioning but also for generating future data in the simulation context to assess the estimation performance for the natural mortality rate. Robust results across four scenarios considered are that for an annual sample size of 100 animals or above, bias reduces to close to zero, and RMSE stabilizes at about 0.005 (Annex 16). Allowing for possible over-dispersion in the age data, the annual sample size for sei whale is 134.

<u>Element 4: “a comparison of the target sample sizes and the actual take”</u>

- As research activities could be disrupted by natural factor such as bad weather and other obstructions, this research plan establishes a contingency backup plan in order to secure the scientific value of data for the purpose of achieving the established scientific objectives (see Section 5.3).

<u>Element 5: “the time frame associated with a programme”</u>

- This research plan has set its research period as 12 years. It has also established “intermediary targets”, as suggested by the Judgment, specifying concrete target outputs of the first 6 years, together with a system of mid-term review. These time frames are determined in view of the prospects for scientific achievements and practical factors including the natural environment in the western North Pacific, required time for verifications and analyses of collected data and information, the capacity of the research and financial constraints (See Sections 3.1.1, 3.2.1 and 5.1).

<u>Element 6: “the programme’s scientific output”</u>

- This research plan is primarily intended to contribute to the improvement of conservation and management of whale resources in the western North Pacific in accordance with the ICRW as shown in its research objectives. It follows that its scientific output will be produced first and primarily for the review and discussion in the IWC SC. At the same time, in line with an observation by the Court, there will be increased efforts to publish its scientific achievements in peer-reviewed journals outside the IWC.
- It should also be noted that scientific data generated from this research will be made available to other scientists both inside and outside the IWC SC in accordance with the IWC Data Availability Agreement (IWC, 2004) and the Institute of Cetacean Research (ICR)’s protocol for access to samples/data. Data availability arrangements are also specified in this plan (see Sections 6.1 and 6.2) in order to ensure that the research results will be utilized broadly by scientists worldwide.

<u>Element 7: “the degree to which a programme co-ordinates its activities with related research projects”</u>

- Scientists of the ICR, which is expected to conduct the research program under this plan, have already started to strengthen existing collaboration with relevant research institutions that have direct interest in the western North Pacific marine ecosystem such as the Tokyo University of Marine Science and Technology, Japan’s National Research Institute of Far Seas Fisheries, National Research Institute of Fisheries Science among others. Scientific outputs of this research plan will be shared with those research institutions and joint research will be proposed to relevant research institutions. Section 6 will deal with specific discussions on this element (see also Annexes 20 and 22).

As the ICJ found that "Japan has complied with its obligations under paragraph 30 of the Schedule" to the ICRW (paragraph 247(6)), it will continue to abide by this provision. This plan specifies, as required, (a) objectives of the research (see Section 2), (b) number of the whales to be taken (see Section 3), (c) opportunities for participation in the research by scientists of other nations (see Section 6) and (d) possible effect on conservation of stock (see Section 4). The plan was completed after the process of "review and comment" by the Scientific Committee, and comments were given due regard.

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Appendix

1. The Transparency of the whole process

As in the case of NEWREP-A, Japan decided to have the draft of NEWREP-NP reviewed by external scientists with a wide range of expertise to get comments and suggestions before it is submitted to the IWC Scientific Committee (i.e. in addition to the official review process in accordance with the “Annex P”). This is a “voluntary” review process open to external experts to obtain valuable inputs, including constructive criticisms, for improving the draft research plan through e-mail correspondence from middle September to early October.

2. Chronology of the actual process for development of this proposed research plan

On September 16, 2016, approximately 150 external experts in the following categories were invited to participate in Japan’s “voluntary” review process of the new research plan, by an e-mail sent from Japanese scientists participating in the IWC Scientific Committee:

- ✓ Members of the IWC Scientific Committee (Participants in the 2016 meeting of the Committee and other regular participants in the past);
- ✓ External expert panel members for the past special permit research reviews held by the IWC Scientific Committee;
- ✓ Experts who provided witness testimony to the ICJ in the case concerning *Whaling in the Antarctic*;
- ✓ Chairs of scientific subsidiary bodies (and panel members) of RFMOs which covers the waters adjacent to the western North Pacific (i.e. WCPFC, IATTC, NPFC and NPAFC);
- ✓ Director and ex-Directors of Fisheries Resources Management and Research Division, Food and Agriculture Organization of the United Nations (FAO); and
- ✓ Other experts who have good insights into the biology of marine mammals, the Pacific marine ecosystem and the conservation or sustainable use of marine living resources.

Seven (7) external experts from four (4) countries other than Japan had confirmed their interests in reviewing the draft of the proposed research plan.

On September 23, 2016, the draft of the new research plan was sent by e-mail to the seven (7) external experts who had confirmed his/her interests in the new research plan by that time. The draft was also sent to the other expert. By October 7, two (2) experts sent their comments on the draft. The received comments were considered by the proponents and taken into account as much as possible in developing the final draft of the research plan that was submitted to the IWC SC on November 8, 2016. Japan had this proposed research plan circulated by the IWC Secretariat to all Contracting Governments to the ICRW, for their review and comments in order to improve the substance of the proposed plan.

More open opportunities for discussing the plan were secured during the official review process at the IWC Scientific Committee after the proposed research plan was submitted in accordance with the “Annex P.” The Expert Panel workshop to review the proposed plan was held in Tokyo from January 30 to February 3 2017. The report of the Expert Panel was published on April 3, 2017 together with the proponents’ preliminary response to the report. The findings and recommendations made by the Panel were duly considered and the proponents submitted the revised proposed plan and results of the additional analyses for further discussions and comments at the IWC SC annual meeting in May 9-21, 2017.

The final research plan for NEWREP-NP was prepared giving due regard to comments from the IWC SC annual meeting in 2017.

Annex 2

CPUE data and trend for O stock of western North Pacific common minke whales

This annex provides some information on the analyses on stock assessment based on CPUE, conducted for coastal minke whaling before the moratorium on commercial whaling.

CPUE series

There were two CPUE series used for the assessment of O stock of western North Pacific common minke whales conducted in 1985 (IWC, 1986). $CPUE_1$ and $CPUE_2$ were used in CPUE analyses conducted by Japanese scientists (Ohsumi 1977; 1980; 1981; 1982; 1983; Wada 1985; 1986). Each CPUE is defined as follows (Wada, 1985);

$CPUE_1$: Catch divided by total tonnage of the operating catcher boat and a corrected factor caused by introduction of the motor boat to small-type whaling (Ohsumi, 1980). Data are available from 1952.
$CPUE_2$: Catch divided by total searching times for all the catcher boats. Data are available from 1977.

Time series of $CPUE_1$ (1952-1983) and $CPUE_2$ (1977-1983) are shown in Table 1. Figure 1 shows catch positions of the common minke whale by small type coastal whaling 1977-1984 by whaling grounds. This figure shows that catch distribution was not substantially change during the period.

Main results in Wada (1985; 1986) and discussions at IWC SC in 1984 and 1985

Wada (1985) estimated yearly trend of $CPUE_1$ (1952-1983) and $CPUE_2$ (1977-1983). Yearly change in $CPUE_1$ and $CPUE_2$ were shown in Figures 2 and 3, respectively. Neither significant increasing nor decreasing trends were observed. This results was submitted to the IWC/SC in 1984.

At the IWC/SC, it was noted that since $CPUE_1$ is the total seasonal catch divided by pooled tonnage, possible shifts in the length of season and availability through the season and possible shifts between whaling grounds may bias the trend in $CPUE_1$ (IWC, 1985). Two opinions about reliability of the available CPUE data for a stock assessment were expressed in the sub-committee. Some members argued that the CPUE series could be used for stock assessment. Other members felt that the $CPUE_1$ was too crude for that use and that the $CPUE_2$ series was too short to be used for calculation of replacement yield. It was agreed that a more refined analysis of the CPUE series was needed to get a more reliable index of stock abundance for the time prior to 1977 (IWC, 1985).

Given the agreement at the IWC/SC, Wada (1986) estimated CPUE trend. First, regression analysis between $CPUE_1$ and $CPUE_2$ for the period of 1977-1984 was conducted to predict $CPUE_2$ in 1975 and 1976 using $CPUE_1$ data. $CPUE_2$ data for the period of 1977-1984 and predicted $CPUE_2$ for 1975 and 1976 are shown in Table 2. Using the $CPUE_2$ data in Table 2, annual $CPUE_2$ trends were estimated for 1977-1984 and 1975-1984. The estimated trends are -1.39% and -1.41% for 1977-1984 and 1975-1984, respectively. Both of the estimated trends were not statistically significant declines (Table 3).

Although the sub-committee recognized that a regression estimate might level off possible variations in the data, and consequently also influence the slope of the extended $CPUE_2$ series, it was plausible that this effect might be small in this case. The sub-committee agreed to analyse the CPUE data from Wada (1986) using a model and procedures analogous to that used in the assessment for the West Greenland stock. Population estimates in 1981 were assumed to be 10,015 (e.h. = 1.00) and 13,520 (e.h. =1.35) (IWC, 1985). Population trajectories using the assessment model are shown in Table 4. Some members of the sub-committee felt that the probabilities estimated in Table 3 were sufficient as a basis for classifying this stock as SMS (provisional) since the apparent trend in CPUE is not statistically significant under a regime of approximately constant catches. Other member considered this stock should be classified as SMS (provisional), although the estimates indicated that the stock may be in the range from 51 to 65% of its initial size, so there may be a possibility that the stock is in the protection category. The sub-committee therefore recommended that the Okhotsk Sea-West Pacific of the common minke whales should be classified provisionally as a Sustainable Management Stock (IWC, 1986).

Discussions on CPUE at previous *Implementation Reviews*

Discussions on the utility of CPUE data for assessment purpose were conducted by the IWC SC during previous *Implementation Reviews* in 2003 and 2013. This was done in the context of evaluation of plausibility of stock structure scenarios (Kawahara, 2003).

In 2003 the IWC SC reminded its discussions held in 1991 that it was not possible to use the $CPUE_2$ series (the 1977-87 data) as an indicator of trend in stock abundance because of i) changes in the focus of operations from year to year; ii) variability arising from other weather or oceanographic factors; and iii) changes in vessel efficiency, for which correction factors were not available (IWC, 1992; 2004).

With regard the analyses conducted by Kawahara (2003) some IWC SC members noted that CPUE may not be a reliable index of abundance especially in coastal operations where there may be changes in the focus of operations from year to year and changes in vessel efficiency for which correction factors are not available. In addition, they asserted that in the absence of a quantitative analysis to estimate the power of these data to detect trends, no conclusion could be drawn as to whether or not the data in Kawahara (2003) are consistent with some stock structure scenarios. Other IWC SC members acknowledged that direct use of these data in a population model fitting exercise, such as an assessment or conditioning, was inappropriate, indeed because of some of the reservations raised. Nevertheless they considered that CPUE data had utility to check/discriminate hypotheses about population trends at a broad level (e.g. IWC, 2001, p178 for southern humpback whale). There was thus no consensus among IWC SC members as to whether or not these CPUE data provided information on the relative plausibility of the different stock structure hypotheses and trials (IWC, 2004).

Miyashita *et al* (2012) summarized information pertaining to catch, sightings and effort data from Japanese small-type whaling during 1977-1987 in relation to the common minke whales and presented results to the IWC/SC in 2012. They concluded that catch or sighting per unit effort data can be useful as an index of population trend if standardised. This analysis covered most of the factors identified during the First intersessional workshop for the Implementation Review of western North Pacific common minke whales (IWC, 2013a). In discussion of Miyashita *et al*. (2012) at the IWC SC in 2012 it was noted that there was considerable variation in where individual vessels operated during the year, and that if vessel movement reflects availability of whales, CPUE or sighting per unit effort data (SPUE) may be biased as an index of relative abundance (IWC, 2013b). It was suggested that focusing on April-May only may provide more consistency, and consequently further GLM-based analyses were conducted.

At the 2013 IWC SC meeting it was discussed whether analyses of CPUE data could be used qualitatively to inform assignment of plausibility weights to the hypotheses (stock structure and MSYR) on which the *ISTs* were based (IWC, 2013b). It was considered that further analysis and model diagnostics would need to be provided before the resultant SPUE trends could be used to assist the assignment of plausibility to hypotheses related to stock structure and MSYR. The proponents are in the process of addressing these issues.

In conclusion some problems on the use of CPUE data were identified by the IWC SC, and some of them were already addressed as explained above. Notwithstanding the proponents consider that the CPUE data can be used as an index of stock trend at a broad level.

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Table 1. Yearly change in $CPUE_1$ and $CPUE_2$ (Wada, 1985).

Yearly change in $CPUE_1$ and $CPUE_2$ of the Okhotsk Sea—West Pacific Stock of minke whales

a. $CPUE_1$

Year	Catch	No. of catchers: With motors	No. of catchers: Total	Total tonnage	Correction for motors	$CPUE_1$
1952	485	0	65	954	1.00	0.508
1953	406	0	58	870	1.00	0.467
1954	365	0	54	864	1.00	0.422
1955	427	0	47	776	1.00	0.550
1956	532	0	54	945	1.00	0.563
1957	423	0	46	851	1.00	0.497
1958	512	0	35	683	1.00	0.750
1959	280	0	32	657	1.00	0.426
1960	253	0	25	525	1.00	0.482
1961	332	0	23	510	1.00	0.651
1962	238	0	20	469	1.00	0.507
1963	220	0	19	475	1.00	0.463
1964	301	0	18	446	1.00	0.675
1965	314	0	17	522	1.00	0.602
1966	363	0	18	542	1.00	0.670
1967	270	0	17	422	1.00	0.517
1968	239	1	10	338	1.10	0.643
1969	202	2	10	338	1.19	0.503
1970	309	4	9	313	1.42	0.695
1971	269	6	9	320	1.63	0.516
1972	337	8	9	320	1.84	0.572
1973	423	6	7	264	1.81	0.885
1974	291	6	7	264	1.81	0.609
1975	282	6	7	264	1.81	0.590
1976	340	6	7	264	1.81	0.712
1977	246	6	7	264	1.81	0.515
1978	400	6	7	264	1.81	0.837
1979	392	9	9	354	2.00	0.554
1980	379	8	8	307	2.00	0.617
1981	374	8	8	307	2.00	0.609
1982	324	8	8	313	2.00	0.518
1983	290	9	9	332	2.00	0.437

b. $CPUE_2$

Year	Catch	A	B	C	A+B+C
1977	246	0.046	0.074	0.049	0.054
1978	400	0.056	0.103	0.081	0.082
1979	392	0.047	0.070	0.052	0.057
1980	379	0.066	0.058	0.052	0.057
1981	374	0.056	0.044	0.065	0.059
1982	324	0.058	0.037	0.052	0.048
1983	290	0.056	0.065	0.051	0.056

Table 2. Yearly change in $CPUE_1$ and extended $CPUE_2$ for 1975-1984 of the Okhotsk Sea-West Pacific stock of the minke whales.

		No. catchers					CPUE2			
Year	Catch	Motor boat	Total	Total tonnage	CM	CPUE1	A	B	C	A+B+C
1975	282	6	7	264	1.81	0.590	–	–	–	0.060[2]
1976	340	6	7	264	1.81	0.712	–	–	–	0.069[2]
1977	246	6	7	264	1.81	0.515	0.046	0.074	0.049	0.054
1978	400	6	7	264	1.81	0.837	0.056	0.103	0.081	0.082
1979	392	9	9	354	1.95[1]	0.568	0.047	0.070	0.052	0.057
1980	379	8	8	307	1.95[1]	0.633	0.066	0.058	0.052	0.057
1981	374	8	8	307	1.95[1]	0.624	0.056	0.044	0.065	0.059
1982	324	8	8	313	1.95[1]	0.531	0.058	0.037	0.052	0.048
1983	290	9	9	332	1.95[1]	0.448	0.056	0.065	0.051	0.056
1984	367	9	9	332	1.95[1]	0.567	0.074	0.065	0.052	0.064

1. Corrected for error in Wada (1985)
2. Predicted by regression model in Figure 3.

Table 3. Trend of the $CPUE_2$ series for the Okhotsk Sea-West Pacific of the common minke whales in Wada (1986).

		CPUE2 series	
		1977–84	1975–84
Correlation coefficient		–0.218	–0.292
Slope (% per year)		–1.39	–1.41
Standard error of the slope (%)		2.54	1.63
t-value		–0.546	–0.864
Degree of freedom		6	8
Probability that CPUE2 is stable or increasing		0.30	0.21
Probability that CPUE2 has declined to at least to a certain percentage of 1977 or 1975 level	90%	0.52 (–0.055)	0.60 (–0.252)
	80%	0.34 (0.436)	0.36 (0.362)
	70%	0.20 (0.927)	0.18 (0.975)
	60%	0.10 (1.418)	0.08 (1.589)

Table 4. Population trajectories for various estimates of exploitable stock size in 1981 (IWC, 1985) and trend (1975-1984) for the O stock of the common minke whales.

Non-linearity factor = 1.0		Non-linearity factor = 2.0	
N(1981) = 10,015 (e h = 1.0)		N(1981) = 10,015 (e h = 1.0)	
Slope*	= -1.4%	Slope	= -2.8%
$\hat{A}$	= 0.406	$\hat{A}$	= 0.0525
N(1952)	= 14,804	N(1952)	= 17,319
N(1986)	= 9,363	N(1986)	= 8,784
N_{86}/N_{52}	= 63.2%	N_{86}/N_{52}	= 50.7%
N(1981) = 13,520 (e h = 1.35)		N(1981) = 13,520 (e h = 1.35)	
Slope	= -1.4%	Slope	= -2.8%
$\hat{A}$	= 0.212	Not possible with $A > 0$	
N(1952)	= 19,446		
N(1986)	= 12,646		
N_{86}/N_{52}	= 65.0%		

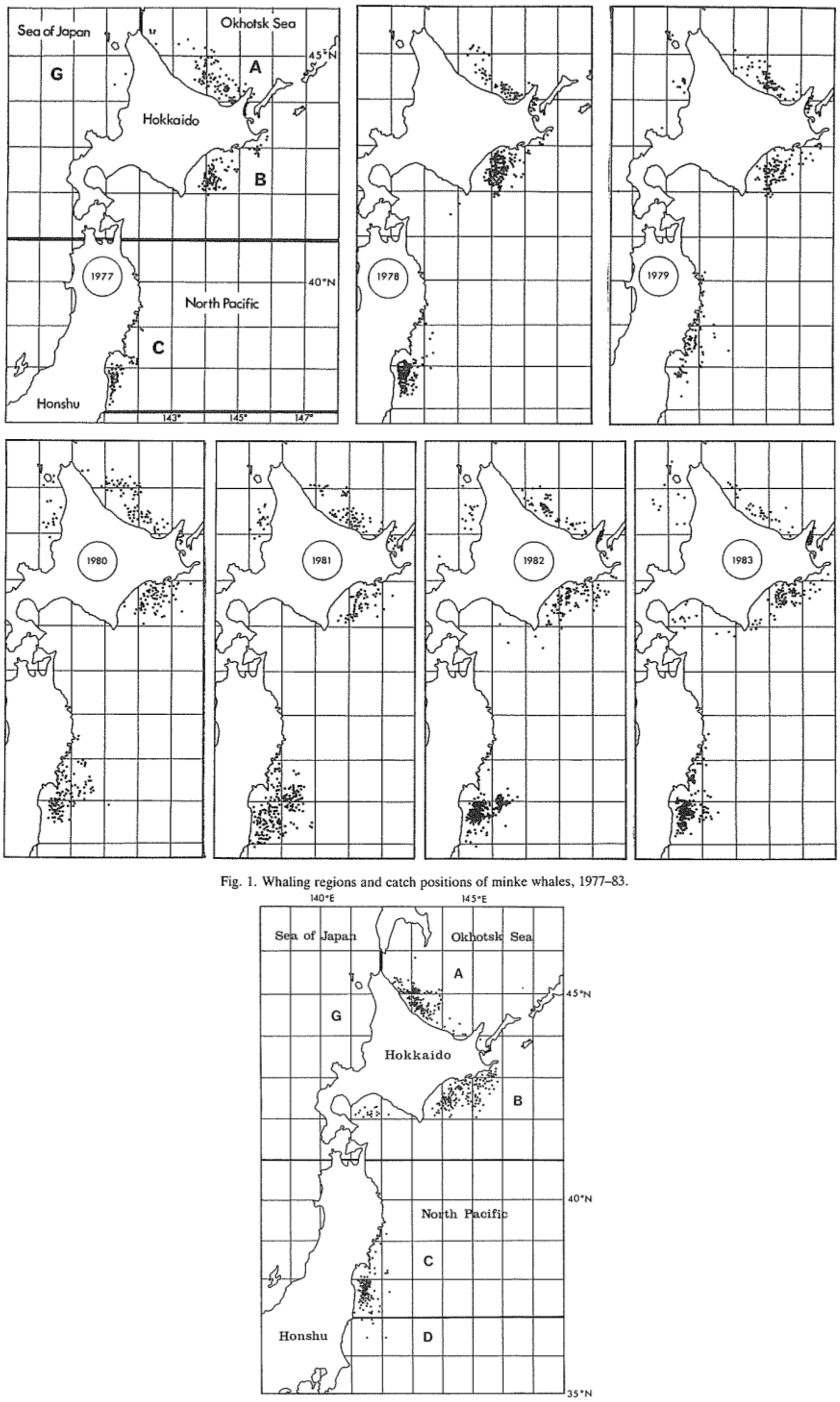


Figure 1. Whaling regions and catch positions of common minke whales, 1977-1984 (Wada, 1985; 1986). Region A: Okhotsk Sea coast of Hokkaido, Region B: Pacific coast of Hokkaido, Region C: Pacific coast of Sanriku, between 37°N and 41°N. Region G: Sea of Japan coast of Hokkaido. Bottom figure shows the catch positions in 1984.

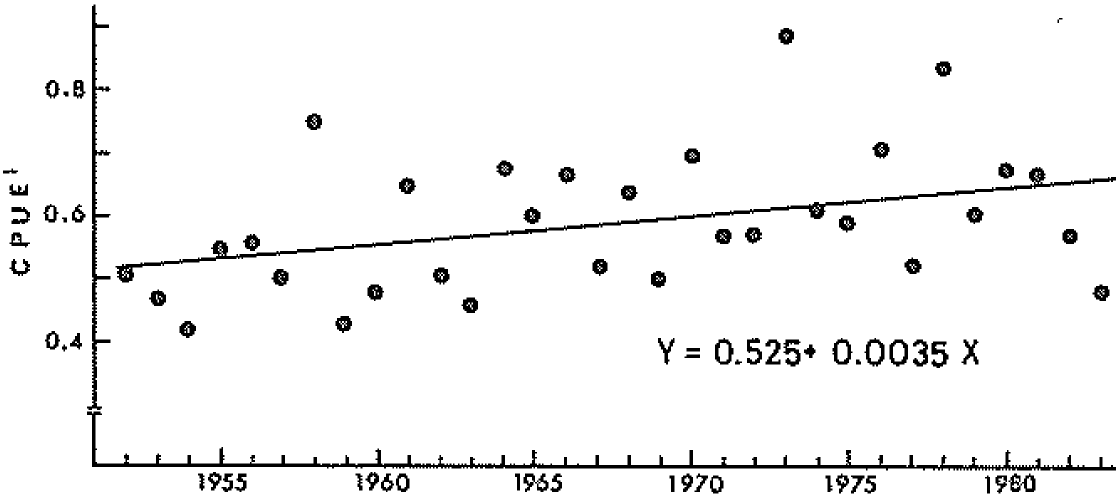


Figure 2. Yearly change in $CPUE_1$ series during 1952-1983 for Japanese coastal common minke whales (Wada, 1985).

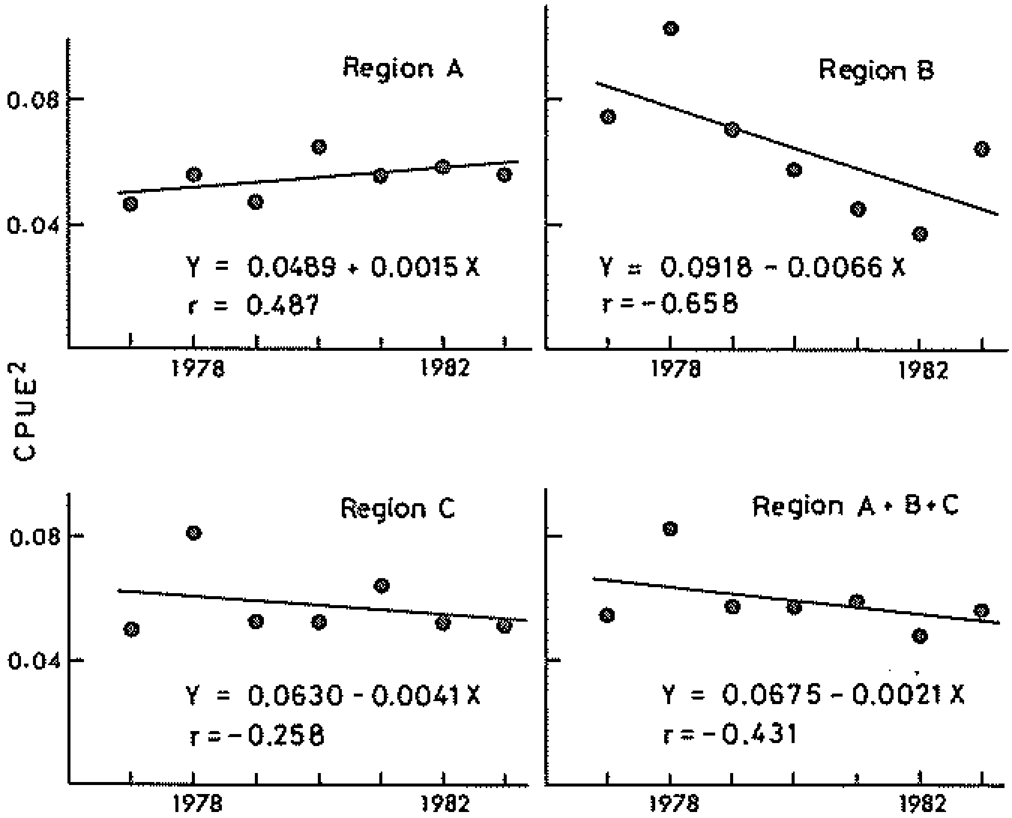


Figure 3. Yearly change in $CPUE_2$ series during 1977-1983 for Japanese coastal common minke whales (Wada, 1985). Region A: Okhotsk Sea coast of Hokkaido, Region B: Pacific coast of Hokkaido, Region C: Pacific coast of Sanriku, between 37°N and 41°N.

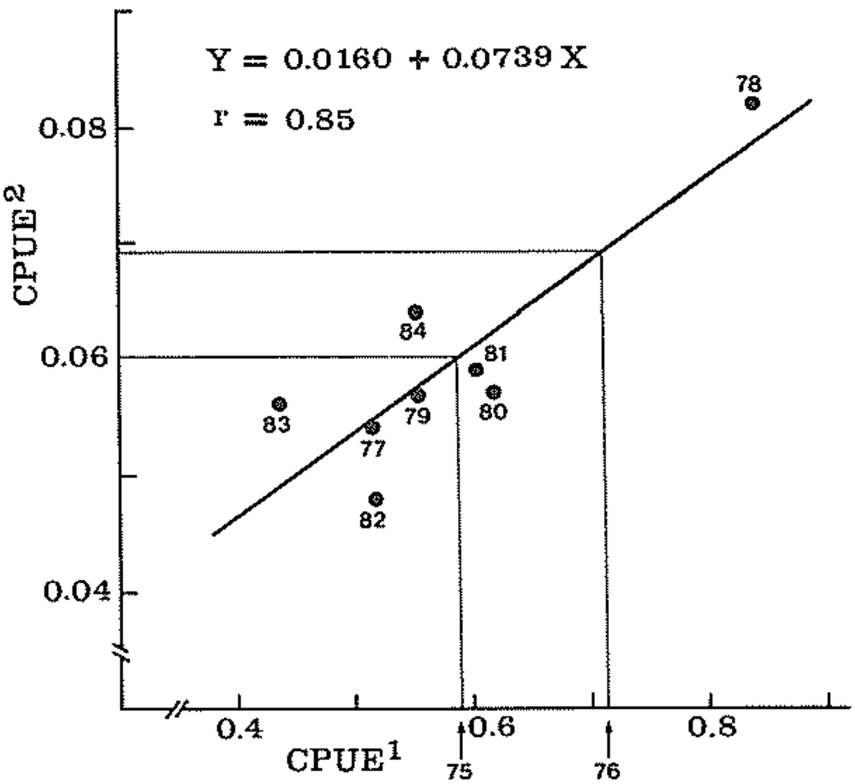


Figure 4. Regression between $CPUE_1$ and $CPUE_2$, for 1977-1984 and predicted $CPUE_2$ for 1975 and 1976 (Wada, 1986).

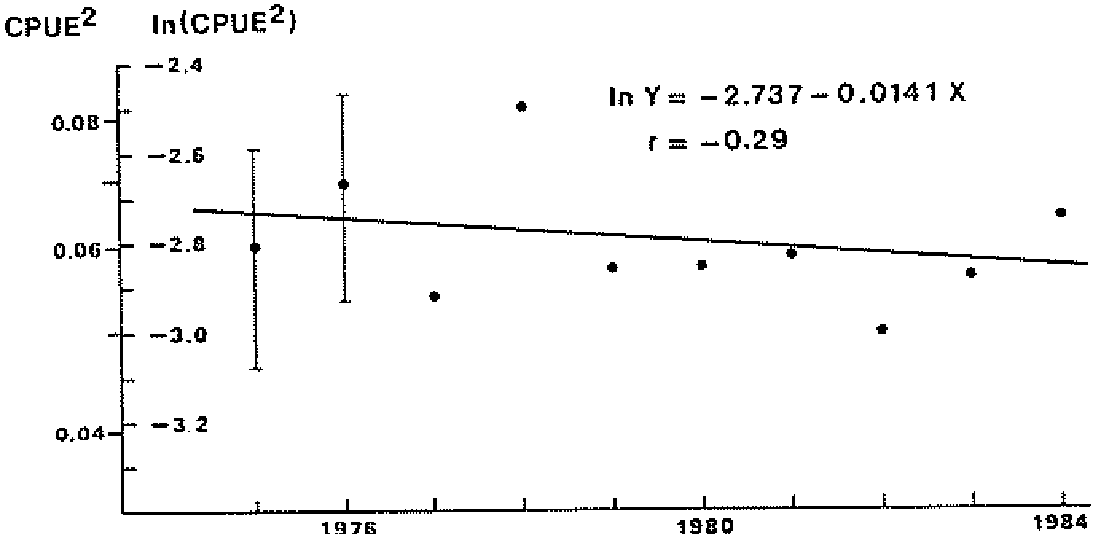


Figure 5. Annual trend of $CPUE_2$ for seasons 1975 to 1984 in Wada (1986). Vertical bars show the 95% confidence intervals of the estimates for 1975 and 1976.

Annex 3

Summary of the results of the 2013 RMP/*Implementation Review* for western North Pacific common minke whales

The main results of the RMP *Implementation Review* completed in 2013 are summarized based on the IWC/SC report (IWC, 2014). Average catch limits over 100 years under 6 base case trials among the variants examined are compared.

Definition of Variant

Figure 1 shows 22 sub-areas used for the *Implementation Review* for the western North Pacific common minke whales. Table 1 summarized the definition of 11 variants examined. Variants 1-4, 6 and 7 didn't include sub-areas 12 SW and 12 NE as a (part of) *Small Areas* whereas Variant 5 and 8-11 included sub-areas 12 SW and 12 NE. Because abundance estimates for *Small Areas* or *Combination Areas* are used as input for application of the *CLA*, abundance estimates for sub-areas 12 SW and 12 NE were used for Variant 5 and 8-11 and were not used under Variants 1-4, 6 and 7. As mentioned in the Remarks in Table 1, catch limits for sub-areas 12 SW and 12 NE were not taken into account under Variant 5. In summary, abundance estimates in sub-areas 12 SW and 12 NE were used for applying the *CLA* under Variants 8-11 and were not used under Variants 1-7.

Average catch limit among the Variants

Table 2 lists the average catches by sub-area for each variant for the six base-case trials. Average catches are reported in Table 5 for years 1-10 and for the entire 100-year projection period. The average catch for Variants 1-7 are smaller than those for Variant 8-11. Sum of average catch (1-100 years) in sub-areas 7CS and 7CN for Variants 9-11 are 17, 15 and 9, respectively.

Acceptability for each Variant

Table 3 shows acceptability of each Variant. Variants 9-11, which were the most appropriate Variants from the viewpoint of utilization of the resource, were not acceptable because performance was not acceptable for stock OW in some trials under stock hypothesis C (Table 3). Figures 2-6 shows performance plot for trials B04, A04, B03, C03 and C04 for two statistics (final depletion, upper panel, and minimum population ratio, lower panel) and for the stocks examined. Variants are 'acceptable' for a stock if their performance exceeds that for the 0.72 tuning of the *CLA* on one of the two statistics (solid dots above the upper horizontal line) and are 'unacceptable' for a stock if their performance is in the hashed area for both statistics. Variants are 'borderline' for a stock if they are neither 'acceptable' nor 'unacceptable'.

These figures show the following:

1. Variants 5 and 10, under which the average catch for 1-100 years was not 0 in sub-area 11, were not acceptable because performance of J stock under stock hypotheses A and B and that of JW stock under stock hypothesis C is borderline (trials A04, B03, C03 and C04) or unacceptable (trial B04).
2. Variance 7, 9 and 11 are potentially acceptable with research and Variant 10 is unacceptable. Performance of OW stock was unacceptable for Variants 7, 9, 10 and borderline for Variant 11 under trials C03 and C04. Performance under some trials with stock hypothesis C were unacceptable for Variants 7, 9, 10 and 11.

Given these results of trials of the RMP/*IR* for the common minke whales, it is necessary to investigate the following:

With respect to input data that could be used for future RMP/*IR* trials

- Abundance estimate for sub-areas where J stock animals are distributed including sub-area 11 and stock structure in sub-area 11 (related to item 1 above).
- Verify that the O stock is not sub-structured into Ow and Oe using non-genetic markers such as age data, body length data and maturity data, in combination with genetic data,.
  (related item 2 above).
- Planning sighting surveys at to avoid increased additional variance in abundance estimate.

With respect to the framework of RMP or RMP/*IR*

- Setting of sub-areas in according the results of the stock structure research i.e. if hypothesis C became not plausible, then there is no need to set up many of the current sub-areas.

- *Catch Cascading* was conducted using abundance estimate in summer season regardless of the timing of the catch. Explore methods for allocating the catch limit for *Combination Area* to *Small Areas* provided that the common minke whales usually migrates during catch season and that catch will be conducted in migration corridor.

References

International whaling Commission. 2014. Annex D1 Report of working group on the Implementation Review for western North Pacific common minke whales. *J. Cetacean Res. Manage.* (*Suppl.*) 15: 112-88.

Table 1. Summary of definition of variants 1-11 in IWC (2014). Description about sub-areas 5, 6 and 10 are omitted for simplicity.

Variant	*Small Area*	Sub-areas where catches are taken	Remarks
1	7CS, 7CN, 7WR, 7E, 8, 9*, 11	7CS, 7CN, 7WR, 7E, 8, 9, 11	
2	7+8, 9*, 11	7CN, 9, 11	Catch limit in *Small Area* 7+8 taken from 7CN
3	7+8, 9*, 11	7CS, 9, 11	Catch limit in *Small Area* 7+8 taken from 7CS
4	7CS, 7CN, 7WR+7E,+8, 9*, 11	7CS, 7CN, 7WR, 9, 11	Catch limit in *Small Area* 7WR+7E+8 taken from 7WR
5	7+8+9*+11+12	7CS, 7CN, 7WR, 7E, 8, 9, 11	The 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*, 11	7CS, 7CN, 9, 11	Catch limit in *Small Area* 7+8 in 7 CS and 7CN
7	7+8+9*+11	7CN	Cacth limit in the *Small Area* is taken from 7CN
8	7+8+9*+11+12	8,9	Cacth limit in the *Small Area* is taken from 8 and 9 using catch cascading
9	7+8+9*+11+12	7CS, 7CN, 7WR, 7E, 8, 9	Cacth limit in the *Small Area* is taken from 7CS, 7CN, 7WR, 7E, 8 and 9 using catch cascading
10	7+8+9*+11+12	7CS, 7CN, 7WR, 7E, 8, 9, 11	Cacth limit in the *Small Area* is taken from 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using catch cascading. Catches sub-area 11 occur in May and June.
11	7+8+9*+11+12	7CS, 7CN, 7WR, 7E, 8, 9	Cacth limit in the *Small Area* is taken from 7CS, 7CN, 7WR, 7E, 8 and 9 using catch cascading. Catches from 7CS, 7CN, 7WR and 7E are reduced by 50%.

9*: Sub-area 9 excluding sub-area 9N.
A+B: *Combination area* of sub-areas A and B

Table 2. Average (over the six base-case trials) median annual commercial catches (years 1-100 and 1-10) by sub-area and RMP variant.

Sub-area	Variant										
Years 1-100											
	1	2	3	4	5	6	7	8	9	10	11
5	0	0	0	0	0	0	0	0	0	0	0
6W	0	0	0	0	0	0	0	0	0	0	0
7CS	0	0	0	0	0	0	0	0	14	12	7
7CN	0	0	0	0	0	0	17	0	3	3	2
7WR	2	0	0	7	3	0	0	0	7	7	4
7E	1	0	0	0	1	0	0	0	3	0	1
8	1	0	0	0	2	0	0	7	5	4	5
9	43	43	43	43	37	43	0	113	82	74	81
11	0	0	0	0	2	0	0	0	0	14	0
Total	48	43	43	50	48	43	17	123	123	122	105
Years 1-10											
5	0	0	0	0	0	0	0	0	0	0	0
6W	0	0	0	0	0	0	0	0	0	0	0
7CS	0	0	0	0	0	0	0	0	7	6	3
7CN	0	0	0	0	0	0	0	0	4	4	2
7WR	1	0	0	2	2	0	0	0	4	4	2
7E	0	0	0	0	1	0	0	0	1	1	1
8	0	0	0	0	1	0	0	5	3	3	3
9	19	19	19	19	20	19	0	60	44	39	44
11	0	0	0	0	0	0	0	0	0	6	0
Total	20	19	19	21	24	19	0	65	65	65	56

Table 3. Summary of the 'medium' plausibility trials on which each of the variants failed to achieve

Variant	Borderline Trials	Unacceptable Trials	Recommendation
1	B04	None	Acceptable without research
2	B04	None	Acceptable without research
3	B04	None	Acceptable without research
4	B04	None	Acceptable without research
5	B03, C03, A04, C04	B04	Potentially acceptable with research
6	B04	None	Acceptable without research
7	A04, B04, C14, C17	C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C15, C18, C19, C20, C22, C23, C28, C30, C31	Potentially acceptable with research
8	None	None	Acceptable without research
9	A04, B04, C11, C14, C17,C30	C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C12, C13, C15, C18, C19, C20, C22, C23, C28, C31	Potentially acceptable with research
10	A03, B03, A04, B05, B06, B09, C17, B18, B20, B22, A28, C27, B28	C01, C02, C03, B04, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C14, C15, C18, C19, C20, C22, C23, C28, C30, C31	Unacceptable
11	C02, C03, A04, B04, C04, C05, C06, C07, C08, C09, C10, C12, C18, C19 C22, C31	C13, C20, C23	Potentially acceptable with research

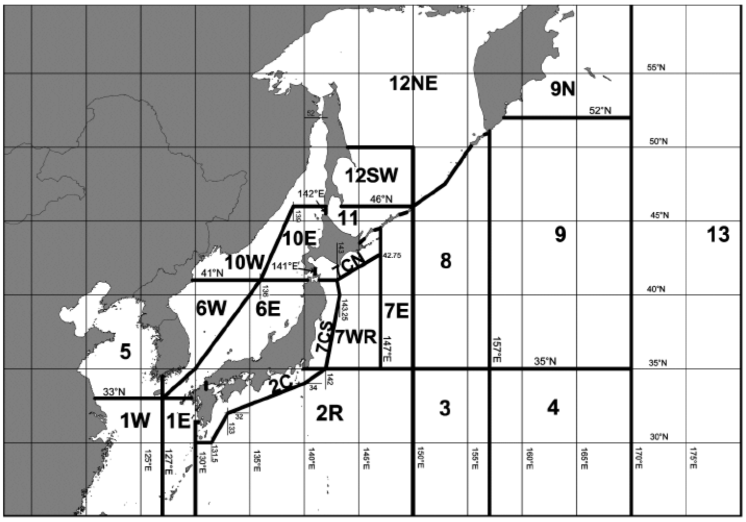


Figure 1. Sub-areas used during the 2013 RMP *Implementation*

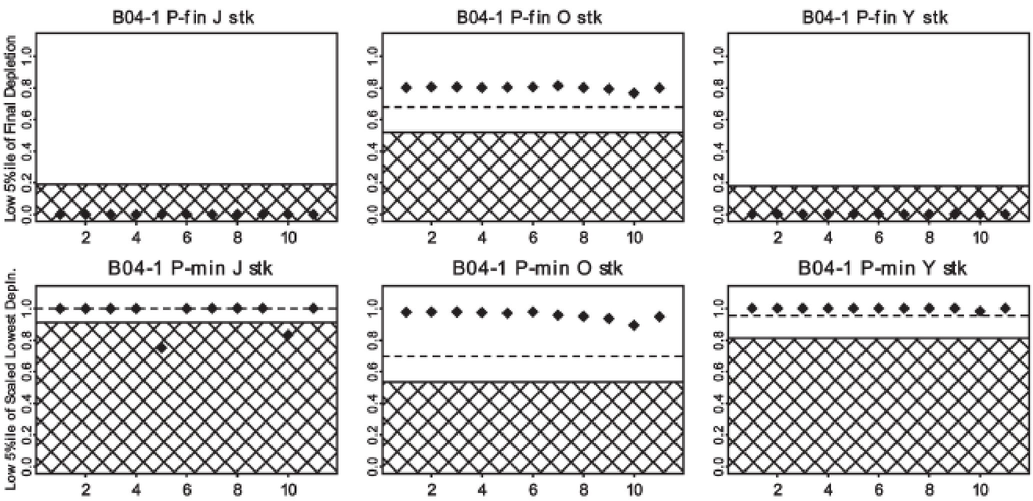


Figure 2. Performance plot for trial B04

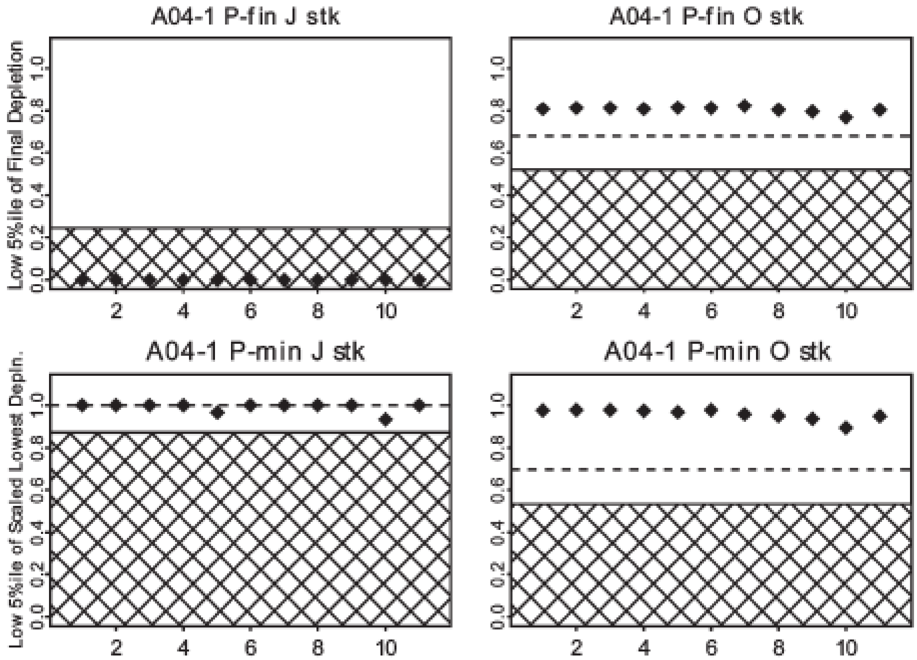


Figure 3. Performance plot for trial A04

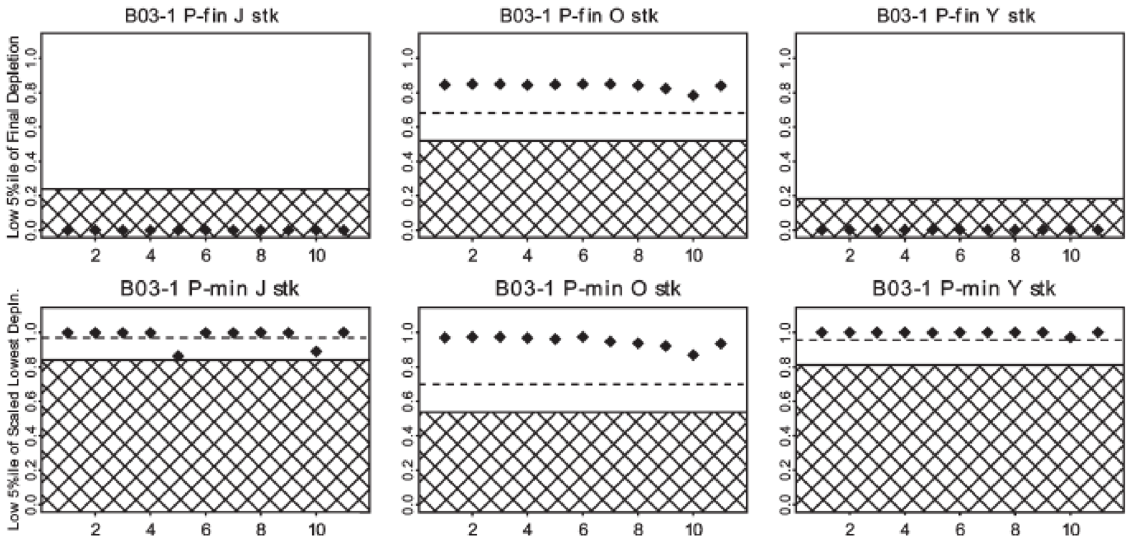


Figure 4. Performance plot for trial B03

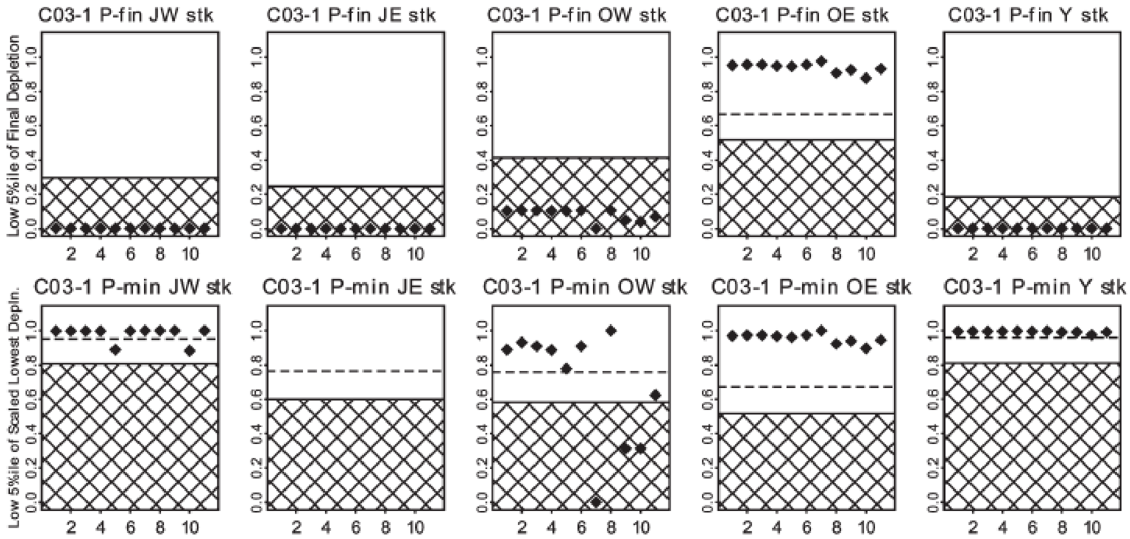


Figure 5. Performance plot for trial C03

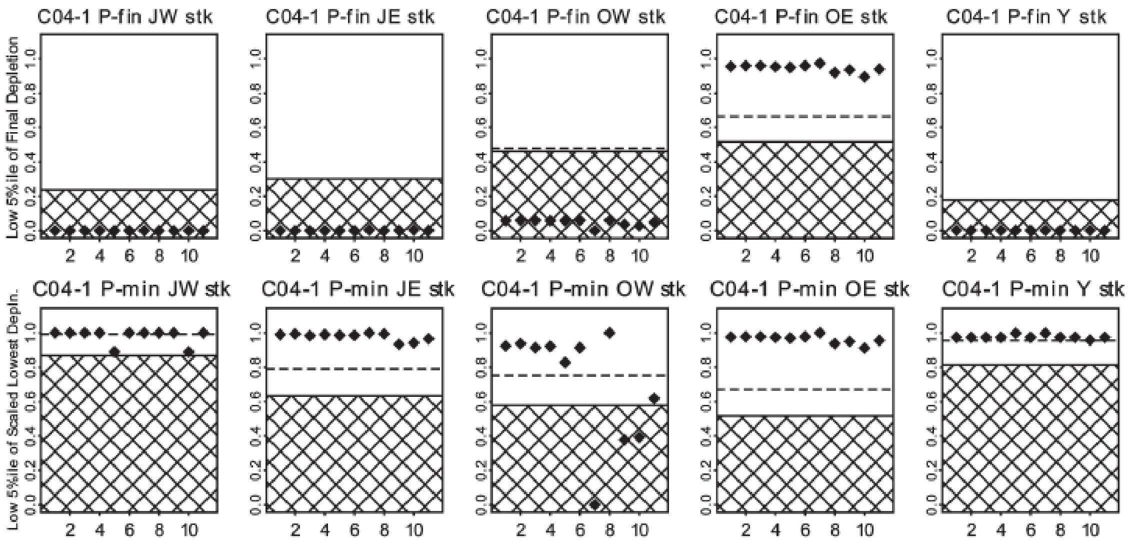


Figure 6. Performance plot for trial C04

Addendum 1. The list of trials. Details of the trials are given in Appendix 2 of IWC (2014). Trial 24 is assigned low plausibility and so is crossed through.

Table 1

The list of trials. Details of the trials are given in Appendix 2. Trial 24 is assigned low plausibility and so is crossed through.

Stock hypothesis	Trial no.	MSYR	Description
A	A01-1 and A01-4	1% and 4%	Baseline A: 2 stocks ('J' and 'O'); *g*(0)=0.8; including Chinese bycatch.
B	B01-1 and B01-4	1% and 4%	Baseline B: 3 stocks ('J', 'O', and 'Y'); *g*(0)=0.8; including Chinese bycatch.
C	C01-1 and C01-4	1% and 4%	Baseline C: 5 stocks ('JW', 'JE', 'OW', 'OE', and 'Y'); *g*(0)=0.8; including Chinese bycatch.
AC	A02-1 etc.	1%/4%	With a 'C' stock.
ABC	A03-1 etc.	1%/4%	Assume *g*(0)=1.
ABC	A04-1 etc.	1%/4%	High direct catches and alternative Korean and Japanese bycatch level.
ABC	A05-1 etc.	1%/4%	Some 'O' or 'OW' animals in sub-area 10E. The mixing matrices will be modified such that the proportion of 'O'/'OW' stock in 10E is ~30% of that in 7CN in all months.
ABC	A06-1 etc.	1%/4%	Mixing proportion in 7CS and 7CN calculated using 2/60 weight for bycatch.
ABC	A07-1 etc.	1%/4%	Mixing proportion in 7CS and 7CN calculated using 10/60 weight for bycatch.
ABC	A08-1 etc.	1%/4%	More Korean catches in sub-area 5 (and fewer in 6W).
ABC	A09-1 etc.	1%/4%	More Korean catches in sub-area 6W (and fewer in 5).
ABC	A10-1 etc.	1%/4%	10% J (/JW) -stock in sub-area 12SW in June (base case value = 25%).
ABC	A11-1 etc.	1%/4%	30% J (/JW) -stock in sub-area 12SW in June (base case value = 25%).
C	C12-1 and 4	1%/4%	No 'C' animals in sub-area 12NE.
C	C13-1 and 4	1%/4%	No 'OW' in 11 or 12 SW. ('OW' and 'OE' whales mix with 'JW' in 11 and 12 SW in the baseline C trials).
C	C14-1 and 4	1%/4%	No 'OE' in 11 or 12 SW.
C	C15-1 and 4	1%/4%	No 'OE' in 7WR. (OE and OW whales mix in 7WR from Apr.-Sep., while OW whales are present year round in the baseline C trials).
C	C16-1 and 4	1%/4%	Dispersal rate of 0.005 between the 'OW' and 'OE' and the 'JW' and 'JE' stocks.
C	C17-1 and 4	1%/4%	Dispersal rate of 0.02 between the 'OW' and 'OE' and the 'JW' and 'JE' stocks.
ABC	A18-1 etc.	1%/4%	Chinese incidental catch=0 (the base case value=twice that of Korea in sub-area 5).
ABC	A19-1 etc.	1%/4%	Alternative abundance estimates in 6E (see table 6a in SC/65a/Rep04, Annex H).
ABC	A20-1 etc.	1%/4%	Additional abundance estimate in 10E in 2007 (see table 6a in SC/65a/Rep04, Annex H).
ABC	A21-1 etc.	1%/4%	Abundance estimate in 5='minimum' value listed in table 6b in SC/65a/Rep04, Annex H, with a CV=0.1.
ABC	A22-1 etc.	1%/4%	Abundance estimate in 5='maximum' value listed in Table 6b in SC/65a/Rep04, Annex H (= 5 *baseline value), with a CV=0.1.
C	C23-1 and 4	1%/4%	Single J-stock (with pure 'J' stock definition using 6E (all months)).
~~C~~	~~C24-1 and 4~~	~~1%/4%~~	~~Single O-stock (with pure 'O' stock definition using 7WR, 7E and 8 (all months)).~~
ABC	A25-1 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	A26-1 etc.	1%/4%	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-area 9 and 9N are no more than half the base case numbers; juveniles will be allowed into subareas 2R, 3 and 4 in the corresponding months.
ABC	A27-1 etc.	1%/4%	Set the proportion of 'O'/'OE' animals of ages 1-4 in sub-area 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 this sub-area will need to account for the implied survey bias.
ABC	A28-1 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).
ABC	A29-1 etc.	1%/4%	Abundance estimate in 6W='minimum' value listed in Table 6b in SC/65a/Rep04, Annex H, with a CV=0.1.
ABC	A30-1 etc.	1%/4%	Abundance estimate in 6W='maximum' value listed in Table 6b in SC/65a/Rep04, Annex H (= 5 * baseline value), with a CV=0.1.
C	C31-1 and 4	1%/4%	Alternative time invariant proportion of 'JE' stock whales in 7CN in Jan.-Jun. used to remove bycatch.

Addendum 2. The factors in the *Implementation Simulation Trials* and their plausibility. The plausibility assigned to the new Trial 31 occurred during 2013 IWC/SC meeting (IWC, 2014).

Factor	Plausibility
Stock structure hypothesis	
Stock structure hypothesis A	M*
Stock structure hypothesis B	M*
Stock structure hypothesis C	M*
$MSYR_{mat}$	
1%	M
4%	H
***g*(0)**	
0.8	H
1.00 (Trial 3)	M
Other stock structure issues	
With a 'C' stock (Trial 2)	M
Some 'O' or "O/W' animals in sub-area 10E (Trial 5)	M
10% J (/JW) – stock in sub-area 12SE in June (Trial 10)	M
30% J (/JW) – stock in sub-area 12SE in June (Trial 11)	M
No 'C' animals in sub-area 12NE (Trial 12)	M
No 'OW' in 11 and 12SW (Trial 13)	M
No 'OE' in 11 or 12SW (Trial 14)	M
No 'OE' in 7WR (Trial 15)	M
Single 'J' stock (Trial 23)	M
Single 'O' stock (Trial 24)	**L**
Catches and bycatches	
High direct catches + alternative Korean + Japanese bycatch level (Trial 4) (Total direct catch = 40,224 *cf* baseline value = 38,174)	M
More Korean catches in sub-area 5 (and fewer in 6W) (Trial 8)	M
More Korean catches in sub-area 6W (and fewer in 5) (Trial 9)	M
Chinese incidental catch = 0 (Trial 18) (Baseline value = 2* Korean bycatch in subarea 5)	M
Number of bycaught animals is proportional to square root of abundance (Trial 25)	
Mixing and dispersion	
Mixing proportion in 7Cs and 7CN calculated using 2/60 weight for bycatch (Trial 6)	M
Mixing proportion in 7Cs and 7CN calculated using 10/60 weight for bycatch (Trial 7)	M
Dispersal rate of 0.005 (Trial 16)	M
Dispersal rate of 0.02 (Trial 17)	M
A substantially larger fraction of whales 1-4 from O-/OE-stock are found in sub-areas 2R, 3 and 4 year round (Trial 26) M	M
Set the proportion of O/OE animals of ages 1-4 in sub-area 9 and 9N to zero (Trial 27)	M
Abundance estimates	
Alternative abundance estimates in 6E (Trial 19)	M
Alternative abundance estimates in 10E in 2007 (Trial 20)	M
Abundance estimate in 5 = 'minimum' (Trial 21)	**L**
Abundance estimate in 5 = 'maximum' (Trial 22)	M
The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (Trial 28)	M
Abundance estimate in 6W = 'minimum' (Trial 29)	**L**
Abundance estimate in 6W = 'maximum' (Trial 30)	M
Alternative time invariant proportion of JE-stock whales in 7CN in Jan-Jun used to remove bycatch (Trial 31)	M

*Treated as 'medium' plausibility because of lack of agreement (IWC, 2013b).

Factor	Plausibility
Stock structure hypothesis	
Stock structure hypothesis A	M*
Stock structure hypothesis B	M*
Stock structure hypothesis C	M*
$MSYR_{mat}$	
1%	M
4%	H
***g*(0)**	
0.8	H
1.00 (Trial 3)	M
Other stock structure issues	
With a 'C' stock (Trial 2)	M
Some 'O' or "O/W' animals in sub-area 10E (Trial 5)	M
10% J (/JW) – stock in sub-area 12SE in June (Trial 10)	M
30% J (/JW) – stock in sub-area 12SE in June (Trial 11)	M
No 'C' animals in sub-area 12NE (Trial 12)	M
No 'OW' in 11 and 12SW (Trial 13)	M
No 'OE' in 11 or 12SW (Trial 14)	M
No 'OE' in 7WR (Trial 15)	M
Single 'J' stock (Trial 23)	M
Single 'O' stock (Trial 24)	**L**
Catches and bycatches	
High direct catches + alternative Korean + Japanese bycatch level (Trial 4) (Total direct catch = 40,224 *cf* baseline value = 38,174)	M
More Korean catches in sub-area 5 (and fewer in 6W) (Trial 8)	M
More Korean catches in sub-area 6W (and fewer in 5) (Trial 9)	M
Chinese incidental catch = 0 (Trial 18) (Baseline value = 2* Korean bycatch in subarea 5)	M
Number of bycaught animals is proportional to square root of abundance (Trial 25)	
Mixing and dispersion	
Mixing proportion in 7Cs and 7CN calculated using 2/60 weight for bycatch (Trial 6)	M
Mixing proportion in 7Cs and 7CN calculated using 10/60 weight for bycatch (Trial 7)	M
Dispersal rate of 0.005 (Trial 16)	M
Dispersal rate of 0.02 (Trial 17)	M
A substantially larger fraction of whales 1-4 from O-/OE-stock are found in sub-areas 2R, 3 and 4 year round (Trial 26) M	M
Set the proportion of O/OE animals of ages 1-4 in sub-area 9 and 9N to zero (Trial 27)	M
Abundance estimates	
Alternative abundance estimates in 6E (Trial 19)	M
Alternative abundance estimates in 10E in 2007 (Trial 20)	M
Abundance estimate in 5 = 'minimum' (Trial 21)	**L**
Abundance estimate in 5 = 'maximum' (Trial 22)	M
The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (Trial 28)	M
Abundance estimate in 6W = 'minimum' (Trial 29)	**L**
Abundance estimate in 6W = 'maximum' (Trial 30)	M
Alternative time invariant proportion of JE-stock whales in 7CN in Jan-Jun used to remove bycatch (Trial 31)	M

*Treated as 'medium' plausibility because of lack of agreement (IWC, 2013b).

Annex 4

A summary of the new information on stock structure in the western North Pacific common minke whales presented to the JARPNII final review workshop

The relevant documents on common minke whale stock structure presented to the JARPNII final review meeting were the following: Pastene *et al*. (2016a; b), Bando and Hakamada (2016) and Kitakado and Maeda (2016). A summary of each of these studies is presented below.

Pastene *et al*. (2016a) examined a total of 4,275 western North Pacific common minke whales with a set of 16 microsatellite DNA loci and the program STRUCTURE to assign individuals to either J or O stocks. The relevant information in this paper for the discussion in the SDWG (stock definition working group) was on the unassigned individuals in the STRUCTURE analyses. A simple simulation exercise showed that the number of unassigned individuals decreased with the increase in the number of microsatellite loci used, and they were widely distributed geographically (Figure 1). It was concluded that the unassigned individuals are not related to the occurrence of additional stock structure. Based on these results, the authors considered that only the animals assigned to the O-stock with assignment probability greater than 90% could be used to investigate additional structure with the O-stock using alternatively analytical approaches.

Pastene *et al*. (2016b) examined the genetic population structure of 'O' stock common minke whale in the western North Pacific based on mitochondrial DNA control region sequencing (487bp) and microsatellite DNA (16 loci). Samples used in the tests of homogeneity were obtained during the surveys of the JARPN and JARPNII in sub-areas of the Pacific side of Japan between 1994 and 2014 (n= 2,071 for microsatellite; n=2,070 for mtDNA). Whales were assigned to the 'O' stock by the analysis of STRUCTURE presented in Pastene *et al*. (2016a). Tests based on both genetic markers and different grouping of the samples showed no evidence of sub-structuring in the 'O' stock common minke whale in the Pacific side of Japan. A simulation exercise showed that the statistical power of the homogeneity test was high. In addition, a Discriminant Analysis of Principal Components (DAPC) based on the total samples used in Pastene *et al*. (2016a) showed clear differentiation between J and O stock whales but no evidence of sub-structuring within the O stock samples. Consequently the results of this study suggested a low plausibility for the hypothesis of sub-division of the O stock common minke whale into OW and OE.

Bando and Hakamada (2016) conducted a morphometric analyses to examine stock structure of western North Pacific common minke whales by using external measurement data collected during 1994 and 2014 JARPN and JARPNII surveys. External measurements of mature males were first compared between O and J stock animals assigned by the microsatellite DNA analysis. Then only O stock animals were compared among sub-areas. The analytical procedures used were the Analysis of Covariance (ANCOVA) and Discriminant Analysis (DA). Significant differences were detected between O and J stock whales. J stock animals had longer head region compared to O stock animals. No significant differences were detected in O stock animals among sub-areas. The results of the present morphometric analyses provided no evidence for sub-structuring of the O stock into Ow and Oe as proposed in one of the hypotheses used in the RMP *Implementation*, as common minke whales from coastal and offshore sub-areas did not differ in morphometric characters.

Kitakado and Maeda (2016) used catch-at-age data for common minke whales in the western North Pacific provided by the JARPN/JARPNII program to refine existing RMP *Implementation Simulation Trials* (*ISTs*) in a simple way, so as to investigate the relative plausibility of the single- and two (Ow and Oe) stock hypotheses for the O whales in the Pacific side of Japan. While the single stock scenario seems consistent with these age data, it is difficult to reconcile the two stock hypothesis with these data particularly because of the relative absence of younger whales in a supposedly separate discrete Oe stock. In other words, the analysis based on age data supports the single O stock scenario. The analysis demonstrates the importance for management purposes of obtaining age data for the common minke whales in the western North Pacific, which in turn necessitates lethal sampling. Such age data need to be incorporated in the conditioning of revised RMP *ISTs* for common minke whales in this region.

During the JARPN II final review meeting the proponents provided preliminary results on kinship analyses. Preliminary results of the analysis of the total samples of over 4,000 animals, found a total of 22 parent-offspring pairs for the O-stock. Half of the pairs showed one in the coastal and the other in the offshore area. This work is in progress and a paper will be prepared for a future meeting.

It is considered that a substantial amount of new information on stock structure of common minke whale has been accumulated since the last *Implementation Review*, which was based on data collected till 2007. Of particular importance was the larger number of new samples (around 1,700), a new analytical procedure (DAPC, kinship, statistical power of the heterogeneity test), and the availability of age data.

Most of the analyses in the documents summarized above responded to recommendations made during the 2009 JARPNII mid-term review. According to these, results of all different analyses indicate a single O stock distributed from the Japanese coast till approximately 170°E. In the last IWC SC meeting in 2016, however, there was not unanimous support for this view, and the IWC SC suggested some additional genetic analyses on kinship. On the other hand the IWC SC broadly agrees on the value of age data in *ISTs*. In the case of western North Pacific common minke whale, additional age data are very important to verify the existence of a single O stock. Both lines of research (kinship and SCAA) will be implemented in NEWREP-NP.

References

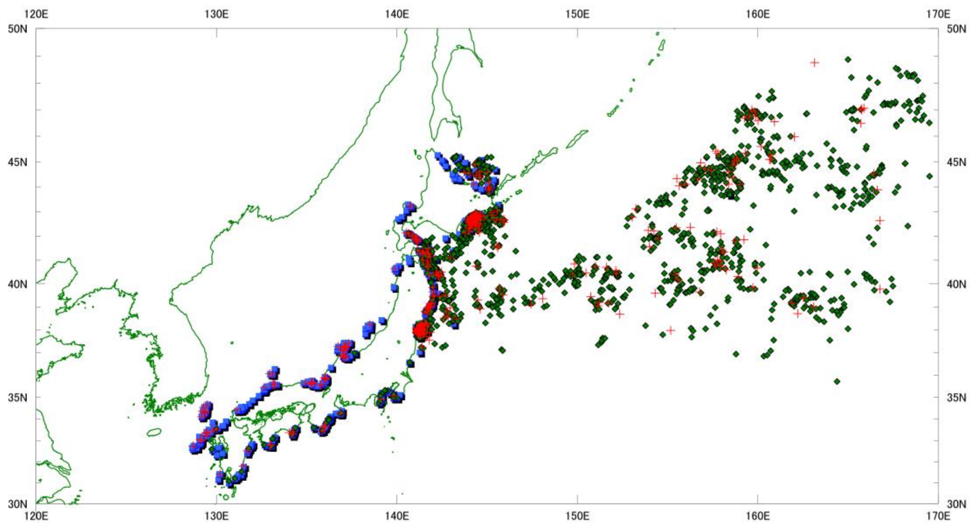
Pastene, L.A., Goto, M., Taguchi, M. and Kitakado, T. 2016a. Temporal and spatial distribution of the 'J' and 'O' stocks of common minke whale in waters around Japan based on microsatellite DNA. Paper SC/F16/JR38 presented to the Expert Panel Workshop of the final review on the western North Pacific Japanese Special Permit programme (JARPN II), Tokyo, February 2016 (unpublished). 14pp.

Pastene, L.A., Goto, M., Taguchi, M. and Kitakado, T. 2016b. Updated genetic analyses based on mitochondrial and microsatellite DNA indicated no sub-structure of the 'O' stock common minke whale in the western North Pacific. Paper SC/F16/JR40 presented to the Expert Panel Workshop of the final review on the western North Pacific Japanese Special Permit programme (JARPN II), Tokyo, February 2016 (unpublished). 19pp.

Bando, T. and Hakamada, T. 2016. Morphometric analysis on stock structure of the O stock common minke whale in the western North Pacific. Paper SC/F16/JR41 presented to the Expert Panel Workshop of the final review on the western North Pacific Japanese Special Permit programme (JARPN II), Tokyo, February 2016 (unpublished).10pp.

Kitakado, T. and Maeda, H. 2016. Fitting to catch-at-age data for North Pacific common minke whales in the Pacific side of Japan. Paper SC/F16/JR43 presented to the Expert Panel Workshop of the final review on the western North Pacific Japanese Special Permit programme (JARPN II), Tokyo, February 2016 (unpublished). 15pp.

A)



B)

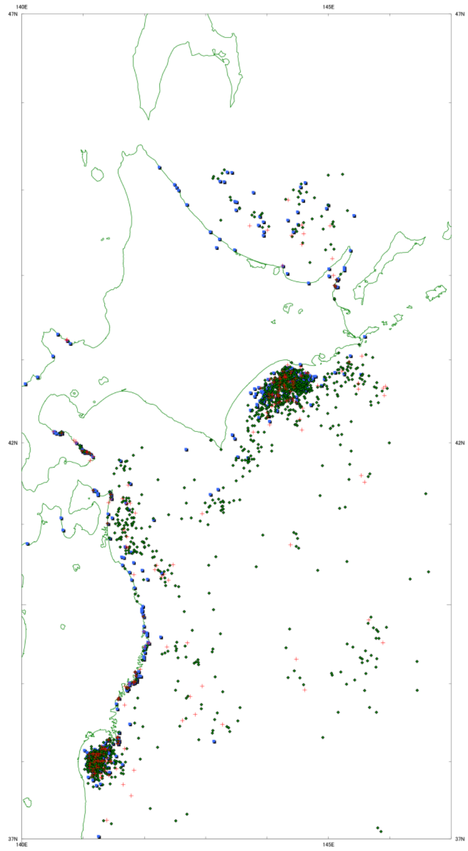


Figure 1. Location of the common minke whales that were assigned to O stock (green), J stock (blue), and unassigned (red), based on STRUCTURE. A) total areas; B) zoom of A) for coastal areas.

Annex 5

Overview of JARPN/JARPNII outcomes

Below are some key scientific outcomes of JARPN and JARPNII combined (see details in Tamura *et al*., 2016 and IWC, 2016):

Feeding ecology and ecosystem studies

- Analyses of seasonal spatial distributions of common minke, sei and Bryde's whales in the JARPNII research area using Generalized Additive Models (GAM) indicated that spatial segregation occurred among the three baleen whale species although some overlaps occurred. Given this, the extent of direct interaction among whale species could be minimal although indirect interaction could occur as they share the same prey species.

- The prey consumption by whales in both offshore and coastal waters were estimated based on energetic equations, and accounted for some uncertainties such as the number of whales distributed in the research area, body weight of whales, consumption models, energy content of prey species, assimilation efficiency and the ratio of low/high feeding intake of whales. As a consequence, estimates of prey consumption of whales in coastal and offshore waters were made with an improved level of precision.

- In offshore waters, the prey preferences of baleen whales were estimated based on data from concurrent surveys of cetacean and prey species. Common minke whale showed preference toward pelagic fishes such as Japanese anchovy and Pacific saury. Bryde's whales showed preference for Japanese anchovy while sei whales showed preference for copepods.

- In offshore waters the yearly trend of prey compositions in Bryde's and sei whales was different. The Bryde's whale showed no trend, feeding every year on krill and Japanese anchovy. On the other hand drastic yearly changes were observed in the prey of sei whales, shifting from Japanese anchovy in the period 2002-2010 to mackerels and Japanese sardine after 2010.

- In coastal waters off Kushiro yearly changes in the prey species of common minke whale, were observed. It shifted from Japanese anchovy and Pacific saury in the period 2002-2011 to Japanese sardine and mackerels after 2011.

- In Kushiro waters immature animals of common minke whale tend to feed on walleye Pollock on the continental shelf and slope regions. Mature animals feed on Japanese common squids and Pacific saury in the area outside of the continental shelf. These results suggested that migration and prey preference of common minke whales in the coastal waters off Kushiro in autumn possibly differ with their maturity stage. It is suggested that the feeding strategy of common minke whales might change to adapt to the local environments.

- The marine ecosystem of the western North Pacific from 1994 to 2013 (20 years) was modeled using a whole ecosystem model, Ecopath with Ecosim (EwE). Although the results are still preliminary, the constructed model will serve as a basis for further investigation on ecosystem level changes (e.g. regime shift) observed in the region.

- A statistical analysis was conducted to assess predation impacts of the common minke whales on the sand lance population off Sanriku region. Results showed that the predation by the common minke whales accounts for a certain proportion of the current adult biomass for the sand lance population although the level of the proportion is sensitive to the model assumption.

Monitoring environmental pollutants in cetaceans and the marine ecosystem

- Yearly changes of Hg (1994-2014) and PCB (2002-2014) levels in tissues of common minke, sei and Bryde's whales from the western North Pacific were examined considering several explanatory variables, such as sampling location, biological data and main prey item. Results suggested that the background levels of Hg and PCB were stable during the JARPN/JARPNII research period.

- Results of organochlorines isomer analyses in whale tissues showed that almost no recent inputs of DDT, HCH and CHLs have been released into the JARPNII research area.

- No significant differences were found in the total levels of Hg between J and O stocks common minke whales off Sanriku.

- The analysis of the relationship between total Hg levels in whale tissue and main prey species in whale's stomachs revealed an effect of prey species on whales. Such effect was not observed for PCB. Based on these results, it is suggested that the influence of prey species on pollutant accumulations in whales, is different depending of the kind of pollutant.

- Monitoring of I131, Cs134 and Cs137 levels in large whales from the western North Pacific after the Fukushima nuclear accident in 2011, was carried out. Based on a comparison with radiation safety threshold in humans, it was suggested that the levels detected do not represent a health risk for whales.

- Information on the utility of new biomarkers for future studies on adverse effects of organochlorines in baleen whales, and for future studies on potential vulnerability to viral infection in whales, was provided.

Stock structure of large whales

- Monitoring of the O and J stock common minke whales in Japanese waters, was attained. Almost all animals from the Sea of Japan belonged to the J stock while all animals in the Pacific side east of SA7WR belonged to the O stock. Intermediate sub-areas (7CN, 7CS, and 11) contained animals from both stocks.

- In SA2 the J stock common minke whale animals were predominant through the year. In SA7CS and SA7CN the proportion of J stock animals increased in autumn/winter and decreased in spring/summer. The O stock had a reverse trend.

- Results of genetics and morphometric analyses showed no evidence of O stock common minke whale sub-structuring into OW and OE in the Pacific side of Japan.

- Preliminary catch-at-age data for common minke whales provided by JARPN/JARPNII were useful to refine existing RMP *ISTs*. Catch-at-age analyses showed that it was difficult to reconcile the two O stock hypothesis (OW and OE) with age data.

- Results of genetic analyses showed no significant heterogeneity between Bryde's whales in sub-areas 1W and 1E. Results suggested genetic differentiation between whales in sub-area 1 and sub-area 2.

- Results of the genetic analysis confirmed the view of a single stock of sei whale in the pelagic regions of the North Pacific.

Others

- Advances were made in ageing western North Pacific common minke whales based on earplugs. Age readability was 45.2% (males) and 41.2% (female) of common minke whales sampled by JARPN and JARPNII.

- Advance were made in ageing western North Pacific sei whales based on earplugs. Readability of all samples was 63%.

References

International Whaling Commission. 2016. Report of the Expert Panel of the final review on the western North Pacific Japanese Special Permit programme (JARPN II). Paper SC/66b/Rep06 presented to IWC Scientific Committee (unpublished). 96pp.

Tamura, T., Kishiro, T., Bando, T., Yasunaga, G., Murase, H., Kitakado, T. and Pastene, L. A. 2016. The Japanese Whale Research Program under Special Permit in the western North Pacific Phase-II (JARPNII): results and conclusions in the context of the three main objectives, and scientific considerations for future research. Paper SC/F16/JR1 presented to The Expert Panel Workshop of the final review on the western North Pacific Japanese Special Permit programme (JARPN II), Tokyo, February 2016 (unpublished). 68pp.

Annex 6

Whale sampling survey design under Primary Objective I (common minke whale)

Research area
Sub-areas 7 (7CN, 7CS, 7WR, 7E), 8, 9 and 11 are proposed as the research areas for Primary Objective I. Sub-areas 7, 8 and 9 are particularly important for the research under Secondary Objective I (iii; iv) while sub-area 11 is particularly important for the research under Secondary Objective I (i).

Research period
Annual surveys in the sub-areas above will be conducted between April and October, which is the migratory season of common minke whale around Japan. The research period under the NEWREP-NP is planned to be 12 years with a mid-term review after the first six years (see rational in section 3.1.1 of the main text).

Target species and sample sizes under Primary Objective I
The target species is the common minke whale. The annual sample size in sub-areas 7-9 will be 123 animals while that in sub-area 11 for the first 6 years will be 47 animals. In the Pacific side of Japan, 80 will be sampled in coastal subareas (7CS and 7CN) and 43 will be sampled in offshore waters (sub-areas 7WR, 7E, 8 and 9) (see details on sample size estimates in Annex 11).

The number of samples by month, year and sub-area collected by JARPN/JARPNII in the period 1994-2016 and the expected number of samples by NEWREP-NP in the period 2017-2022, are shown in Tables 1 and 2, respectively.

Research vessels
Five small type whaling catcher vessels (*Sumitomo Maru No. 51*; *Taisho Maru No. 3*; *Koei Maru No. 8, Katsu Maru No. 7* and *Seiwa Maru*) will be employed for sampling of common minke whales in sub-area 11 and sub-areas 7CS and 7CN. The pelagic research vessels (*Nisshin Maru* research base and two sampling and sighting vessels, *Yushin Maru No. 1* and *3*) will be employed for sampling common minke whales in offshore waters (sub-areas 7-9). See details of the research vessels in Annex 21.

Survey procedures
Sampling in sub areas 7CN, 7CS and 11
A land-based operation system will be incorporated for whale sampling in the coastal sub-areas. Basically the vessels depart the port every morning, and return to the port every night. In order to cover a larger area within sub areas 7CS, 7CN and 11 (excluding the EEZ zones of foreign countries), whales will be sampled in different ports regardless of whether or not those ports have a land station to conduct the biological survey. All whales sampled will be transported by tracks from the port to the nearest land station. *Nisshin Maru* may be used as a research station when necessary.

Land stations with a research head office will be established in the respective season for biological sampling, flensing, and commanding the operation of the sampling vessels. Land stations will be established in Kushiro (sub-area 7CN), Ayukawa (sub-area 7CS) and Abashiri (sub-area 11).

The sampling procedure is designed taking account operational capacity, ability, and arrangements of the small boats, and is different from the random sampling procedures adopted by the NEWREP-NP offshore component using large vessels (*Nisshin Maru* research fleet). The general procedure is as follows:

(1) A predetermined course (direction from the port) at an angle of regular intervals (usually 10-15 degree intervals) are set up by the head office, and allocated to the respective boat (Figure 1-A). The boats depart the port with respective course, and start searching at a survey speed of 10-11 knots.

(2) The boats search along the course until common minke whales are sighted, or continue the search until they arrive at 30 n. miles from the port (Figure 1-B). Each boat tries to take her first encountered whale. If the boats miss the targeted whale, they resume searching along the course.

(3) If the boat captures a whale, the boat returns to the port transporting the animal to the research station. During the return, searching is resumed, and other common minke whales sighted are targeted for sampling, when the situation allows it. After the whale is transported to the station, the boat departs again

from the port. Carrying vessel (s) might be deployed to transfer caught whales from the small boats to the port so that the boats could focus on sampling.

(4) After arriving at 30 n. miles from the port, the boats change the course freely, and continue the searching (Figures C, D).

(5) When the weather or sea state are expected to worsen before arriving at 30 n. miles from the port, then the boats change the course freely at that point. When the weather changed to more bad conditions (waves of around 2m height or Beaufort 4 or more), the boats return to the port.

(6) Searching is continued until 30 minutes before sunset, and then all boats return to the port.

(7) The predetermined course is changed every day to cover broader areas.

(8) If the vessels could not reach the number of common minke whales targeted, *Nisshin Maru* research fleet will conduct sampling activity in sub areas 7CN, 7CS as a backup survey to increase the sampling effort.

Searching will be carried out from the top barrel (6 to 7m above the surface) by all crew members (4 to 5 persons), except those persons handling the boat. Searching will be also conducted occasionally from the upper bridge by one or two crew members and a researcher. At least one researcher will be on board in each boat, and will record information on sighting, sampling and searching effort, *e.g.*, time and location of sighting and sampling, species and school size sighted, and activity and cruise tracks of the boat. Weather information (weather, visibility, wind force, and sea surface water temperature) will be also recorded at every hour.

Sightings of whales will be classified into primary and secondary sightings. The primary sightings are those seen during normal searching mode (sighting effort from the top barrel). The secondary sightings are those made in mode other than normal searching mode, *e.g.*, during closing or chasing target whales, when there is no observer in the top barrel, or outside of the research time.

All primary and secondary sighting, excluding cow and calf pairs, will be targeted for sampling. Observers on the top barrel will count the number of whales in the school and will estimate the body length of each animal. If a sighting is a solitary whale, the whale will be sampled immediately after the body length estimation. If a school consists of two or more animals, the researcher will assign a serial number to each individual and the first targeted whale will be chose for sampling using tables of random sampling numbers (TRS). When two whales are sampled from a school, the second target whale will be selected by the same manner after the first animal is sampled. In this case, the remaining individuals are renumbered according to the latest position in the school.

Sampling is made by 50mm whaling cannon. In order to maintain the human safety during the operations, chasing will be usually limited to a maximum of 120min.

The whale sampled will be pulled onto the rear deck of the vessel and will be transported to the port. At the port, the whale will be lifted up from the vessel by a crane, using a wire net, and transported to the land station by an 11-tons freight trailer. All the whales sampled will be biologically examined by researchers on the land station in almost the same manner as that for the JARPNII.

Details of the field, laboratory and analytical procedures are given in section 3.1 of the main text.

Ayukawa and Kushiro land stations will be switched depending on the migration of the common minke whale; e.g. Ayukawa from spring to summer: Kushiro from summer to autumn.

Abashiri (sub-area 11) will be surveyed in different seasons as follows (just for indication):

2017: Summer
2018: Autumn
2019: Spring
2020: Autumn
2021: Spring
2022: Autumn

(ii) Sampling in sub-areas 7WR, 7E, 8 and 9

As indicated above sampling of common minke whales in offshore waters will be carried out by the sampling and sighting vessels attached to the research base *Nisshin Maru*, which will be also engaged in sampling of sei whales under Primary Objective II. Sampling procedure for minke and sei whales in offshore waters is described in Annex 12.

Table 1. Distribution of available samples of common minke whale, by year, month and sub-area.

Year-Month	Tot	Sub-areas						
		11	7CS	7CN	7WR	7E	8	9
1994-4								
1994-5								
1994-6								
1994-7	21							8
1994-8								9
1994-9								4
1994-10								
1995-4								
1995-5								
1995-6								14
1995-7	100							61
1995-8								25
1995-9								
1995-10								
1996-4								
1996-5								
1996-6								
1996-7	77				1		11	
1996-8		30		15			5	
1996-9				15				
1996-10								
1997-4								
1997-5								27
1997-6					1	1		40
1997-7	100						31	
1997-8								
1997-9								
1997-10								
1998-4								
1998-5					25	31	8	
1998-6							36	
1998-7	100							
1998-8								
1998-9								
1998-10								
1999-4								
1999-5								
1999-6			1	47	2			
1999-7	100	50						
1999-8								
1999-9								
1999-10								

Year-Month	Tot	Sub-areas						
		11	7CS	7CN	7WR	7E	8	9
2000-4								
2000-5								
2000-6								
2000-7	40							
2000-8			4	2				16
2000-9			1	17				
2000-10								
2001-4								
2001-5			14		14			
2001-6				10	5	7		
2001-7	100						21	24
2001-8								5
2001-9								
2001-10								
2002-4								
2002-5								
2002-6								
2002-7	150							21
2002-8				5	1		7	5
2002-9				91			1	6
2002-10				13				
2003-4			49					
2003-5			13		5	5	19	
2003-6							18	11
2003-7	150					2		
2003-8								28
2003-9								
2003-10								
2004-4								
2004-5								
2004-6								
2004-7	159							24
2004-8								60
2004-9				51				
2004-10				24				
2005-4			32					
2005-5			28				10	10
2005-6			5	9				3
2005-7	220			17	1		4	3
2005-8								38
2005-9				35				
2005-10				25				

Table 1 (Cont.)

Year-Month	Tot	Sub-areas						
		11	7CS	7CN	7WR	7E	8	9
2006-4			19					
2006-5			54		3			
2006-6			3		6	2	26	10
2006-7	195			10	1		12	14
2006-8								
2006-9				22				
2006-10				13				
2007-4			10					
2007-5			47				1	1
2007-6			40	33	6		14	5
2007-7	207							
2007-8								
2007-9				21				
2007-10				29				
2008-4			37					
2008-5			23					
2008-6							5	3
2008-7	169							29
2008-8								22
2008-9				32				
2008-10				18				
2009-4			15					
2009-5			45			4	1	3
2009-6			1	2	8			4
2009-7	162			4			16	
2009-8								
2009-9				34				
2009-10				25				
2010-4			4					
2010-5			36					
2010-6			5					
2010-7	119							12
2010-8								2
2010-9				50				
2010-10				10				
2011-4								
2011-5				15				
2011-6				2				1
2011-7	126		23	24				
2011-8								1
2011-9				31				
2011-10				29				
2012-4			9					
2012-5			76	32				
2012-6				9	5		3	
2012-7	182							
2012-8								
2012-9				26				
2012-10				22				
2013-4			4					
2013-5			28					
2013-6			2					
2013-7	95							
2013-8								3
2013-9				46				
2013-10				12				
2014-4			7					
2014-5			19					
2014-6			4					
2014-7	81							
2014-8								
2014-9				51				
2014-10								
2015-4			15					
2015-5			4					
2015-6								
2015-7	70							
2015-8								
2015-9				33				
2015-10				18				
2016-4			7					
2016-5			9					
2016-6								
2016-7	37							
2016-8								
2016-9				11				
2016-10				10				

Table 2. Tentative distribution of common minke whale samples under the NEWREP-NP, by year, month and sub-area

Year-Month	Tot	Sub-areas: 11	7CS	7CN	7WR	7E	8	9
2017-4								
2017-5								
2017-6		47						
2017-7						43		
2017-8	170		80					
2017-9								
2017-10								
2017-11								
2018-4								
2018-5								
2018-6								
2018-7			80			43		
2018-8	170	47						
2018-9								
2018-10								
2018-11								
2019-4								
2019-5		47						
2019-6								
2019-7			80			43		
2019-8	170							
2019-9								
2019-10								
2019-11								
2020-4								
2020-5								
2020-6								
2020-7	170		80			43		
2020-8		47						
2020-9								
2020-10								
2020-11								
2021-4								
2021-5		47						
2021-6								
2021-7	170		80			43		
2021-8								
2021-9								
2021-10								
2021-11								
2022-4								
2022-5								
2022-6								
2022-7			80			43		
2022-8	170	47						
2022-9								
2022-10								
2022-11								

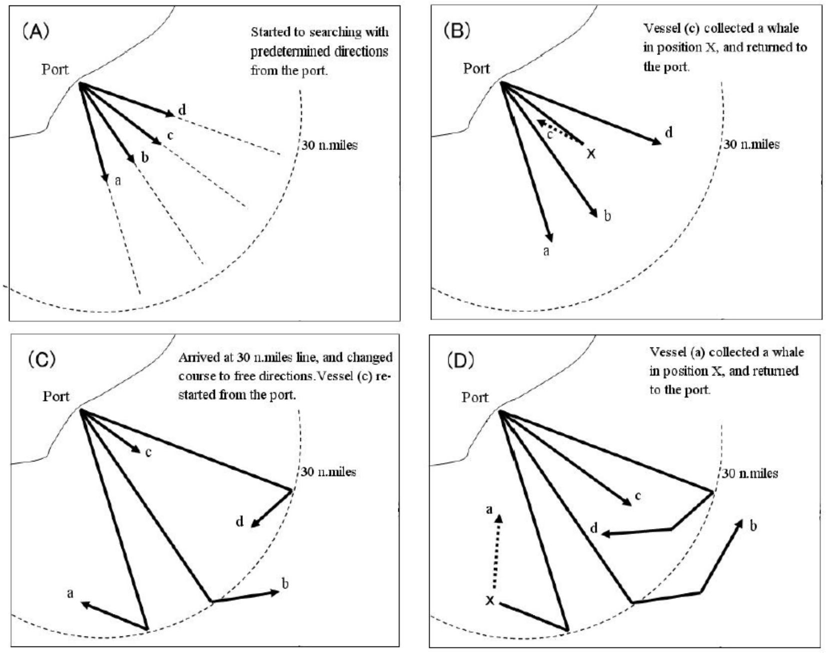


Figure 1. Schematic diagram showing the searching mode for sampling in the coastal component of the NEWREP-NP. Arrows with letters 'a' to'd' indicate examples of the movements of respective small-type whaling catcher boat.

Annex 7

Secondary Objective I (i)
Investigate the spatial and temporal occurrence of J stock common minke whales around Japan, by sex, age and reproductive status

Field and laboratory work, and analytical procedure

Background
Information on stock structure, including the information on distribution, movement and mixing of the O and J stocks is important for the RMP *Implementation* of western North Pacific common minke whale. With the implementation of JARPN and JARPNII and the development of analytical techniques for examining genetic data, a substantial amount of information has been obtained on the distribution and mixing of O and J stocks around Japanese waters.

The last genetic study on distribution and mixing proportion of O and J stocks around Japanese waters was based on JARPN/JARPNII and bycatch samples obtained till 2014 (Pastene *et al*., 2016). The study showed that the composition of O and J stocks, estimated by microsatellite DNA and the STRUCTURE program, differs among areas and survey component (Figures 1 and 2).

It was concluded during the RMP *Implementation* that the J stock is heavily depleted. However this perception is difficult to reconcile with several lines of evidence. For example J stock animals showed a sustained or increasing trend of bycatches for a recent period of more than 10 years, while decreasing in the amount of set nets in which this bycatch occur (Table 1).

Another line of evidence is the proportion of J-stock animals in sub-area 7, which increased from 1.8% in the commercial whaling in 1983-1987 (Goto, unpublished data) to 21.7% for the coastal JARPNII surveys in 2002-2014 (Pastene *et al*., 2016). Commercial whaling in 1983-1987 in sub-area 7CS (Sanriku) was conducted mainly in the months April-June, which is similar to the period of coastal whaling by JARPNII in the same sub-area. The distribution range of J stock animals on the Pacific side of Japan is limited to the coastal zone, mainly within 30 miles from the coastline. When commercial whaling-Sanriku is compared with JARPNII whaling-Sanriku, a larger percentage of J stock animals was estimated for the later, for distances <10n miles and 10-20n miles from the coastline. Sample size for distances >20n miles is very small for JARPNII (see details in Appendix 1).

The information summarized above could indicate the possibility of an increasing J stock that is expanding its distribution.

Information on distribution and mixing proportion of J and O stocks in sub-area 11 is limited (see details in Table 2), but a similar trend for the J stock proportion as that observed in sub-area 7 is expected. Clearly additional sampling in different months is required for sub-area 11, and NEWREP-NP will carry out such sampling and analyses on J and O stocks mix proportion trend in that sub-area.

Hatanaka and Miyashita (1997) showed that O stock animals segregate by sex and reproductive status in the western North Pacific. A similar pattern of segregation can be expected for J stock animals. The study suggested that in order to evaluate the spatial and temporal migration pattern of whales, both genetic and non-genetic data such as age, sex, body length and sexual maturity, is required.

This annex explains the field, laboratory and analytical procedures associated with this Secondary Objective.

Methods
Field work
<u>Genetic samples</u>
Skin tissues of common minke whales will be taken during NEWREP-NP and stored in 99% ethanol until DNA extraction. In the case of biopsy sampling, the details of equipment and sampling procedure are described in Annex 19.

<u>Morphology (flipper coloration pattern)</u>
Morphological differences in the size and pattern of the white patch on the flipper of each whale (Nakamura *et al*., 2016) will be examined to assist the genetic assignment into J and O stock animals (see below). The proportional size and boundary area pattern of the white patch on the flipper of each whale will be the focus for

this study. The following three flipper characteristics are measured after the flipper is dissected from the whale's body: flipper length, distance from the tip of the flipper to the distal end of the white patch and the tip to mesial end of the white patch. These points will be measured to millimeter scale accuracy using measuring tape or a stainless steel caliper.

Biological samples

(1) Age

There are two potential methods to collect age-data for common minke whales: counting of growth layer groups (GLGs) accumulated in the earplug of whales and the use of racemization ratio of aspartic acid in eye lens.

Earplug

The left and right earplugs with glove-finger are collected carefully, and immediately fixed in 10% formalin solution until age estimation. Because young whales have soft and easily broken earplugs, earplugs of small individuals are collected using the method of gelatinized extraction, following Maeda *et al*. (2013).

Racemization

Eye lens from both sides will be collected from each whale and stored in polyethylene bags at -80°C until analysis.

(2) Body length

Body length is measured in a straight line from the tip of the snout to the notch of the flukes for all animals.

(3) Maturity status

Maturity of females will be preliminary determined in the field by the presence or absence of corpora lutea/albicantia in both ovaries. Both ovaries are preserved at -20℃.

Maturity of males will be preliminary determined in the field by testis weight, and confirmed later by examination of histological testis samples. Testis weight (heavier side) of more than 290g is defined as sexually mature (Bando unpublished data). Testis tissue samples will be collected from all males and fixed in 10% formalin solution.

Presence of fetus will be examined by cutting both sides of the uterine horn. Photographic records, body length and weight measurements and sex identification will be conducted for each fetus.

Laboratory work

Genetics

Laboratory work and data analyses described in this Annex will follow the IWC SC's guidelines for DNA data quality (IWC, 2009) as much as possible. Sampling and laboratory procedures of the genetic laboratory of the Institute of Cetacean Research were summarized by Kanda *et al*. (2014), and the IWC SC agreed that the paper had responded appropriately to some relevant recommendations on DNA data quality from the JARPA II review workshop (IWC, 2015a, b). In 2016 additional information was provided by the proponents on estimates of microsatellite genotyping error rates and again, the IWC SC agreed that the work presented had addressed a recommendation on DNA data quality from the JARPNII final review workshop (IWC, 2016).

Total genomic DNA is extracted from tissue pieces preserved in 99% ethanol at room temperature, using Gentra Puregene kits (QIAGEN). Extracted DNA is stored in the TE buffer (10 mM Tris-HCl, 1 mM EDTA, pH 8.0).

For microsatellite DNA (msDNA), a set of 16 loci are used: EV1, EV14, EV21, EV37, EV94, (Valsecchi and Amos, 1996), GT23, GT195, GT211, GT310, GT509, GT575, (Bérubé *et al*., 2000), GATA28, GATA98, GATA417, TAA31, (Palsbøll *et al*., 1997), and DlrFCB14 (Buchanan *et al*., 1996). Ten additional microsatellite loci will be considered in an effort to decrease the number of unassigned animals by the STRUCTURE analysis (see below). PCR amplifications will be performed following the manufacturer's instructions for the use of Ex *Taq* DNA polymerase (Takara Shuzo). All PCR products will be electrophoresed on an ABI 3500 Automated DNA Sequencer. Allele sizes will be determined using a 600 LIZ size standard and GeneMapper v. 4.0 (Applied Biosystems, Inc).

For mitochondrial DNA (mtDNA), approximately 500 base pairs of the hypervariable portion from the 5' end of the control region and flanking genes will be amplified by the polymerase chain reaction (PCR) with a set of primers, light-strand MT4 (5'-CCTCCCTAAGACTCAAGGAAG-3'; Árnason *et al*., 1993) and heavy-strand Dlp5R (5′-CCATCGAGATGTCTTATTTAAGGGGAAC-3′). PCR is carried out in a 25 µL reaction mixture containing PCR buffer (10 mM KCl, 2 mM Tris-HCl [pH 8.0], 2 mM $MgCl_2$), 0.5

mM dNTPs, 1.25 µM primers, 0.65 units Taq DNA polymerase (Takara, Otsu, Japan), and 10−100 ng DNA template. PCR products will be purified by MicroSpin S-400HR columns (Pharmacia Biotech), and cycle sequenced using BigDye terminator v3.1 cycle sequence Kit (Applied Biosystems, Inc). All samples will be sequenced for both strands with the primers used in PCR amplification, which will be purified using AutoSeq G-50 spin Columns (Pharmacia Biotech). The labeled sequencing fragments will be resolved by electrophoresis on ABI 3500 Automated DNA Sequencer (Applied Biosystems, Inc).

<u>Biological samples</u>
(1) Age
Earplug
In the laboratory, the flat along the central axis of the earplug will be cut using a sharp blade, then it will be ground on a wet stone to expose the neonatal line and growth layers. Growth layers will be counted under water using stereoscopic microscope. A year of age is defined as one pair of the light and dark laminae in the core in accordance with Best (1982) and Lockyer (1984). Age reading will be conducted in the following manner: i) earplug of the left side will be read. If the growth layers in the earplug are ambiguous, the earplug from the right side will also be read. Reading from the less ambiguous side will be adopted; ii) age reading will be conducted only once without any knowledge of biological information such as body length or sex; iii) when reading of all sample is completed, age data will be compared with biological data such as body length or sexual maturity, and some samples will be re-read to check for outliers, incomplete samples or invalid readings. An inter-reader calibration experiment, following the method of Kitakado *et al*. (2013), will be conducted if necessary.

Racemization
Analysis of the ratio of D- and L-aspartic acids (Asp D/L) will follow the method previously described (Yasunaga *et al.*, 2014). The core samples will be carefully taken from the lens samples to avoid contamination and homogenized with Tris-buffer (200mM Tris, 150mM NaCl, pH 8.0) using ultrasonic disruptors. The homogenate will be centrifuged at 15,000 × g for 15 min. at 4°C, and it will then be desalted with acetone and air-dried. The purified samples will be lyophilized in tubes and hydrolyzed in the gas-phase 6N-HCl for 7 hr at 108°C. The hydrolysates will be dissolved and incubated in 0.1N-HCl and Borate buffer (0.1M, pH10.4), and incubated with o-phthalaldehyde (OPA) and n-tert-butyloxycarbonyl-L-cysteine (Boc-L-Cys) to form diastereoisomers. The D/L ratio of aspartic acid will be determined using RP-HPCL (Alliance ® HPLC systems e2696, Waters) with a Nova-Pak ODS column (3.9mm ×300mm, Waters) using fluorescence detection (344 nm excitation wavelength and 433 emission wave length). Elution will be carried out with a simple isocratic adsorption of 3% acetonitril+3% tetrahydrofuran /0.1M acetate buffer pH6.0 in 45 min at a flow rate of 0.8 ml/min, at 23°C. To estimate ages by ratio of enantiomers of aspartic acid, the formula of Bada *et al.* (1980): $2Kasp \cdot t = Ln((1 + D/L) / (1 - D/L)) - Ln((1 + D/L) / (1 - D/L))_{t=0}$, where Kasp is the rate constant of conversion between L and D enantiomers, t is the age of the whale, D/L is the ratio of the enantiomers in the lens, and "t=0" is the ratio at birth, will be used. The specific coefficients in each whale species will be determined by comparing with their earplug ages.

(2) Maturity status
Counting the number of corpora lutea/albicantia in both ovary will be conducted by cutting the surface of ovary with a scalpel.

HE stained testis section will be created and observed under a standard microscope for identification of sexual maturity status. Males with seminiferous tubules over 100µm diameter, spermatid or open lumen in the tubules have been determined to be sexually mature (Kato, 1986; Kato *et al*., 1990, 1991).

Analytical procedure
<u>Genetics</u>
The newly obtained samples will be assigned to either O or J-stocks, applying all available microsatellite data to a Bayesian clustering analysis in the program STRUCTURE version2.0 (Pritchard *et al*., 2000). The program implements a model-based clustering method for inferring stock structure (K, the number of stocks in the model) using multilocus genotype data with and without information on sampling locations, which allows for the analyses of the samples without choosing sample units. The posterior probability for $K = 2$ will be estimated from ten independent runs without information on sampling locations. All runs will be performed with 100,000 Markov chain Monte Carlo repetitions and 10,000 burn-in length using the admixture model which assumes individuals may have mixed ancestry, with correlated allele frequencies which assumes frequencies in the different stocks are likely to be similar due to migration or shared ancestry. Individual assignment will be conducted using estimated individual proportion of membership probability (>90%). In addition, the number of alleles, expected heterozygosity and inbreeding coefficient, per locus and across loci will be calculated in sub-area 11 using the FSTAT 2.9.3 (Goudet, 1995) to understand the genetic variations of the

present msDNA data. The deviations from expected Hardy-Weinberg equilibrium will be assessed using the GENEPOP 4.0 (Rousset, 2008). The False Discovery Rate approach (Benjamini and Yekutieli, 2001) will be used to adjust *p*-value for all multiple comparisons.

The phylogenetic analysis based on the Neighbor-Joining method (Saitou and Nei, 1987) will be performed using mitochondrial sequences, in the program PHYLIP (Felsenstein, 1993) to complement the individual assignment by the STRUCTURE analysis. The program DNADIST of PHYLIP will be used to estimate the genetic distances among haplotypes based on Kimura's two-parameter model (Kimura, 1980) and the transition-transversion ratio of five to one. The genealogy will be rooted using the homologous sequence from North Atlantic common and Antarctic minke whales. To estimate reliability for each node, a total of 1,000 bootstrap simulations will be conducted and the majority-rule consensus genealogy estimated. In addition, the number of haplotypes, haplotype (Nei, 1987) and nucleotide diversities (Nei, 1987: equation 10.5) based on the Kimura's two-parameter (Kimura, 1980) with its standard errors will be calculated in sub-area 11 as one of ancillary data.

Flipper coloration pattern

The boundary area pattern of the white patch named as "Grayish Accessary Layer (GAL)" will be classified into four groups. In the process of the statistical analysis, the Mann–Whitney *U*-test will be adopted to compare the proportional size of the white patch on the flipper and Pearson's chi-square test will be adopted to compare the frequency of GAL types between two stocks. Each analysis will use the statistic software R 2.13.0.

Spatial and temporal occurrence of J stock by sex, age and reproductive status

The pattern of spatial and temporal occurrence of J stock animals in sub-area 11 by sex, age and reproductive status will be examined after the first year period of NEWREP-NP. Yearly trend in the J stock proportion will be estimated by Linear Regression Models.

Table 3 shows the number of historical samples in sub-area 11 by month, year and the tentative sampling under NEWREP-NP during the first six years of the program.

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Table 1. Number of bycaught common minke whales around Japanese waters, and the number of large set nets, by year and stock.

Year	J stock	O stock	Unassigned	No. of large set nets
2001	37	3	5	774
2002	74	9	10	781
2003	81	18	9	781
2004	86	6	12	757
2005	90	14	9	729
2006	103	18	10	703
2007	108	20	12	654
2008	97	11	13	651
2009	95	6	10	648
2010	96	6	9	644
2011	75	6	4	617
2012	83	9	8	617
2013	77	9	8	598
2014	107	13	11	594

Table 2. Number of available samples from Pacific and Okhotsk coastal area of Japan by month, sub-areas and sources. CW: commercial whaling from 1983 to 1987, JARPN: 1994-1999, JARPNII: 1994-2014, BC: Bycatch 2001-2014

	2		7CN			7CS			7WR		11		
Month	CW	BC	CW	JARPN(II)	BC	CW	JARPN(II)	BC	CW	JARPN(II)	CW	JARPN	BC
1		69						31					
2		58						7					
3		51						19					
4		68	1		8	25	185	44			54		
5		54		48	13	14	369	52		58	39		9
6		29	7	112	21	13	57	44		37	19		11
7		18	15	54	19	6	23	12	1	4	1	50	2
8		10	5	22	5		4	7		1	4	30	
9		1	23	521	5		1	4			5		3
10		11		219	2			5					10
11		38			7			26					13
12		81			10			31					
	0	488	51	976	90	58	639	282	1	100	122	80	48

Table 3. Number of historical and future sample/data of common minke whales in sub-area 11 (allocation to month is tentative)

Year	Source	April	May	June	July	August	September	October	November	Total
1984	Commercial	13	24				2			46
1985	Commercial	13								13
1986	Commercial	13	10	6		2				31
1987	Commercial	13	4	6	1	2	3			31
1996	JARPN					30				30
1999	JARPN				50					50
2001	Bycatch						2	1		3
2002	Bycatch		1		1			1	2	5
2003	Bycatch			1				3	4	8
2004	Bycatch		2	1						3
2005	Bycatch		1	2					3	6
2006	Bycatch			1				2		3
2007	Bycatch		1	1				2	2	6
2008	Bycatch		1					1	1	3
2009	Bycatch								1	1
2010	Bycatch		1	2			1			4
2011	Bycatch			1						1
2012	Bycatch		1	2					1	4
2014	Bycatch		1		1					2
2017	NEWREP-NP			47						47
2018	NEWREP-NP					47				47
2019	NEWREP-NP		47							47
2020	NEWREP-NP					47				47
2021	NEWREP-NP		47							47
2022	NEWREP-NP					47				47

*DNA and other biological data from whales sampled in a given year will be available in the next year

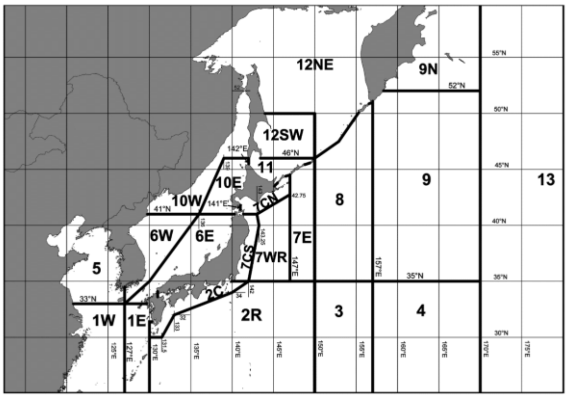

Figure 1. Sub-areas used for the management of common minke whale under the RMP.

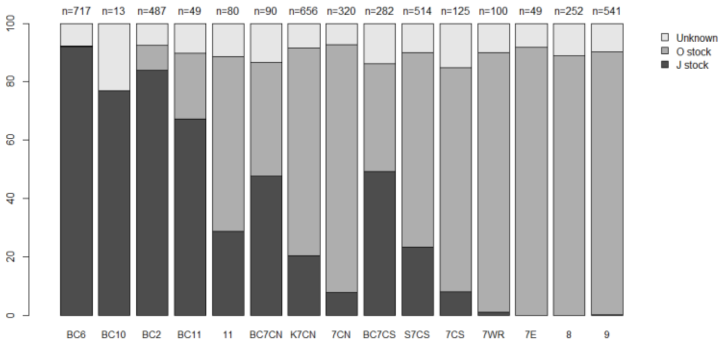

Figure 2. Spatial occurrence of O and J stocks in waters around Japan. BC2, BC6, BC7CS, BC7CN, BC10, BC11= bycatches from sub-areas 2, 6, 7CS, 7CN, 10 and 11. K7CN= coastal survey at Kushiro. S7CS= coastal survey at Sanriku. 7CS, 7CN, 7WR, 7E, 8, 9 and 11= offshore survey of JARPN and JARPNII. Sample size is on the top of each bar. Each whale was assigned to the 'O', 'J' and 'Unassigned' stock based on the microsatellite analysis (Pastene *et al*., 2016).

Appendix 1

Mixing of J and O stock common minke whales in the coastal area of Japan

Common minke whales have been caught by past commercial whaling, JARPN/JARPNII and bycaught by set net fisheries along the Japanese coast. Composition of J and O stock common minke whales estimated by microsatellite assignment differs among sub-areas and survey components. Although some of the J stock animals migrate into the Pacific side of Japan, their distribution range is limited to the coastal zone, mainly within 30 miles from the coastline (Figures 1 and 2).

The mixing proportion of J stock animals in sub-area 7 during the 1983-1987 commercial whaling period was 1.8% (Goto, unpublished data). On the other hand, the mixing proportion of J stock animals during the 2002-2014 JARPNII coastal surveys conducted in sub-area 7 was 21.7% which was much larger than the commercial whaling period (Figure 1).

Sampling of commercial whaling and JARPNII coastal survey was conducted at approximately the same season at the Sanriku region (sub-area 7CS): April to June. However, mixing proportion of J stock animals differs between commercial and JARPNII coastal survey in each distance from the coastline in Sanriku, being larger in the JARPNII coastal survey (Table 1, Figure 1).

The information above suggests a possible recovery of J stock common minke whales and an ensuing increased ‘spill over’ from the Sea of Japan to the Pacific side of Japan. Further investigation is necessary to confirm this.

There is no much data to speculate on the J stock proportion yearly trend in sub-area 11. Monthly composition of J and O stock animals in sub-area 11 collected by commercial whaling, JARPN and bycatches are shown in Figure 3. In the commercial whaling samples, the proportion of J stock animals was over 60% in the April, however, the few samples from other months had a low proportion of J stock animals. On the other hand, available samples from JARPN were limited to two months (July and August) and the proportion of J stock in both months was around 30%. Clearly the number of samples are very limited in sub-area 11.

Table 1. Mixing proportion of J stock common minke whales in sub-area 7CS by distance from coastline. Samples were collected by commercial whaling (1983-1987) and JARPNII coastal Sanriku survey (2003-2014) in spring season (April to June).

Distance from coastline (n.miles)	Commercial				JARPNII (coastal Sanriku)			
	J stock	O stock	Unassigned	J stock ratio (%)	J stock	O stock	Unassigned	J stock ratio (%)
<10	0	6	0	0.0	39	120	20	21.8
10-20	1	25	2	3.6	81	218	32	24.5
20-30	1	18	2	4.8	0	5	1	0.0

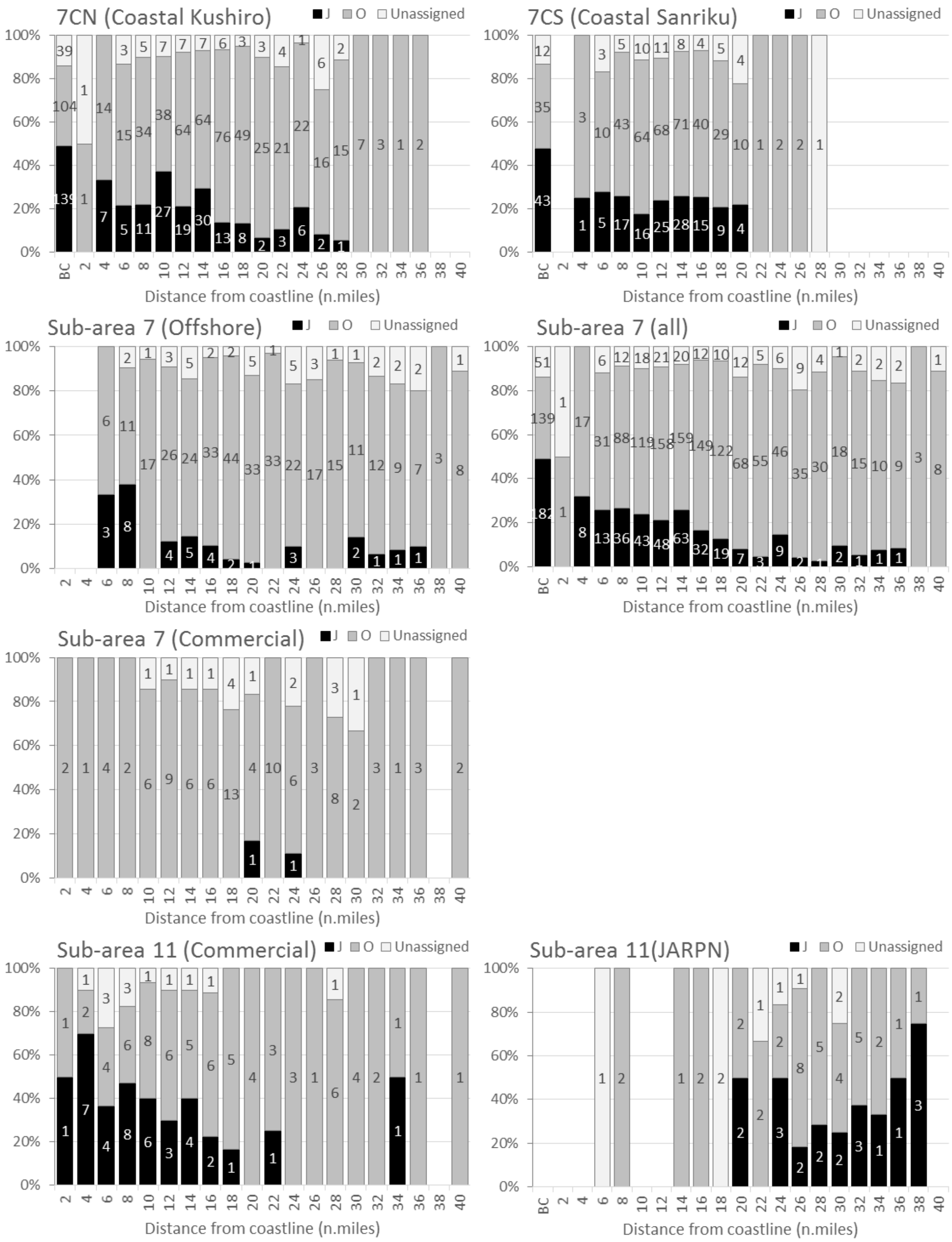

Figure 1. Differences in composition of J and O stock common minke whales in relation to the distance from the coastline. Data of sub-area 7 were summarized for JARPNII coastal component off Sanriku and Kushiro, offshore component and commercial whaling. Data of sub-area 11 were summarized for commercial whaling and JARPN survey. Sample size is shown in the graph. The figures for bycatch samples (BC) in each sub-area was added to each plot.

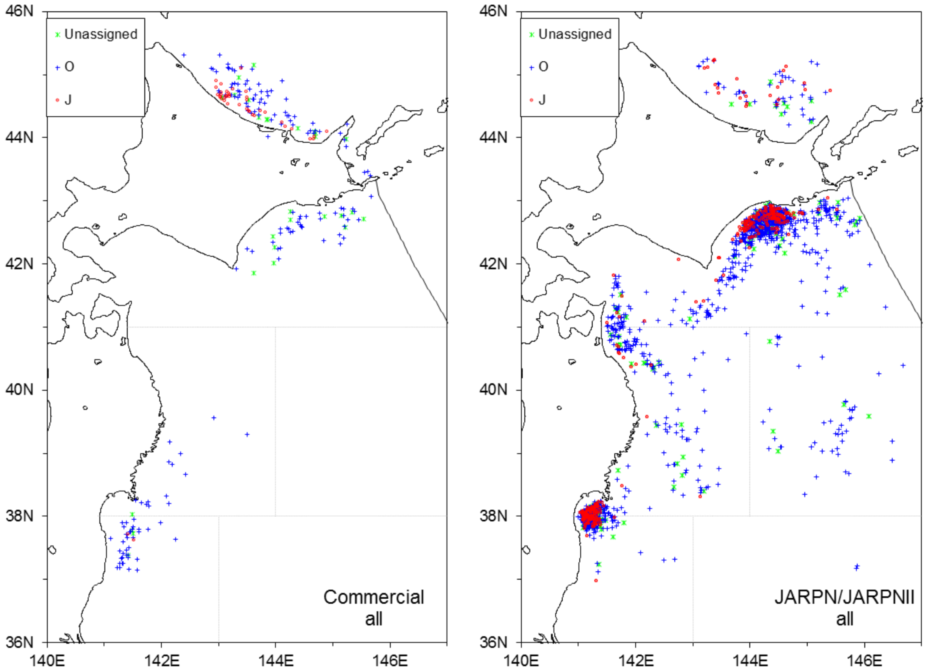

Figure 2. Sighting/catch position of common minke whales collected during 1983-1987 commercial whaling (left) and 1994-2014 JARPN/JARPNII surveys (right) in sub-areas 7 and 11 assigned as O stock (blue), J stock (red) and unassigned (green), based on microsatellite DNA and STRUCTURE analysis.

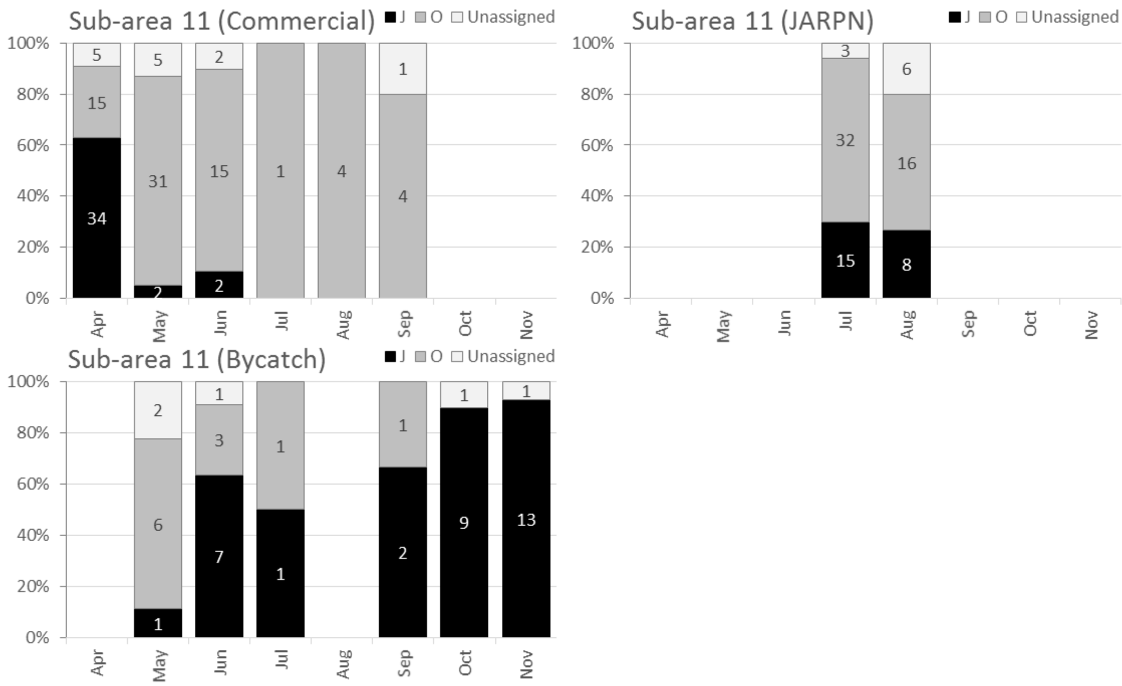

Figure 3. Monthly composition of J and O stock common minke whales collected in sub-area 11 by commercial whaling, JARPN and bycatches.

Annex 8

Secondary Objective I (ii)
Estimate the abundance of the J and O stocks in coastal waters of Japan

Field and laboratory work, and analytical procedure

Background
Most of the common minke whales are considered J stock animals in sub-areas 5, 6W, 6E, 10W and 10E. Most of the common minke whales are considered O stock animals in sub-areas 7WR, 7E, 8, 9 and 12NE. In sub-areas 7CS, 7CN, 11 and 12SW, it is necessary to estimate the mixing proportion of the J and O stocks because the two stocks are mixing in these areas. In order to fully estimate abundance for the J and O stock, information on mixing estimates in these sub-areas are necessary.

Dedicated sighting surveys in sub-areas 6E, 10E and 10W were conducted in May-June by the National Research Institute of Far Seas Fisheries (NRIFSF) for 2002-2007 (Miyashita *et al*., 2009; IWC, 2014). Sub-area 11 was surveyed in August-September for 1990, 1999, 2003 and 2007 (IWC, 2014). Sub-areas 12SW and 12NE were surveyed in August-September for 1990, 1999, 2003 and 2007 (IWC, 2014). In 2010, sighting surveys and biopsy sampling of the common minke whales was conducted for genetic analysis in these sub-areas (Yoshida *et al*., 2011). Restricted areas in the Sea of Okhotsk were surveyed in 2015 and 2016 under the cooperation between the Russian Federation and Japan (Myasnikov *et al*., 2016; Tiupeleev *et al*., 2016). Some parts of sub-areas 5 and 6W were surveyed in April-June by Korean sighting survey for 2000-2011 (IWC, 2014). In the JARPN II, dedicated sighting surveys were conducted sub-areas 7, 8 and 9 excluding foreign EEZ in early and late seasons (Kiwada *et al*, 2009; Matsuoka *et al*., 2016).

From these surveys, abundance estimates assuming g(0)=1, which were used in the RMP/IST of the common minke whales, were summarized including information on primary effort, primary sighting position, survey blocks, sub-areas, and area definitions for surveys for western North Pacific common minke whales in Appendices 3 and 4 of IWC (2014). Based on these appendices, IWC (2014) listed the accepted abundance estimates used in the RMP context for the common minke whales (JCRM (suppl) 15: 128-9). This table also summarized the extent of the acceptability and the extent of the evaluation. Additional abundance estimates based on JARPNII were added to the list (see p12 of Annex D of IWC, 2016b).

Okamura *et al*. (2009) estimated abundance considering g(0) estimates for each platform and their combinations. The results were presented to IWC/SC in 2009. In the discussion, it was noted that although there had been no IO data collection in surveys in previous years, in the absence of direct estimates of g(0) , the estimates of g(0) presented in Okamura *et al*. (2009) could be used for the top barrel and the upper bridge for these earlier surveys.

Field work
Sighting surveys are planned to be conducted by line transect method following the survey protocols set out in the Requirements and Guidelines for Conducting Surveys and analyzing data within the Revised Management Scheme (IWC, 2012) so that sighting surveys will be conducted under oversight by the IWC SC. Considering the recommendation from the NEWREP-A expert panel (IWC, 2015), the proponents will consider the following; (a) survey design and methods will be reviewed taken into account previous IWC sighting surveys and spatial model developments; (b) they will work closely with the IWC SC before finalizing survey approaches; (c) they will also ensure that future survey plans submitted to IWC SC follow fully the guidelines for such surveys, including the incorporation of planned track-lines.

Survey area and period
To conduct sighting surveys in sub-areas 5, 6W and 10W, it is necessary to collaborate with foreign countries, such as Korea, Russia. If the proponents cannot collaborate with the foreign countries in sighting surveys, abundance estimate based on the sighting surveys would not be available and it would be necessary to conduct indirect methods to estimate abundance such as spatial modelling framework and mark-recapture using genetic data.

Sighting surveys in sub-areas 6E and 10E in May-June will be conducted as in 2002-2007. Sighting surveys in sub-area 11 in summer will be conducted. Sighting surveys in the Sea of Okhotsk conducted in summer are necessary to estimate abundance for J and O stocks. Sighting data obtained during the sighting surveys in the restricted area in the Sea of Okhotsk for 2015 and 2016 can be used for abundance estimation. If the framework of dedicated sighting surveys in the Sea of Okhotsk under the cooperation between the Russian Federation and Japan will be continue, it would not be necessary to conduct sighting surveys in the Sea of Okhotsk under the NEWREP-NP.

Sighting survey in sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 are planned for summer (See also Annex 13).

Survey months are selected according to previous sighting surveys mentioned above. In order to estimate abundance for use in the assessment of the J and O stocks and to obtain inter-annual variance from the NEWREP-NP data, it would be better to obtain abundance estimates every three years. However, considering the availability of the dedicated sighting vessels, it is more realistic to estimate abundance every six years.

Survey mode

The sighting surveys will be conducted using Passing with Independent Observer (IO) mode, as in the past, in sub-areas 6E, 10E and 11, which are in marginal seas. Weather conditions and sea state are generally not good and there are high swells in sub-areas 7, 8 and 9, as these sub-areas are in open sea. For this reason passing mode with abeam closing mode will be conducted in these sub-areas as in the past instead of the Passing with IO mode. Passing with IO mode is to be conducted as follows. Two topmen in the top barrel and two topmen on the independent observer platform (IOP) observe at all times. Communications are essentially one-directional, with the topmen reporting information to the upper bridge observers, but no information being exchanged between the top barrel and IOP. The observers on the upper bridge should communicate with the topmen only to clarify information on the sightings (Miyashita and Okamura, 2011). The sighting method followed the Guideline for sighting survey under RMS (IWC, 2012). In order to conduct the survey, it is necessary to collaborate and to consult with NRIFSF staff, who have much experience and know-how of sighting surveys for the common minke whales using IO mode.

Biopsy sampling

In order to complement the estimate of mixing rate of J and O stocks (Annex 7), feasibility study of biopsy sampling for genetic analysis are planned. When biopsy sampling is conducted using the Larsen gun system, restricted closing mode will be conducted (Yoshida *et al*., 2011).

Analytical procedure

Design-based estimator

For preliminary analysis, mark-recapture distance sampling (Borchers *et al*., 1988, 2006; Laake 1999), which is one of the packages in the DISTANCE grogram (Thomas *et al*., 2010), will be applied to estimate abundance considering preliminary g(0) estimate. In order to estimate parameters in the detection function from each observer, likelihood of the mark-recapture component and the distance sampling component are maximized, followed by use of Horvitz-Thompson-like estimator to estimate the number of objects in the covered region (i.e. the strips searched on the survey) (Borchers *et al*., 2006) and therefore abundance estimate in the survey areas can be obtained. If sufficient sightings during IO mode will become available, a more sophisticated model such as the OK model (Okamura and Kitakado, 2012) will be applied to estimate abundance taking g(0) estimate into account using sighting data obtained in closing and IO mode so that the effects of covariates such as school size estimate and weather condition can be estimated on the g(0) estimation

Model-based estimator

Density Surface Modeling (DSM) (Miller *et al*., 2013) will be used, which is one of the packages in the DISTANCE grogram (Thomas *et al.*, 2010). But there is room for trying other options (e.g. smoother, modeling framework, variance estimation method etc.) to improve abundance estimates. For example, an approach presented by Murase *et al*. (2016) would be used as a template of this type of analysis bearing in mind the comments from the JARPNII final review workshop (IWC, 2016a). Sea Surface Temperature (SST), Sea Surface Height anomaly (SSHa) and sea surface chlorophyll-a concentration (Chl-a) recorded by satellites and digital seafloor depth data would be used as environmental covariates in the models. Data from ocean circulation models such as FRA-ROMS would also be used as covariates. It is also planned to compare abundance from model-based estimates with those from the design-based estimates. This work would be response to recommendation at the JARPNII final review workshop (IWC, 2016a).

Inter-annual variance (Additional variance)

The approach in Kitakado *et al* (2012) can be used to estimate yearly variation in abundance levels due to inter-annual change in distribution of the common minke whale population and abundance trend of the common minke whales. By considering the inter-annual variance, underestimating the variance of the abundance estimate can be avoided. This work would be response to recommendation at the JARPNII review workshop (IWC, 2016a).

Genetic mark-recapture analysis

The common minke whales will be taken in sub-areas 7CS, 7CN and 11. In these sub-areas, pregnant animals can be taken. Kanda *et al*. (2014) conducted the paternity analysis using genetic data of mother-fetus pairs and potential fathers of the fetus. This method estimated the number of the mature male in the stock. By applying the method to the samples in sub-areas 7CS, 7CN and 11, mature male numbers of the O and J stocks can be obtained if sufficient samples are available. In addition to samples from NEWREP-NP, samples from JARPN/JARPNII surveys can be used for this analysis.

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Annex 9

Secondary Objective I (iii)
Verify that there is no structure in the O stock common minke whale in the Pacific side of Japan

Field and laboratory work, and analytical procedure

Background
Despite considerable investment in the analyses of genetic and non-genetic data, different views remain in the IWC Scientific Committee (IWC SC) on the plausibility of sub-structure within the O stock of common minke whales in the Pacific side of Japan. In terms of the 2013 RMP trials for common minke whales in the western North Pacific, there could be only one stock (hypotheses A and B), or there could be two: a coastal (Ow) and an offshore (Oe) stock (hypothesis C) (IWC, 2014).

After the 2013 *Implementation Review*, several new genetic and non-genetic analyses were conducted to evaluate the plausibility of an Ow stock. The studies followed specific recommendations from the 2009 JARPNII review workshop. All these studies provided support for a single O stock in the Pacific side of Japan (see a summary of the studies in Annex 4). Therefore the proponents believe that the plausibility of hypothesis C is very low.

Research under this Secondary Objective involves new genetic analyses, particularly kinship analyses, to verify that there is no structure in the O stock common minke whale.

Methods
Field work
Genetic samples
Skin tissue samples of common minke whales will be taken during NEWREP-NP and stored in 99% ethanol until DNA extraction. In the case of biopsy sampling, the details of equipment and sampling procedures are described in Annex 19.

Satellite tagging
Feasibility trials on satellite tracking will be conducted to address the question of movement across the boundaries separating sub-areas 7CS and 7CN from offshore sub-areas. Under the single O stock structure, movement will be expected across those boundaries. Also if trials are conducted late in the feeding season, it could be possible to investigate migration routes of common minke whales to lower latitudes areas. Tracking trials will be conducted when dedicated sighting surveys are carried out in coastal areas. On such occasions, a total of five trials will be attempted in the research period.

The study will be based on a pneumatic tool (e. g. the whale tag launcher: Aerial Rocket Tag System (ARTS), Lars Kleivane and Restech Norway A/S, Norway and satellite tag: SPOT6, Wildlife computers, WA, USA) (Isoda *et al*., 2016). Satellite tags with a blubber penetration-type mount system will be shot by this tool from the bow deck. The tagged whales will be also target of biopsy sampling using the Larsen-gun system.

As the first step, satellite tagging will be carried out close to Japanese coastal waters. If a biopsy sample is obtained from the same animal which the satellite tags were attached to, genetic information with migrating route to potential breeding grounds will contribute to clarify the exact stock structure.

In planning this feasibility trial, effort is spent in developing an attachment system in consultation with staff of the National Research Institute of Far Seas Fisheries (NRIFSF, Yokohama, Japan) and Lars Kleivane from Norway, all of whom are experienced in telemetry studies on common minke whale (see Kishiro and Miyashita, 2011).

In addition a member of the proponents will attend the IWC-ONR Joint Workshop on Tag Development, Follow-Up Studies and best Practices to be held in September 2017 in Silver Spring, MD (USA) to become acquainted with the most current tagging technologies and deployment methods.

Laboratory work
Genetics
Details of laboratory work for genetics on common minke whale are described in Annex 7.

Analytical procedure
Kinship analysis
At the 2014 IWC SC meeting, Tiedemann *et al*. (2014) reported a method for finding relatives among North Atlantic common minke whales based on microsatellite data. The method involves the investigation of the relationship between false discovery rate and detection power.

The application of the method involves the following steps (see details in Tiedemann *et al.*, 2014):

1) Calculation of the locus-wise relative allele frequencies for mother-fetus pairs.
2) Calculation of the pairwise logarithm of the odds (LOD) scores among all pairs of individuals.
3) Estimation of the p-values for each LOD score of the original data set by comparing them to LOD scores obtained in a random data set of unrelated specimens.
4) Significance is established controlling for the false discovery rate (FDR).
5) Simulation of a data set of 10,000 specimens with the relatedness of interest, taking into account the applicable probabilities of locus-specific numbers of alleles identical-by-descent. The detection power of a given FDR and relatedness category will be calculated as the relative proportion of the simulated related specimens with a LOD score equal to or exceeding the FDR-specific LOD_q score threshold.

This method will be used for investigating relatives among western North Pacific common minke whales, and this information will be very valuable for verifying the single O stock scenario. Under this scenario we will expect kinship relationship between offshore and coastal animals. For this purpose, both JARPN/JARPNII and newly collected samples will be used.

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Annex 10

Secondary Objective I (iv)
Improve RMP trials by incorporating age data in their conditioning

Field and laboratory work, and analytical procedure

Background
The IWC SC broadly agreed on the value of age data in *ISTs* (e.g. conditioning operating models). In the case of common minke whale, ageing techniques have been improved and as a consequence age information is available for a larger number of animals. Additional age data is very important for the aim of improving RMP trials, and this is the main aim under this Secondary Objective.

Methods
Field work
Biological samples for SCAA
Procedures for sampling to obtain information required for SCAA such as age, body length and reproductive status are described in Annex 7.

Laboratory work
Biological information
Details of laboratory work for biological information on common minke whale are described in Annex 7.

Analytical procedure

SCAA
The recent availability of age data from western North Pacific common minke whale (Maeda *et al*., 2016) provides a basis to improve the accuracy of the RMP *ISTs* of IWC (2014a) for these common minke whales through taking these data into account when conditioning these trials. In this research the new age data will be used by the Statistical-Catch-At-Age (SCAA) assessment approach. The SCAA was applied to Antarctic minke whale (Punt *et al*., 2014) and the SCAA model was recognized by the IWC SC as the 'best currently available model for examining stock dynamics for Antarctic minke whales' (IWC, 2014b). Details of the model are presented in Annex 12.

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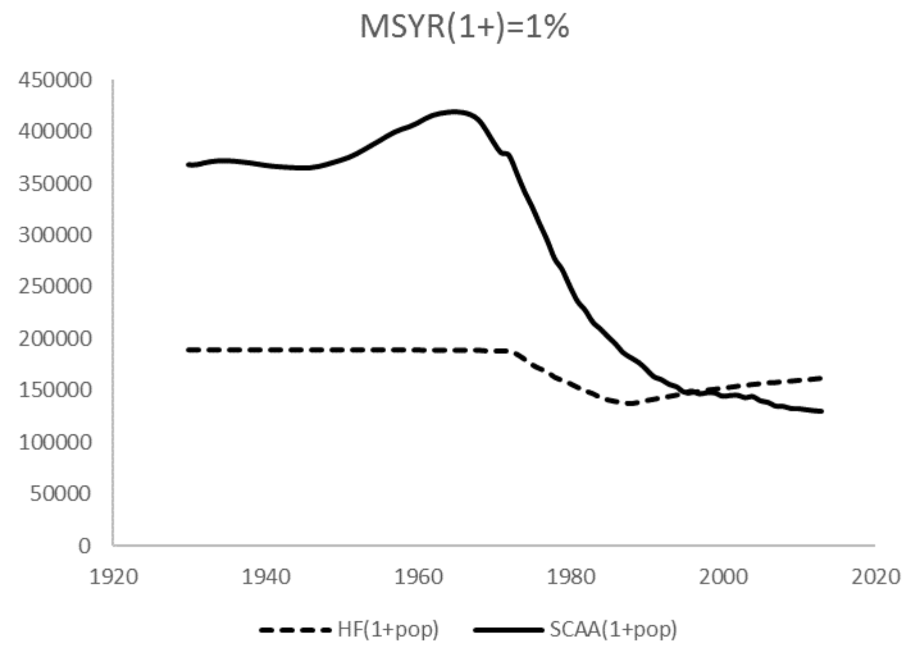
Annex 11

Estimates of sample size for Primary Objective I (common minke whale)

General background and rationale for the sample size on the Pacific side of Japan (sub-areas 7-9)

The SCAA assessment of Antarctic minke whale populations by Punt *et al*. (2014) was a watershed advance for the IWC SC because, through its ability to take account of age in addition to survey abundance data, it pointed to the extent of recruitment changes[4] that could occur, and its results did not conform particularly closely to the behaviour predicted by the standard population models used to assess and hence to provide baseline *ISTs* for baleen whale populations. Figure 1 contrasts the results from an application by GOJ (2016) of the Punt *et al.* SCAA methodology to those that would follow from a FITTER approach necessitated if only catch and survey abundance information were available (as required for the RMP).



[4] Recruitment refers to the numbers of young whales added to the population each year (also called a 'cohort'). This cannot be determined well if only a series of abundance estimates of the whole population are available. The availability of age data, however, allows estimates of total population numbers to be split into the numbers of each cohort present that year. From one survey only, such estimates would not be precise, but the accumulation of age data over successive years allows for multiple estimates of the size of each cohort, and it is effectively the combination of these which ultimately allows for reasonable estimates of annual recruitment to be obtained.

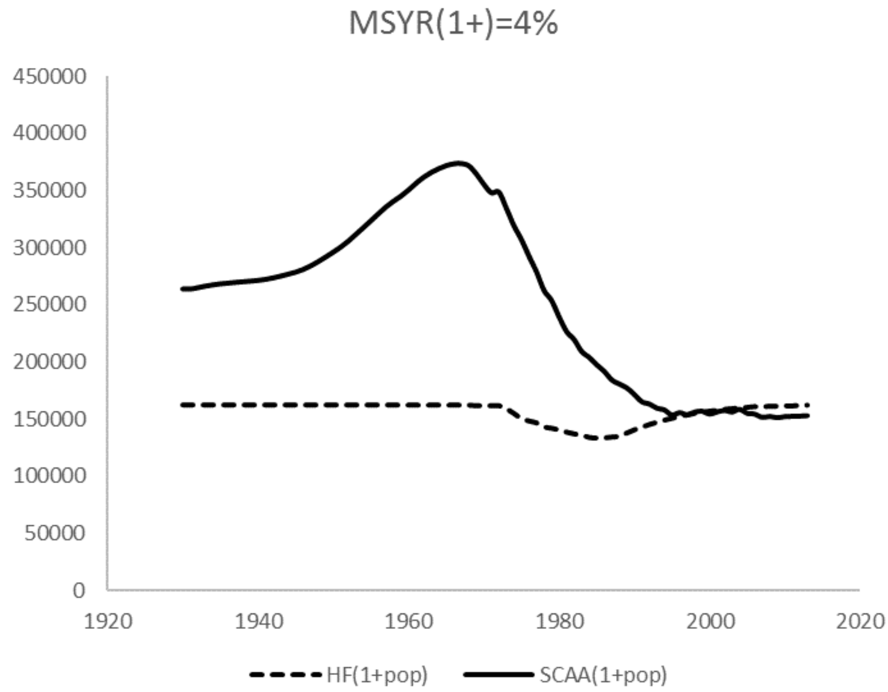


Figure 1: Two approaches to conditioning potential *IST*s for the I stock of Antarctic minke whales are compared. The first uses the conventional approach for baseline trials in RMP *Implementations*, with only past catch and survey abundance estimates (in this instance from the IDCR-SOWER cruises) available, and is calculated here using the FITTER-with-fixed-MSYR methodology. The second uses the SCAA approach of Punt *et al*. (2014), as implemented by GOJ (2016), which can in addition take age data into account. Results are shown for the 1+ population trajectory for two different values of MSYR(1+). The very different perception of the dynamics of the population that follows once age data are available for use in the conditioning, and show that catches have not been the primary determinant of the population's behaviour, is readily evident.

The considerable difference is obvious; self-evidently optimal management based the scenario (and associated sensitivities) provided by the SCAA, which can estimate recruitment directly through the availability of age data, would be very different to that from the deterministic stock-recruitment relationship scenarios (as, e.g., the FITTER methodology has to assume), which at best would need to consider a very wide range of robust tests, resulting in an inefficient approach (less allowable catch for the same perceived risk).

The Punt *et al*. (2014) analysis constitutes an important step in contributing to the evolution of the RMP towards a more efficient version which is based on better conditioned operating models, and is stock specific (as are the various current AWMPs) rather than generic as at present. Age data contribute to this better conditioning through allowing much improved estimation of recruitment and its changes and may also be able to improve the performance of a refined version of the RMP, as has been demonstrated in the case of Antarctic minke whales (GOJ, 2016). The NEWREP-NP proposal, with its analyses, has the intent that the age data to be collected will contribute to this evolutionary process.

The JARPN II Final review workshop report, endorsed by the IWC SC, noted that 'if the *Implementation Simulation Trials* (*IST*s) for the western North Pacific minke whales are to be revised in future, the age data should be included in the conditioning process' (SC/66b/Rep06, Report of the Expert Panel of the final review on the western North Pacific Japanese Special Permit program (JARPN II), 4.4.1). The example above shows that age data, whenever potentially available, are needed for conditioning such trials so that recruitment and its changes may be reflected far better. This is the primary reason why the proponents support the use of age data for the conditioning of the next set of *ISTs* for the North Pacific common minke whale, which they understand to be endorsed also by the IWC SC. Naturally recruitment is hardly estimable for other than past years spanned by the collection of age data, so for future sets of *ISTs* also to best reflect underlying dynamics, age data must continue to be collected, notwithstanding the fact that the impact of data from the first few years of NEWREP-NP to the next NP common minke whale *Implementation Review* may not be that large.

The proponents' approach is entirely in line with fisheries management approaches elsewhere, including in the development of MPs in other Regional Fisheries Management Organizations (RFMO). There a high premium is placed on obtaining and improving age data and/or on equivalent information to provide information on recruitment changes. Further comments on this and other aspects of the use of age data in fisheries management may be found in Adjunct 1. Furthermore Adjunct 2 provides an example of how the availability of age data aids the estimation of the extent of the impact of environmental factors on recruitment trends – a matter of importance at this time given concerns about the possible impacts of Climate Change.

Note that while age data could be used in a future RMP in a similar way to that in the proposal in Government of Japan (2016), the primary contribution of such data remains to the conditioning of *ISTs*, and (as has proven to be the preferred approach for other MPs internationally) their contribution to feedback adjustments to management measures might be through the regular re-conditioning of the *ISTs* rather than by changes to the MP itself.

Moving to the matter of sample size, it is perhaps helpful to first summarise the proponents' rationale for the number advanced, before elaborating upon it in more detail. This rationale is that:

- Age data are needed for improved conditioning of *IST*s for testing management procedures, to inform better on recruitment changes and hence improves the trials' realism
- Simulation results (see Adjunct 2) indicate that larger age samples would allow better estimation of recruitment changes for this NP minke situation
- On the other hand, operational considerations regarding the practically maximum sample size and the effect on the population must also be taken into account in determining the optimal sample size
- Therefore, the optimal sample size should meet both of these criteria: that it is operationally maximal and is also sufficient to provide meaningful improvement in the estimation of recruitment changes; simulation results (see Adjunct 3) indicate that is the case for this NP minke situation. (The matter of effect on the population is dealt with in Section 4.1 of the main text of Revised Research Plan.)

To elaborate then, given the clear and widely accepted benefits in principle of the inclusion of ageing data to the *IST* conditioning process, the only question that then remains is how much age data is needed to make a meaningful improvement to that NP minke whale conditioning. A detailed calculation for this would need to be based on the planned updated conditioned (including with the age data available at that time) set of NP minke *ISTs*, and consequently would need to await completion of that exercise which is the responsibility of the IWC SC.

However, in the interim, much simpler computations are adequate to bound the problem, and are conducted in Adjunct 3. These are based on a simpler model broadly accepted when presented to the JARPN II review, which was intended to be illustrative and to assist this bounding.

Note first that the model showed performance improved with increases in the sample size aged, and that these improvements are meaningful over the sample sizes examined which were consistent with what was operationally practical[5]. This last consideration then provides the desirable sample size, but always provided that a) the criterion of no adverse effect on the population is met, and b) that sample size is itself sufficient to provide a meaningful improvement in performance. The intent of the calculations of Adjunct 3 is to address this last question, and this is successfully achieved – note that this is an exercise for which primarily only relative measures of performance when comparing results with to those without ageing data are needed. Once the updated conditioning is complete, that could be used to update these overall results, though any difference would not be expected to be large, and the priority for such an update would not seem to be very high, and results from this bounding an illustrative exercise are sufficient to address the immediate question.

Given the relatively slow dynamics of minke whales, coupled to the nature of the information content of age data, the improvements to *IST*s achieved by use of these data take time to reveal their full extent (see the plots in Adjunct 3), so that there is a need to show results for projections over a number of decades, extending beyond the time-frame of the current research program. Self-evidently the results for these larger numbers of years must be taken

[5] Based on the scientific knowledge on minke whale distribution around Japan, estimated sampling efforts given the available research vessels (see Annex 21 of the proposed proposal) and the allocation of efforts to the two target species, annual sample size of 107 for minke whales was found to be optimal and feasible.

into account; otherwise the injudicious situation would arise that research with longer term benefits would never commence because those benefits could never become evident in the short term.

In summary it is considered that the annual sample size of 107 minke whales in sub-areas 7-9, which is the maximum feasible within the operational constraints of the program, is sufficient to result in meaningful improvement in the detection of minke whale recruitment changes.

This intended sample size applies to O stock whales. It is planned that 60% of this sample size be taken in coastal sub-areas (7CS and 7CN) and 40% in offshore sub-areas (7WR, 7E, 8 and 9). Evaluating an optimal coastal:offshore ratio for this sample would be an enormous task technically, but it seems reasonable to expect that a 50:50 split would be near optimal in terms of distinguishing possible differences between the two regions if any. Taking into account operational reasons as well, the ratio has been decided to be 60:40, noting that typically such "distinguishability" performance behaves quadratically, so does not deteriorate much with relatively small movement away from the actual optimal split. Hence it is planned that 64 animals will be sampled in coastal sub-areas and 43 in offshore sub-areas. Because around 20% of the animals in sub-areas 7CS and 7CN are from the J stock (Annex 7), the sample size in the coastal sub-areas needs to be adjusted upwards to 80 animals in total to achieve sampling of 64 O stock whales. Thus the total sample size planned on the Pacific side of Japan becomes 123 whales.

Rationale for the sample size selected for the area north of Hokkaido (sub-area 11)

For the area north of Hokkaido (sub-area 11), the main objective is to estimate the J-O mixing proportion in this subarea annually with a standard error of no more than 0.1 irrespective of the true proportion. The sample size selected is 47. The basis for the selection of this value is explained in Adjunct 4.

Total planned sample size

With 123 whales to be taken on the Pacific side of Japan, and 47 north of Hokkaido, the total sample size planned for common minke whales is 170.

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ADJUNCT 1

On the Use and Utility of Catch–at-Age Data in Marine Resource Assessment and Management

The inclusion of age data in fishery assessments is widespread in fishery management agencies worldwide, including in Regional Fisheries Management Organisations (RFMOs). This use can also extend there to the process of developing management procedures (MPs), certainly for conditioning the operating models used for testing those MPs, and sometimes directly in the MPs themselves. Generally a high premium is placed on obtaining and improving age data and/or equivalent information to provide information on recruitment changes.

Examples of this in RFMOs are provided, for example, by:

> **CCAMLR:** Further collection of age data for the assessment of toothfish stocks is recommended (e.g. CCAMLR 2016).
> **CCSBT:** Age data are used in conditioning the operating models used for MP selection for southern bluefin tuna (SBT), and indirectly (through recruitment indices) in the MP itself (e.g. CCSBT 2016).
> **ICCAT**: Age data are used in assessments of, for example, Atlantic bluefin tuna, and in the development of operating models for the MP in development for that resource (e.g. ICCAT 2014).
> **NAFO**: Age data were used in conditioning the operating models for the MP previously adopted for Greenland halibut, and are similarly in use for the revision of this MP that is currently in progress (e.g. NAFO 2010).
> **WCPFC**: Age data are used in the assessments of various stocks, including bigeye tuna (e.g. Harley *et al*. 2014).

Many of the species involved above are long-lived, some to four decades which approaches the longevity of many whale species, so that dynamics, time scales, and management concerns are not dissimilar from those for whales. One reason that perhaps increases the priority for ageing information for the species above compared to whales is its contribution towards estimation of abundance in absolute terms – whale sightings surveys provide better approximations to this than are obtainable from abundance indices for many fish species. Nonetheless the primary improvement provided by the availability of age data is the ability to assess year-class (recruitment) strength and its variations. The identification of (series of) good and of poor recruitment plays an important role in the management of these species despite their longevity, both as regards increasing and reducing catch limits. Thus there is, for example, absolute unanimity in the CCSBT Scientific Committee on the need for recruitment monitoring inputs in the MP used to recommend catch limits for SBT, following experience in that case of the consequences of a run of poor recruitments across the turn of the century.

These same considerations apply to whales, where the absence of age data accordingly necessitates more conservative management than might otherwise be necessary, i.e. lower catches for the same perceived risk.

The current IWC RMP relies (historical catches aside) on the input of survey based indices of abundance (with CVs) only. The assessment of the US Gulf of Maine winter flounder (NEFSC 2011) provides a note of caution in this regard. If survey indices of abundance only were considered, that stock appeared perfectly healthy; however a full assessment taking age data into account as well led to a different appreciation, suggesting a resource appreciably reduced in abundance over recent decades. This points again to the sound management of a marine resource requiring that age information (in addition to survey-based indices in isolation) be obtained and taken into account whenever possible.

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ADJUNCT 2

Enhancement of the Detection of the Effects of Environmental Factors on Whale Dynamics given the Availability of Catch–at-Age Data

Introduction

This Appendix intends to provide an **illustration** of how the availability of catch-at-age data may lead to improved estimation of the effect of an environmental factor (or factors in combination) on whale population dynamics. Specifically the magnitude (*G*) of the trend in an enhancement of recruitment success is estimated without and with the availability of catch-at-age data, and estimation performance contrasted in terms of bias, variance and root mean square error.

The situation modelled is loosely based on the O stock of North Pacific common minke whales, and is developed from the model of Kitakado and Maeda (2016), and as refined further in Adjunct 3. Details of the methods applied are set out in Appendix A. The data available to the estimator are the results of six-yearly sightings surveys of 1+ abundance, and annual catch-at-age information with an effective (i.e. "independent") sample size of either 0 or 80.

Estimation performance for the environmental effect (*G*) parameter is compared after 20 and after 50 years for the two different sample sizes for catch-at-age data.

Results and discussion

Table 1 summarises the results for 20, and 50 year projections given 0 and 80[6] age samples each year, while Figures 1 plots the results.

The bottom row of Figure 1 in particular makes visually evident that there is an improvement in precision of the estimated trajectory of female births when the age data are also available to the estimator.

The extent of this improvement is best quantified by the statistics in Table 1 which relate to estimation performance for *G*. After 20 years there is appreciable negative bias in the absence of age data and variances are large, but the RMSE is appreciably less when age data are available. After 50 years bias and variance are substantially reduced, and the RMSE (which still remains less if age data are provided) is reduced in that last case to a level where a result is obtained which is almost statistically significant at the 5% level.

References

Kitakado, T and Maeda H. 2016. Fitting to catch-at-age data for North Pacific common minke whales in the Pacific side of Japan. Paper SC/F16/JR43 presented to the Expert Panel of the final review on the western North Pacific Japanese Special Permit programme (JARPN II) (unpublished) 12pp.

[6] As in Adjunct 3, the actual annual catch here is 107, but after allowing for over-dispersion, the effective "independent" sample size is 80.

Table 1: Mean, standard deviation, CV and root mean square error (RMSE) for the estimated environmental effect on recruitment parameter *G* (the true value of *G* is 0.005) after periods of 20 and 50 years, and given either an effective *n*=0 or *n*=80 age samples each year

	20yrs		50yrs	
	n=0	n=80	n=0	n=80
mean	0.01393	0.00634	0.00662	0.00598
stdev	0.03106	0.01127	0.00387	0.00251
CV	2.22993	1.77744	0.58345	0.41898
RMSE	0.03217	0.01129	0.00417	0.00268

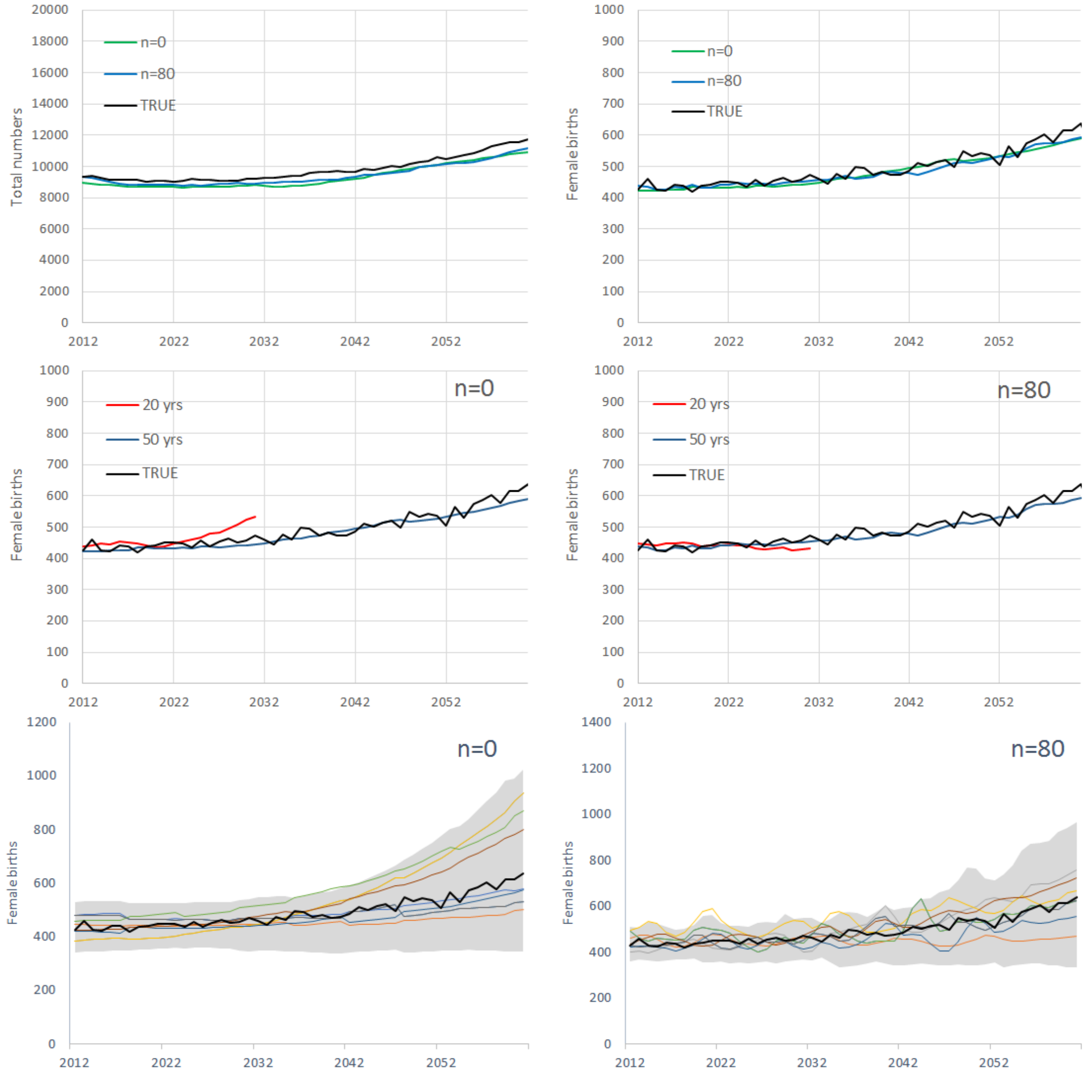

Figure 1: Top row: Medians for "true" and estimated total numbers and female births for sample sizes of 0 and 80 after 50 years. Second row: Medians for "true" and estimated female births for a sample size of 0 (LHS) and 80 (RHS), estimated after 20 and 50 years. Third row: Estimated 95%iles, some individual trajectories estimated and "true" female births for a sample size of 0 (LHS) and 80 (RHS) after 50 years.

Appendix A – Methodology

The text following sets out the equations and other general specifications of the SCAA estimation approach followed by details of the contributions to the log-likelihood function from the different sources of data available. Quasi-Newton minimization is then applied to minimize the total negative log-likelihood function to estimate parameter values (the package AD Model Builder™ (Fournier *et al*. 2012) is used for this purpose).

A.1. Population dynamics

A.1.1 ***NUMBERS-AT-AGE***

The resource dynamics are modelled by the following set of population dynamics equations:

$$N^g_{y+1,a} = \begin{cases} 0.5 b^i_{y+1} & \text{if } a = 0 \\ \left(N^g_{y,a-1} - C^g_{y,a-1}\right) S_{a-1} & \text{if } 1 \le a < m \\ \left(N^g_{y,m-1} - C^g_{y,m-1}\right) S_{m-1} + \left(N^g_{y,m} - C^g_m\right) S_m & \text{if } a = m \end{cases} \quad \text{(A1)}$$

where

$N^g_{y,a}$ is the number of whales of gender g and age a at the start of year y,

$C^g_{y,a}$ is the catch (in number) of whales of gender g and age a during year y,

b^i_y is the number of calves born at the start of year y,

S_a is the survival rate e^{-M_a} where M_a is the instantaneous rate of natural mortality (assumed to be independent of gender),

$m = 50$ is the maximum age (treated as a plus-group).

A.1.2. ***BIRTHS***

Density-dependence is assumed to act on the female component of the mature population.

$$b_y = B N^f_y \left\{1 + A\left[1 - \left(N^f_y / K^f\right)^z\right]\right\} \quad \text{(A2)}$$

where

B is the average number of births (of both genders) per year for a mature female in the pristine population,

A is the resilience parameter,

z is the degree of compensation,

$N^f_y = \sum_{a_m} f^f_a N^f_{y,a}$ is the number of mature females at the start of year y,

a_m is the earliest age-at-first parturition;

f^f_a is the proportion of females of age a which have reached the age at first parturition (ogive with parameters given in Table A.1), and

K^f is the number of mature females in the pristine population.

A.1.3. *TOTAL CATCH AND CATCHES-AT-AGE*

The catch-at-age is given by:

$$C_{y,a}^g = F_y^g v_{y,a}^g N_{y,a}^g \qquad \text{(A3)}$$

where

$C_{y,a}^g$ is the catch-at-age, i.e. the number of animal of gender *g* and age *a* caught during year *y*,

$v_{y,a}^g$ is the commercial selectivity of an animal of gender g and age *a* for year *y*; when $v_{y,a}^g = 1$, the age-class *a* is said to be fully selected, and

$F_y^g = \frac{C_y^g}{\sum_a v_{y,a}^g N_{y,a}^g}$ is the proportion of a fully selected age class that is caught.

A.1.4. *INITIAL CONDITIONS*

For the first year (y_0) considered in the model, the numbers-at-age are taken to be at unexploited equilibrium, i.e.:

$$N_{y_0,a}^g = \begin{cases} 0.5BK^f & \text{if } a = 0 \\ N_{y_0,a-1}^g S_{a-1} & \text{if } 1 \le a < m \\ N_{y_0,m-1}^g S_{m-1}/(1-S_m) & \text{if } a = m \end{cases} \qquad \text{(A4)}$$

Input values for the model parameters and data were selected to give a typical population trajectory, which is at about 50% of carrying capacity in the year the projections start (see Tables A1 and A2).

A.2. Projections

For each simulation *i*, the population is projected forward using equation A1 and a constant catch of 107 animals per year.

Future recruitments include residuals and an environmental effect *G* = 0.005 which reflects a 0.5% increase per annum in recruitment (density dependent effects aside):

$$b_y^i = \left(1 + G(y - 2011)\right) B N_y^{f,i} \left\{1 + A\left[1 - \left(N_y^{f,i}/K^f\right)^z\right]\right\} e^{\varphi_y^i} \qquad \text{(A5)}$$

φ_y^i generated from $N(0, (\sigma_R)^2)$ with $\sigma_R = 0.25$.

Future observed abundance indices are computed as:

$I_y^i = \sum_{a=1}^{m} N_{y,a}^{f,i} \, e^{\varepsilon_y^i}$ (A6)

ε_y^i are generated from $N(0, (\sigma_I)^2)$ with $\sigma_I = 0.25$

Future catch-at-age data are generated under the assumption of a multinomial error distribution:

$O_{y,a}^{g,i} = \sum_{a'} F_y^{g,i} v_{y,a'}^{g} r_{a'}^{g} N_{y,a'}^{g,i} \, E_{a,a'}$ (A7)

where

$O_{y,a}^{g,i}$ is the observed number of whale of age a and gender g caught in year y for simulation i,

$E_{a,a}$ is the ageing error matrix (Table A3), and

r_a^g is the age readability at age a for gender g (Table A4).

The standardised residuals are computed as:

$\omega_{y,a}^{g,i} = \frac{O_{y,a}^{g,i}/\sum_{a'} O_{y,a'}^{g,i} - \hat{O}_{y,a}^{g,i}/\sum_{a'} \hat{O}_{y,a'}^{g,i}}{\sigma_{y,a}^{g,i}}$ (A8)

with

$\sigma_{y,a}^{g,i} = \frac{O_{y,a}^{g,i} \frac{\hat{O}_{y,a}^{g,i}}{\sum_{a'} \hat{O}_{y,a'}^{g}} \left(1 - \frac{\hat{O}_{y,a}^{g,i}}{\sum_{a'} \hat{O}_{y,a'}^{g,i}}\right)}{\sum_{a'} O_{y,a'}^{g,i}}$ (A9)

A.3. The likelihood function

The model is fitted to projected estimates of total (1+) numbers (from surveys every six years, starting in the first year of the projection) and annual catch-at-age data to estimate model parameters. Contributions by each of these to the negative of the log-likelihood ($-lnL$) are as follows.

A.3.1 ***ESTIMATES OF TOTAL (1+) NUMBERS***

$-lnL^{abund} = \sum_y \left\{ \frac{\left(\varepsilon_y^i\right)^2}{2\sigma^2} \right\}$ (A10)

with

$\varepsilon_y^i = ln\left(I_y^i\right) - ln\left(\sum_a f_a^{f,i} N_{y,a}^{f,i}\right)$ (A11)

A.3.2. ***COMMERCIAL CATCHES-AT-AGE***

The contribution of the catch-at-age data to the negative of the log-likelihood function under the assumption of a multinomial error distribution is given by:

$$-lnL^{CAA} = \sum_{y,g,a} -O_{y,a}^{g,i} ln\left(\frac{\hat{O}_{y,a}^{g,i}}{\sum_{a'} \hat{O}_{y,a'}^{g,i}}\right) \qquad \text{(A12)}$$

A.3.3. ***FEMALE BIRTHS***

The following penalty added to the negative log-likelihood given the variability about the stock-recruitment relationship:

$$pen_{birth} = \sum_{y} \left\{\frac{\left(\varphi_y^i\right)^2}{2\sigma_R^2}\right\} \qquad \text{(A13)}$$

The model assumes an unexploited equilibrium age structure in the starting year (1930). The estimable parameters of the model are *K*, the environmental effect *G*, and the annual recruitment residuals φ_y.

References

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Table A1: Model parameter values assumed. Note that maturity and selectivity are logistic, with a_m referring to the earliest age at which first parturition can occur.

Parameter	Value
Carrying capacity, K^f	4160
Initial year, y_0	1930
Age at first parturition, a_m	5
Age-at-50% maturity	7
Steepness of the ascending limb of the maturity ogive	1.2
Age-at-50% selectivity	4
Steepness of the ascending limb of the selectivity ogive	1.2
Natural mortality, M_a:	
4-	0.085000
5	0.077500
6	0.072098
7	0.066696
8	0.061295
9	0.055893
10	0.050491
11	0.045089
12	0.039688
13	0.034286
14	0.028884
15	0.023482
16	0.018080
17	0.012679
18	0.007277
19	0.001875
20+	0.115000
MSYR(mat)	1%
Resilience parameter	0.12053
Degree of compensation	2.38475

Table A2: Historical male and female catches assumed.

	♂	♀		♂	♀
1930	3	3	1971	81	81
1931	4	4	1972	97	97
1932	5	5	1973	165	165
1933	6	6	1974	121	121
1934	9	9	1975	104	104
1935	9	9	1976	107	107
1936	6	6	1977	84	84
1937	15	15	1978	124	124
1938	17	17	1979	122	122
1939	19	19	1980	124	124
1940	20	20	1981	123	123
1941	16	16	1982	105	105
1942	19	19	1983	97	97
1943	26	26	1984	132	132
1944	20	20	1985	118	118
1945	18	18	1986	112	112
1946	29	29	1987	111	111
1947	36	36	1988	11	11
1948	43	43	1989	11	11
1949	42	42	1990	11	11
1950	58	58	1991	11	11
1951	64	64	1992	11	11
1952	82	82	1993	11	11
1953	63	63	1994	21	21
1954	77	77	1995	60	60
1955	101	101	1996	38	38
1956	124	124	1997	60	60
1957	101	101	1998	60	60
1958	150	150	1999	47	47
1959	78	78	2000	27	27
1960	73	73	2001	58	58
1961	94	94	2002	71	71
1962	71	71	2003	73	73
1963	63	63	2004	82	82
1964	80	80	2005	100	100
1965	94	94	2006	93	93
1966	102	102	2007	94	94
1967	86	86	2008	80	80
1968	72	72	2009	77	77
1969	71	71	2010	57	57
1970	97	97	2011	58	58

Table A3: Ageing error matrix.

	Expected age in observation																																																		
True age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	0.86	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.16	0.67	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.01	0.19	0.60	0.19	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0.01	0.21	0.55	0.21	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0.02	0.23	0.50	0.23	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0.03	0.24	0.47	0.24	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0.04	0.24	0.43	0.24	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0.05	0.24	0.40	0.24	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0.01	0.06	0.24	0.38	0.24	0.06	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0.01	0.07	0.24	0.36	0.24	0.07	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0.01	0.08	0.24	0.34	0.24	0.08	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0.02	0.09	0.23	0.32	0.23	0.09	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0.02	0.10	0.23	0.30	0.23	0.10	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0.03	0.10	0.22	0.29	0.22	0.10	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.11	0.22	0.28	0.22	0.11	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0.01	0.04	0.11	0.21	0.26	0.21	0.11	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.04	0.11	0.21	0.25	0.21	0.11	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.05	0.12	0.20	0.24	0.20	0.12	0.05	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.12	0.20	0.23	0.20	0.12	0.05	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.12	0.19	0.22	0.19	0.12	0.05	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.06	0.12	0.19	0.22	0.19	0.12	0.06	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.06	0.12	0.18	0.21	0.18	0.12	0.06	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.06	0.12	0.18	0.20	0.18	0.12	0.06	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.07	0.12	0.17	0.20	0.17	0.12	0.07	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.07	0.12	0.17	0.19	0.17	0.12	0.07	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.07	0.12	0.17	0.18	0.17	0.12	0.07	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.04	0.07	0.12	0.16	0.18	0.16	0.12	0.07	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.07	0.12	0.16	0.17	0.16	0.12	0.07	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.08	0.12	0.15	0.17	0.15	0.12	0.08	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.08	0.12	0.15	0.16	0.15	0.12	0.08	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.08	0.12	0.15	0.16	0.15	0.12	0.08	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.05	0.08	0.11	0.14	0.16	0.14	0.11	0.08	0.05	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.05	0.08	0.11	0.14	0.15	0.14	0.11	0.08	0.05	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.05	0.08	0.11	0.14	0.15	0.14	0.11	0.08	0.05	0.03	0.01	0.01	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.05	0.08	0.11	0.14	0.14	0.14	0.11	0.08	0.05	0.03	0.01	0.01	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.05	0.08	0.11	0.13	0.14	0.13	0.11	0.08	0.05	0.03	0.01	0.01	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.05	0.08	0.11	0.13	0.14	0.13	0.11	0.08	0.05	0.03	0.02	0.01	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.05	0.08	0.11	0.13	0.13	0.13	0.11	0.08	0.05	0.03	0.02	0.01	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.06	0.08	0.11	0.12	0.13	0.12	0.11	0.08	0.06	0.03	0.02	0.01	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.06	0.08	0.10	0.12	0.13	0.12	0.10	0.08	0.06	0.03	0.02	0.01	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.13	0.12	0.10	0.08	0.06	0.04	0.02	0.01	0.01	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.02	0.01	0.01	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.02	0.01	0.01
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.02	0.01
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.03
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.03	0.05	0.07	0.09	0.11	0.12	0.13	0.12	0.11	0.09	0.07
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.03	0.05	0.07	0.09	0.11	0.13	0.13	0.13	0.11	0.09
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.14	0.14	0.12
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.05	0.07	0.09	0.12	0.14	0.16	0.16	0.16
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.05	0.08	0.11	0.14	0.17	0.18	0.19

Table A4: Age readability proportion for males and females.

Age	Males	Females
0	0.1981	0.1998
1	0.2047	0.2134
2	0.2764	0.2757
3	0.4232	0.3906
4	0.4874	0.4678
5	0.5042	0.4969
6	0.5091	0.5067
7	0.5109	0.5102
8	0.5117	0.5116
9	0.5121	0.5123
10	0.5123	0.5126
11	0.5125	0.5128
12	0.5125	0.5129
13	0.5126	0.5129
14	0.5126	0.5130
15	0.5127	0.5130
16	0.5127	0.5130
17	0.5127	0.5130
18	0.5127	0.5130
19	0.5127	0.5130
20+	0.5127	0.5130

ADJUNCT 3

Analyses underlying choice of sample size for Primary Objective I (common minke whale) for the Pacific side of Japan (sub-areas 7-9)

Introduction

This Adjunct provides the details of an **illustrative** example of the extent of improvement achievable for the assessment of the dynamics of the O stock of western North Pacific common minke whales in relation to the size of the sample taken to provide age data.

The approach followed is founded on the SCAA methodology applied to this stock by Kitakado and Maeda (2016), which is used to generate future data in a simulation testing context. The intent is to **illustrate** how well, using the SCAA methodology to analyse the future data generated, it is possible to detect changes in recruitment (strictly in the number of recruits per adult female) – specifically whether the sample sizes proposed do secure a meaningful improvement in this detectability.

Data and Methodology

The data used for these analyses are set out in Appendix A. Appendix B provides details of the SCAA assessment methodology. Note that this remains as in Kitakado and Maeda (2016), and has not been extended to incorporate some of the suggestions made by the 2016 JARPNII review panel, such as allowing for dome-shaped selectivity. The reason is that those extensions are not of particular pertinence to the issue under examination in the **illustrative** exercise here, and are considered to better await subsequent work when the NP minke RMP trials are re-conditioned on a basis that includes the use of age data, when they will likely also estimate rather than pre-fix natural mortality (note that estimates of natural mortality at age for larger ages and the extent of doming in the selectivity function are confounded).

Appendix C details how the population model of Appendix B is used to generate the future data required to test how well the SCAA approach can estimate future recruitments. These data comprise annual catches at age as well as six-yearly estimates of population abundance. Note that the effects of ageing error are incorporated in both the assessment (Appendix B) and in the projections (Appendix C). The age data are generated using a multinomial distribution, but analysis of existing data suggests some over-dispersion. Appendix D explains this and how it is taken into account.

Results

Results are presented to show first the dependence on (aged) sample size of the detectability of a 30% **decrease** in recruits per adult female. Changes of such a magnitude over a relatively short period are evident from the SCAA assessments of Antarctic minke whales (GOJ, 2015). For the scenario examined, this change is assumed to take place 10 years into the projection period (corresponding to 2022).

The second scenario considered includes instead a 30% **increase** in recruits per adult female, taking place 10 years into the projection period.

The third scenario considered is based on the recruitment variability evident for Antarctic minke (stocks I and P) as estimated in SCAA results for Antarctic minke whales reported to the 2016 annual meeting of the Scientific Committee. The 1970-2010 vector $\boldsymbol{X}$ of moving averages for recruitment variability (renormalized so that the 1970 value is 1, see Table 1 for I and P stocks) is used to project recruitment forward from 2011 (using the 1971 value) onwards, with the 2051 value taken to apply to all years from 2052 onwards. A three-year moving average is used to eliminate some of the estimation error around the real underlying trend; values prior to 1970 are not used as they reflect more model assumptions than being informed by the actual age data. Equation C8 (see Appendix C) for future births is modified:

$$b_y^i = B^j N_y^{f,j} X_y \qquad (1)$$

Results are shown for estimation of O-stock trajectories in terms of annual female births. They compare across different "multinomial" sample sizes (n) for the acquisition of age information (see Appendix D for how these "effective" sizes are related to actual sample sizes when allowance is made for over-dispersion). Figure 1 reports results for a scenario which considers a 30% drop in recruits per adult female after the 10th year of the projections for the A01_1 RMP trial (IWC, 2014) which sets MSYR(mature) equal to 1%. The results are shown for estimation after 20 and after 50 years, and include both medians and worm plots (for ten realisations/individual trajectories, and also showing the 90% probability envelopes shaded). Figure 2 shows similar results for this same situation except that recruits per adult female increase instead of decreasing by 30%. Figure 3 shows such results for the A01_1 trial for P stock MSYR(mature) 1% equivalent recruitment variations.

These **illustrative** results show clearly that the recruitment change is not detected in the absence of age data. Furthermore detectability improves with both an increasing age sample size and a longer period of data availability, and is meaningful for the sample size (*n*=80) proposed (even after 20 years). Note that after adjustment for over-dispersion as indicated in Appendix D, this effective sample size of *n*=80 is increased to an actual size of 107.

References

Government of Japan, 2015. Proponents additional responses to the Report of the Expert Panel to review the proposal for NEWREP-A. Paper SC/66a/SP8 presented to the IWC Scientific Committee meeting, May 2015 (unpublished) 37pp.

International Whaling Commission. 2014. 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.

Kitakado, T and Maeda H. 2016. Fitting to catch-at-age data for North Pacific common minke whales in the Pacific side of Japan. Paper SC/F16/JR43 presented to the Expert Panel of the final review on the western North Pacific Japanese Special Permit programme (JARPN II) (unpublished) 12pp.

Table 1: Moving averages of recruitment variability (renormalized so that the values for 1970 for Antarctic minke and for 2011 for the assumed projected values for the North Pacific O stock of minke whales are 1). The Antarctic values correspond to those reported for the I and P stocks of Antarctic minke whales for an MSYR of 1% in analyses presented by Kitakado to the 2016 meeting of the IWC Scientific Committee. The 1970-2010 values from the Antarctic are used in the projections for the 2011-2051 period for the North Pacific, with values being kept constant after 2051.

Year		I-stock (1%)	P-stock (1%)
Antarctic	North Pacific		
1970	2011	1.0000	1.0000
1971	2012	0.9126	0.9964
1972	2013	0.8973	0.9739
1973	2014	0.8204	0.9444
1974	2015	0.6548	0.8903
1975	2016	0.6164	0.7994
1976	2017	0.6395	0.7106
1977	2018	0.5629	0.6338
1978	2019	0.5564	0.5823
1979	2020	0.6362	0.5473
1980	2021	0.6759	0.5475
1981	2022	0.7580	0.6199
1982	2023	0.8806	0.6581
1983	2024	0.9840	0.6786
1984	2025	0.9714	0.6824
1985	2026	1.1005	0.6860
1986	2027	1.0904	0.6196
1987	2028	1.0511	0.5675
1988	2029	0.9935	0.5201
1989	2030	1.0772	0.5039
1990	2031	1.0321	0.4938
1991	2032	1.0715	0.4973
1992	2033	1.0963	0.5278
1993	2034	1.3100	0.5197
1994	2035	1.3289	0.5045
1995	2036	1.4931	0.5570
1996	2037	1.5884	0.6024
1997	2038	1.6565	0.6185
1998	2039	1.6914	0.7480
1999	2040	1.7960	0.8030
2000	2041	1.7229	0.8751
2001	2042	1.7694	0.8129
2002	2043	1.7485	0.7998
2003	2044	1.6526	0.6842
2004	2045	1.5270	0.6529
2005	2046	1.5480	0.5344
2006	2047	1.4261	0.6040
2007	2048	1.5137	0.6128
2008	2049	1.5242	0.6493
2009	2050	1.5664	0.7044
2010	2051+	1.5430	0.7387

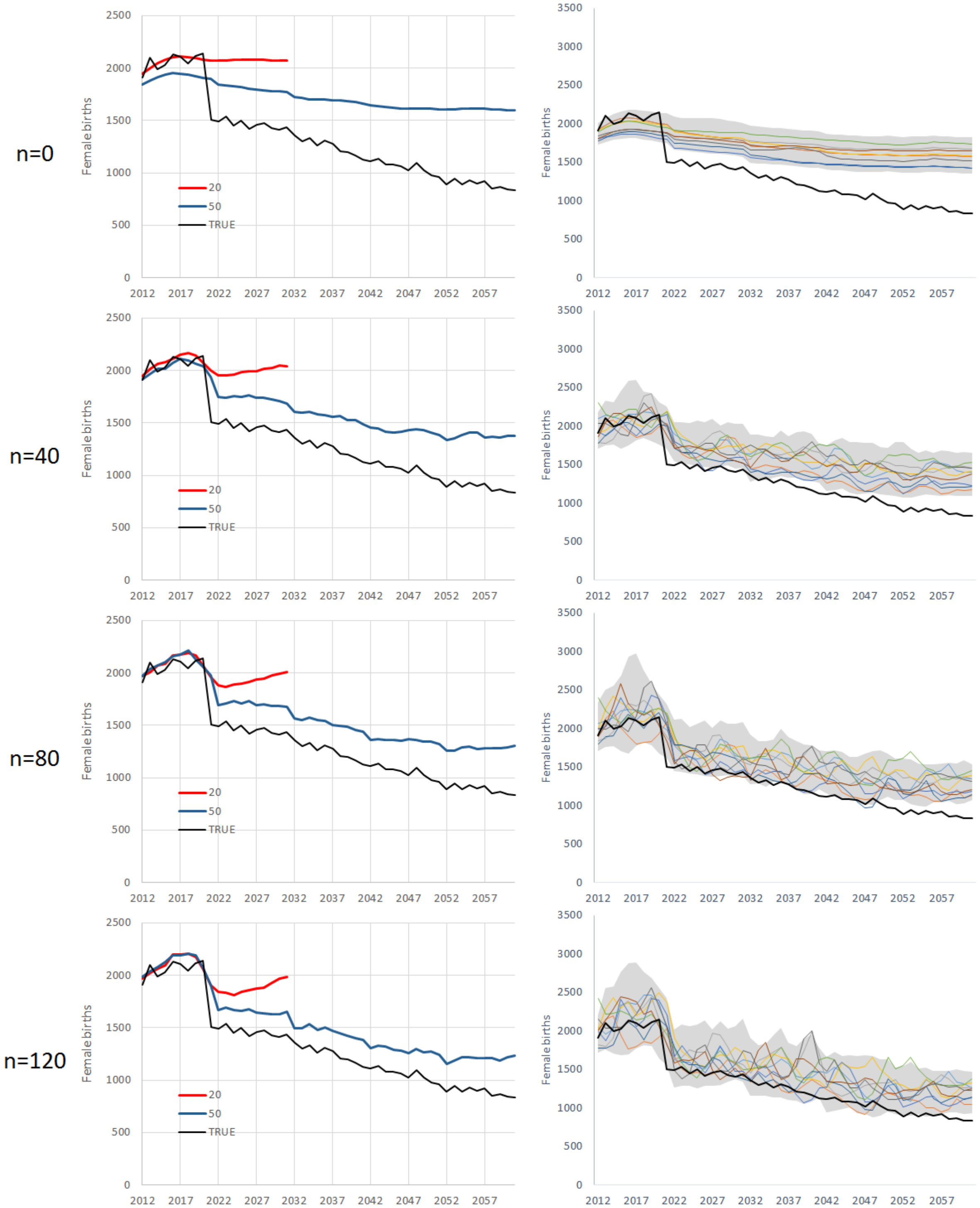

Figure 1: Estimates of female births for scenario **A01_1, with MSYR 1% recruitments, with a 30% drop in (per capita) recruitment after 10 years**. The left side plots compare medians of estimates after 20 and after 50 years with the true values. The right side plots show worms (individual realizations) after 50 years together with 90% probability envelopes (shaded). The rows reflect different effective (i.e. "independent") annual sample sizes for age, ranging from *n*=0 to *n*=120.

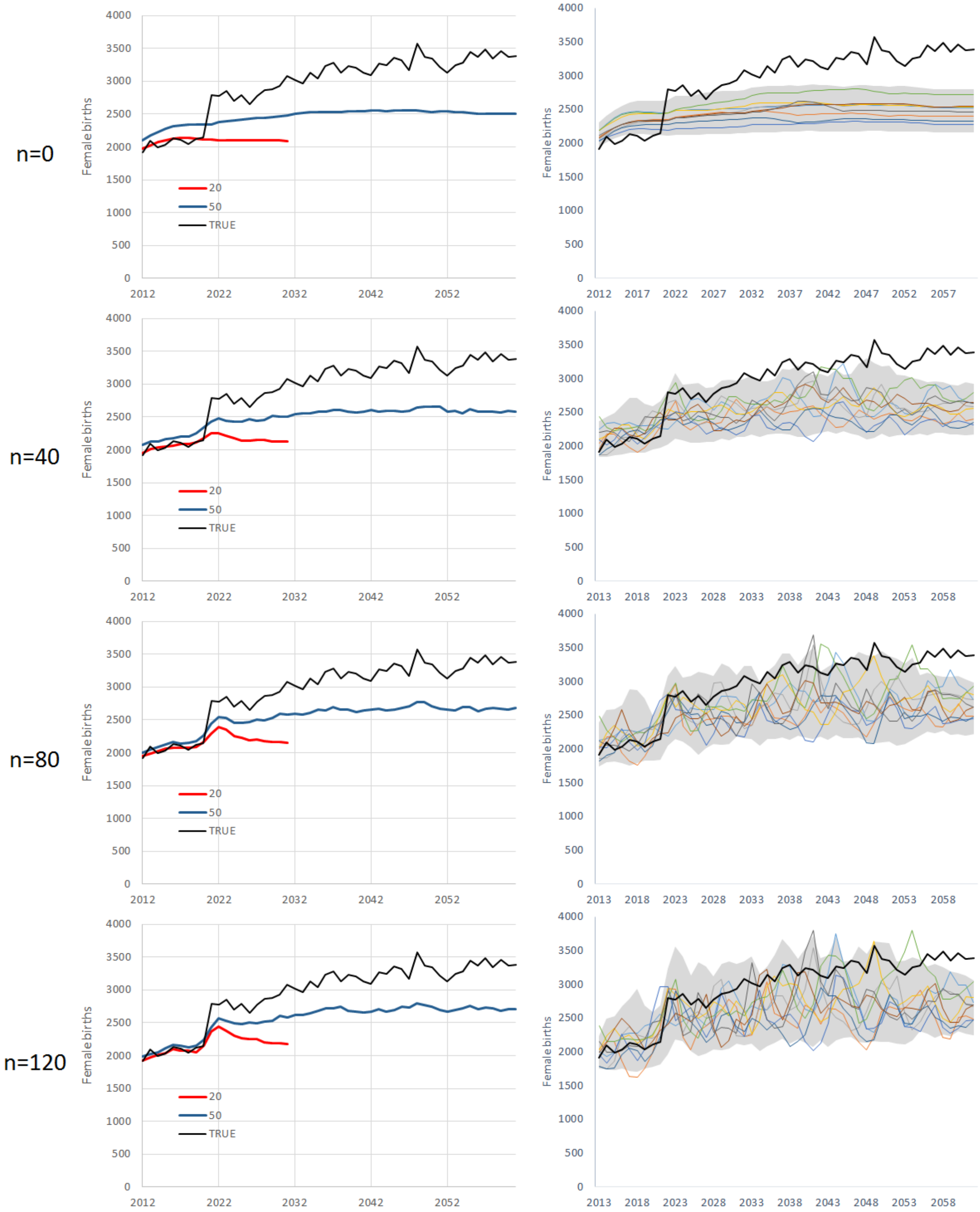

Figure 2: Estimates of female births for scenario **A01_1, with MSYR 1% recruitments, with a 30% increase in (per capita) recruitment after 10 years**. The left side plots compare medians of estimates after 20 and after 50 years with the true values. The right side plots show worms (individual realizations) after 50 years together with 90% probability envelopes (shaded). The rows reflect different effective (i.e. "independent") annual sample sizes for age, ranging from *n*=0 to *n*=120.

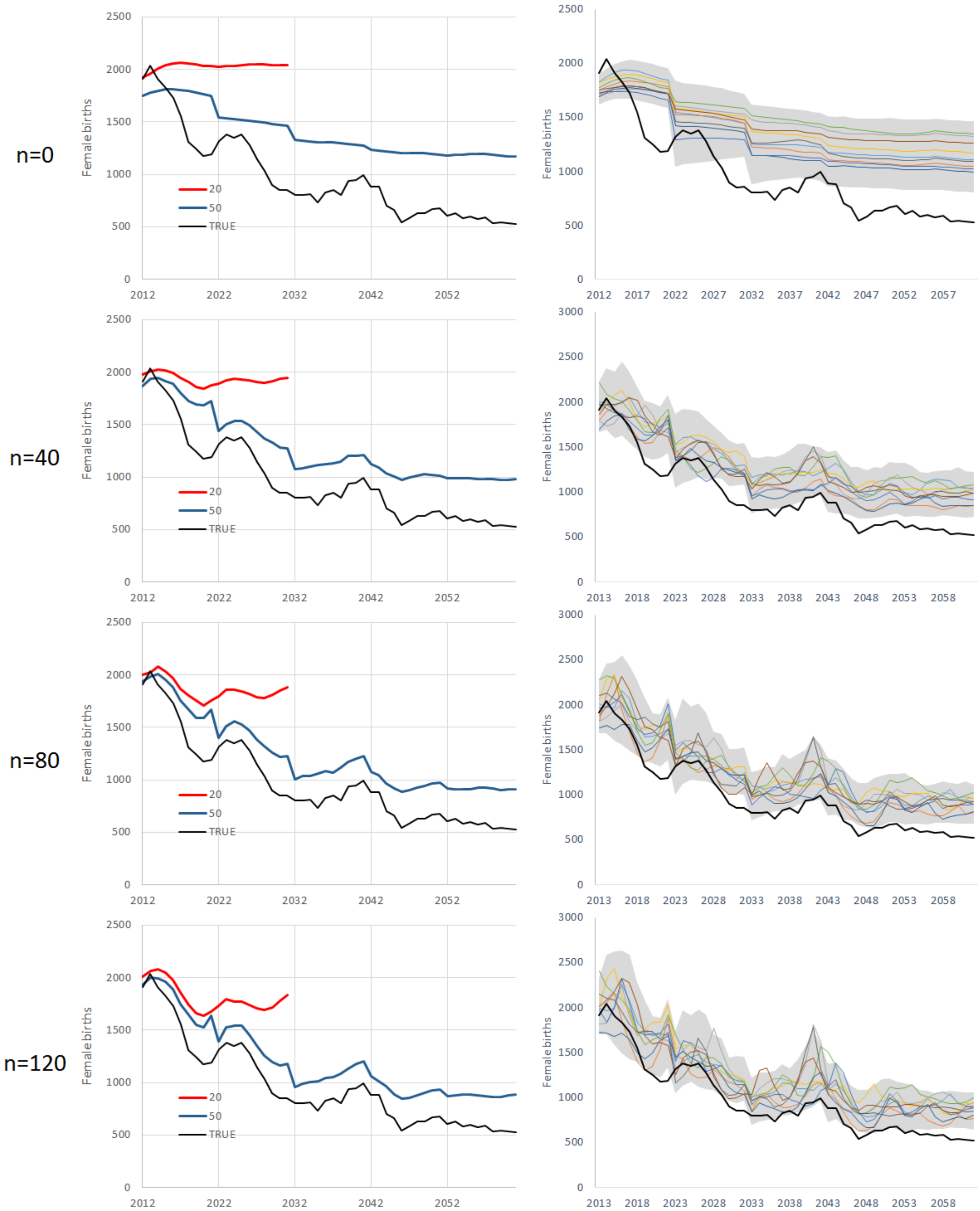

Figure 3: Estimates of female births for scenario **A01_1,** for **P stock MSYR 1% equivalent recruitment variations**. The left side plots compare medians of estimates after 20 and after 50 years with the true values. The right side plots show worms (individual realizations) after 50 years together with 90% probability envelopes (shaded). The rows reflect different effective (i.e. "independent") annual sample sizes for age, ranging from *n*=0 to *n*=120.

Appendix A - The data

The catches assumed by regions/stocks for males and females separately are given in Table A1 (Cherry Allison, pers. commn). These catches are median outputs from trials A01_1/4 which are detailed in IWC (2014). For the one stock hypotheses, the catches for males and females have been split by region corresponding to OW and OE (see details given below), assuming the same OW:OE proportions as those in the corresponding C01_1 and C01_4 trials.

The numbers assumed for mature females in 2000 are provided in Table A2. They correspond to deterministic values for the associated trials, kindly provided by Cherry Allison.

Table A3 gives the males and females catches-at-age from JARPN surveys for the regions corresponding to OW and OE. Catches in sub-areas 8, 9 and 7E have been assigned to region/stock OE. Catches in sub-areas 11, 7CN and 7CS have been assigned to region/stock OW. Catches in sub-area 7WR have been assumed to belong to region/stock OE if taken east of 145E and OW otherwise.

Table A4 lists the life history parameters used (IWC, 2014).

The ageing error matrix is given in Table A5 and is taken to be the same for males and females, across regions. The sex-specific age readability vectors are listed in Table A6. The assumed proportion of the total sample of males and females in each region, based on averages over the 2000-2010 period for JARPN and JARPNII is shown in Table A7.

Table A1: Historical male and female minke catches assumed (see text above for source).

A01_1

	Regions corresponding to:					Regions corresponding to:			
	OW		OE			OW		OE	
	♂	♀	♂	♀		♂	♀	♂	♀
1930	4	2	0	0	1971	58	55	23	26
1931	4	2	0	1	1972	39	69	35	50
1932	6	4	0	0	1973	75	85	81	89
1933	6	5	0	0	1974	66	67	47	62
1934	10	6	0	1	1975	68	70	32	38
1935	10	6	0	1	1976	45	59	47	63
1936	7	4	0	1	1977	66	39	32	31
1937	18	11	0	0	1978	122	80	10	36
1938	20	13	1	0	1979	136	56	8	44
1939	22	13	1	2	1980	99	66	22	61
1940	25	15	0	0	1981	120	65	17	44
1941	19	10	1	1	1982	99	70	4	37
1942	21	13	1	2	1983	85	78	3	28
1943	32	18	0	1	1984	100	79	30	55
1944	25	14	0	1	1985	108	60	20	48
1945	21	13	0	1	1986	100	70	12	41
1946	30	18	2	7	1987	110	64	11	36
1947	35	22	3	11	1988	9	11	0	2
1948	33	23	8	21	1989	9	11	0	2
1949	36	26	5	16	1990	9	11	0	2
1950	54	33	9	20	1991	9	11	0	2
1951	54	33	7	33	1992	9	11	0	2
1952	52	55	9	48	1993	9	11	0	2
1953	42	42	14	27	1994	7	10	19	5
1954	34	34	26	59	1995	6	10	93	11
1955	66	59	17	59	1996	27	12	27	9
1956	92	70	29	56	1997	7	10	88	15
1957	64	68	13	56	1998	14	10	83	13
1958	83	95	38	83	1999	42	17	19	15
1959	47	53	18	38	2000	21	15	16	1
1960	41	49	18	38	2001	29	11	67	8
1961	54	63	23	47	2002	65	37	36	3
1962	35	41	21	44	2003	28	30	80	8
1963	36	42	16	31	2004	57	22	74	10
1964	51	61	14	33	2005	77	53	57	13
1965	39	73	29	46	2006	63	46	68	8
1966	57	79	30	37	2007	100	65	21	2
1967	42	59	25	46	2008	48	51	52	8
1968	40	61	10	33	2009	61	56	28	8
1969	25	32	23	62	2010	49	49	12	4
1970	66	65	24	39	2011	33	30	34	18

A01_4

	Regions corresponding to:					Regions corresponding to:			
	OW		OE			OW		OE	
	♂	♀	♂	♀		♂	♀	♂	♀
1930	4	3	0	0	1971	60	57	26	29
1931	4	2	0	1	1972	39	72	38	55
1932	7	5	0	0	1973	76	88	87	94
1933	7	5	0	0	1974	68	69	51	65
1934	11	6	0	1	1975	71	73	36	40
1935	10	6	1	1	1976	46	61	51	68
1936	8	4	0	1	1977	69	39	36	33
1937	20	12	0	0	1978	135	85	11	38
1938	23	14	1	0	1979	150	58	10	46
1939	24	14	2	2	1980	107	68	25	65
1940	28	16	0	0	1981	131	66	20	48
1941	20	12	2	1	1982	110	74	4	39
1942	23	14	2	2	1983	93	83	4	29
1943	36	20	0	1	1984	108	82	33	58
1944	28	16	0	1	1985	117	60	22	51
1945	24	14	0	1	1986	109	71	13	43
1946	32	19	2	7	1987	119	66	12	37
1947	37	23	4	11	1988	8	10	0	2
1948	35	22	10	23	1989	9	11	0	2
1949	38	26	6	17	1990	8	10	0	2
1950	59	33	11	22	1991	8	11	0	1
1951	58	32	8	36	1992	8	11	0	1
1952	56	56	10	52	1993	8	10	0	2
1953	44	43	17	30	1994	7	10	20	5
1954	34	32	29	63	1995	6	9	93	12
1955	70	59	21	65	1996	27	12	27	9
1956	98	72	34	60	1997	7	10	88	15
1957	69	69	15	61	1998	14	10	83	13
1958	86	96	44	91	1999	43	17	18	14
1959	49	53	21	42	2000	21	15	16	1
1960	43	50	20	41	2001	29	11	67	8
1961	56	64	27	52	2002	64	37	36	3
1962	36	41	23	47	2003	28	31	80	8
1963	37	41	18	35	2004	56	22	74	10
1964	53	64	17	37	2005	77	53	56	13
1965	39	75	32	51	2006	63	46	67	7
1966	59	82	33	42	2007	98	64	21	2
1967	42	58	28	50	2008	47	51	51	8
1968	42	63	11	36	2009	60	55	27	8
1969	24	31	25	65	2010	47	48	12	4
1970	69	67	27	43	2011	63	45	1	2

Table A2: Number of mature females in 2000 (from NP minke *IST*s – see text above - Cherry Allisson, pers. commn). Only the A01_1 scenario is considered here.

		Year	Number of mature females
A01_1:	O	2000	9562
A01_4:	O	2000	9581
C01_1:	OW	2000	2000
	OE	2000	8119
C01_4:	OW	2000	1894
	OE	2000	8071

Table A3: Catch-at-age data from JARPN and JARPN II surveys for regions corresponding to OW and OE.

Region OW, males

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1996	0	0	2	0	0	1	2	0	1	2	0	1	3	3	0	0	0	0	0	1	2
1999	0	0	0	0	1	1	3	0	1	2	2	3	2	1	4	0	1	1	0	0	5
2000	0	0	0	2	1	1	1	2	0	0	0	0	0	1	0	0	0	0	0	0	0
2001	0	0	0	2	0	1	0	0	0	0	2	1	1	1	1	0	0	0	1	1	4
2002	0	1	2	1	3	0	0	1	1	0	0	1	3	0	3	0	2	2	4	0	6
2003	0	1	2	2	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	1	0
2004	0	2	0	1	2	1	2	4	0	2	2	2	2	2	1	1	6	0	0	1	0
2005	0	2	2	4	7	3	0	4	1	1	2	3	1	1	0	6	0	3	1	2	3
2006	0	4	5	4	4	3	1	0	2	3	2	1	1	0	2	0	2	2	2	0	5
2007	0	2	2	4	6	6	4	0	2	4	1	3	4	0	0	2	3	4	2	2	5
2008	0	2	5	3	4	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0	1
2009	0	5	2	3	4	3	1	1	1	0	2	0	1	1	1	1	1	0	0	0	6
2010	0	2	2	2	2	1	1	1	0	0	2	1	1	0	1	2	0	0	1	0	2
2011	0	1	1	3	4	4	3	2	5	4	0	1	1	4	2	0	1	0	0	2	3

Region OW, females

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	2
1999	0	0	0	0	0	0	0	0	0	0	1	1	2	3	1	2	1	0	0	1	1
2000	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1
2001	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	1	2	1	0	1	0	2	1	0	0	0	1	0	1	0	0	0	0	2
2003	0	2	2	2	1	2	0	2	0	0	1	1	1	0	0	0	0	0	0	0	1
2004	0	3	1	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2005	0	4	5	4	2	0	2	4	0	1	1	2	1	1	0	2	1	0	1	0	1
2006	0	2	0	6	3	4	0	3	0	0	1	0	0	1	0	0	0	0	1	0	1
2007	0	5	5	5	2	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1
2008	0	3	3	3	5	0	1	0	1	1	0	1	1	1	0	2	0	0	0	1	1
2009	0	6	4	1	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2010	0	6	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2011	0	2	4	0	1	5	4	0	2	1	0	0	1	1	0	0	0	1	0	0	2

Region OE, males

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1994	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0	2	0	0	2	2
1995	0	0	1	0	0	0	2	1	3	2	3	3	3	0	1	0	2	3	2	3	5
1996	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	1	1	0	0	1	3
1997	0	0	0	2	4	0	1	2	3	0	4	3	2	5	3	2	2	1	1	0	6
1998	0	0	1	2	1	0	1	0	1	0	3	2	3	2	2	1	1	3	0	1	10
1999	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2001	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	1	4	0	1	12
2002	0	0	0	0	0	0	0	0	1	0	2	0	0	0	2	0	2	1	3	2	8
2003	0	0	1	1	2	1	1	2	3	0	1	0	2	2	5	2	2	1	0	0	18
2004	0	0	0	0	1	1	0	0	1	0	3	1	0	1	3	4	1	0	1	3	11
2005	0	0	1	1	0	2	1	2	0	1	0	1	1	1	1	1	1	1	2	2	8
2006	0	0	0	0	3	0	0	1	3	1	3	1	1	0	0	0	2	1	0	0	8
2007	0	0	1	1	0	1	0	0	1	2	1	1	0	0	0	0	0	0	1	1	7
2008	0	0	0	0	0	1	3	2	0	0	1	1	1	0	2	3	1	1	1	2	7
2009	0	0	0	0	0	0	1	0	0	0	2	0	1	0	1	0	0	0	0	0	4
2010	0	0	2	0	1	1	0	0	0	0	0	1	0	1	0	2	1	0	0	0	0

Region OE, females

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1995	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4
1996	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2001	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2004	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
2005	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
2008	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2
2009	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
2010	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A4: Life history parameter values (as defined for the *IST*s detailed in IWC (2014)). The maturity ogive is logistic, with a_m the earliest age at which first parturition can occur.

Parameter	Value	
Age at first parturition	5	
Age-at-50% maturity	7	
Steepness of the ascending limb of the maturity ogive	1.2	
Natural mortality:		
4-	0.085000	
5	0.077500	
6	0.072098	
7	0.066696	
8	0.061295	
9	0.055893	
10	0.050491	
11	0.045089	
12	0.039688	
13	0.034286	
14	0.028884	
15	0.023482	
16	0.018080	
17	0.012679	
18	0.007277	
19	0.001875	
20+	0.115000	
	MSYR=1%	MSYR=4%
Resilience parameter	0.12053	0.48523
Degree of compensation	2.38475	2.37389

Table A5: Ageing error matrix.

Expected age in observation (columns); True age (rows)

True age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	0.86	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.16	0.67	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.01	0.19	0.60	0.19	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0.01	0.21	0.55	0.21	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0.02	0.23	0.50	0.23	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0.03	0.24	0.47	0.24	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0.04	0.24	0.43	0.24	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0.05	0.24	0.40	0.24	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0.01	0.06	0.24	0.38	0.24	0.06	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0.01	0.07	0.24	0.36	0.24	0.07	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0.01	0.08	0.24	0.34	0.24	0.08	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0.02	0.09	0.23	0.32	0.23	0.09	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0.02	0.10	0.23	0.30	0.23	0.10	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0.03	0.10	0.22	0.29	0.22	0.10	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.11	0.22	0.28	0.22	0.11	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0.01	0.04	0.11	0.21	0.26	0.21	0.11	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.04	0.11	0.21	0.25	0.21	0.11	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.05	0.12	0.20	0.24	0.20	0.12	0.05	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.12	0.20	0.23	0.20	0.12	0.05	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.12	0.19	0.22	0.19	0.12	0.05	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.06	0.12	0.19	0.22	0.19	0.12	0.06	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.06	0.12	0.18	0.21	0.18	0.12	0.06	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.06	0.12	0.18	0.20	0.18	0.12	0.06	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.07	0.12	0.17	0.20	0.17	0.12	0.07	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.07	0.12	0.17	0.19	0.17	0.12	0.07	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.07	0.12	0.17	0.18	0.17	0.12	0.07	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.04	0.07	0.12	0.16	0.18	0.16	0.12	0.07	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.07	0.12	0.16	0.17	0.16	0.12	0.07	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.08	0.12	0.15	0.17	0.15	0.12	0.08	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.08	0.12	0.15	0.16	0.15	0.12	0.08	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.04	0.08	0.12	0.15	0.16	0.15	0.12	0.08	0.04	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.05	0.08	0.11	0.14	0.16	0.14	0.11	0.08	0.05	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.05	0.08	0.11	0.14	0.15	0.14	0.11	0.08	0.05	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.05	0.08	0.11	0.14	0.15	0.14	0.11	0.08	0.05	0.03	0.01	0.01	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.05	0.08	0.11	0.14	0.14	0.14	0.11	0.08	0.05	0.03	0.01	0.01	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.05	0.08	0.11	0.13	0.14	0.13	0.11	0.08	0.05	0.03	0.01	0.01	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.05	0.08	0.11	0.13	0.14	0.13	0.11	0.08	0.05	0.03	0.02	0.01	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.05	0.08	0.11	0.13	0.13	0.13	0.11	0.08	0.05	0.03	0.02	0.01	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.06	0.08	0.11	0.12	0.13	0.12	0.11	0.08	0.06	0.03	0.02	0.01	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.06	0.08	0.10	0.12	0.13	0.12	0.10	0.08	0.06	0.03	0.02	0.01	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.13	0.12	0.10	0.08	0.06	0.04	0.02	0.01	0.01	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.02	0.01	0.01	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.02	0.01	0.01
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.02	0.01
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04	0.03
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.04	0.06	0.08	0.10	0.12	0.12	0.12	0.10	0.08	0.06	0.04
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.03	0.05	0.07	0.09	0.11	0.12	0.13	0.12	0.11	0.09	0.07
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.03	0.05	0.07	0.09	0.11	0.13	0.13	0.13	0.11	0.09
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.14	0.14	0.12
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0.03	0.05	0.07	0.09	0.12	0.14	0.16	0.16	0.16
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0.04	0.05	0.08	0.11	0.14	0.17	0.18	0.19

Table A6: Age readability proportion for males and females. These values were obtained by fitting logistic curves to the data available.

Age	Males	Females
0	0.1981	0.1998
1	0.2047	0.2134
2	0.2764	0.2757
3	0.4232	0.3906
4	0.4874	0.4678
5	0.5042	0.4969
6	0.5091	0.5067
7	0.5109	0.5102
8	0.5117	0.5116
9	0.5121	0.5123
10	0.5123	0.5126
11	0.5125	0.5128
12	0.5125	0.5129
13	0.5126	0.5129
14	0.5126	0.5130
15	0.5127	0.5130
16	0.5127	0.5130
17	0.5127	0.5130
18	0.5127	0.5130
19	0.5127	0.5130
20+	0.5127	0.5130

Table A7: Assumed proportion of the total sample of males and females in each region, based on averages over the 2000-2010 period for JARPN and JARPNII.

	Males	Females
OW	0.471	0.279
OE	0.200	0.050

Appendix B - The Statistical Catch-at-Age Model

The text following sets out the equations and other general specifications of the SCAA followed by details of the contributions to the log-likelihood function from the different sources of data available. Quasi-Newton minimization is then applied to minimize the total negative log-likelihood function to estimate parameter values (the package AD Model Builder[TM] (Fournier *et al*., 2012) is used for this purpose).

B.1. Population dynamics

B.1.1 NUMBERS-AT-AGE

The resource dynamics are modelled by the following set of population dynamics equations:

$$N_{y+1,a}^{g} = \begin{cases} 0.5b_{y+1} & \text{if } a = 0 \\ \left(N_{y,a-1}^{g} - C_{y,a-1}^{g}\right)S_{a-1} & \text{if } 1 \leq a < m \\ \left(N_{y,m-1}^{g} - C_{y,m-1}^{g}\right)S_{m-1} + \left(N_{y,m}^{g} - C_{m}^{g}\right)S_{m} & \text{if } a = m \end{cases} \qquad \text{(B1)}$$

where

$N_{y,a}^{g}$ is the number of animal of gender g and age a at the start of year y,

$C_{y,a}^{g}$ is the catch (in number) of animal of gender g and age a during year y,

b_y is the number of calves born to females at the start of year y,

S_a is the survival rate e^{-M_a} where M_a is the instantaneous rate of natural mortality (assumed to be independent of gender),

$m = 50$ is the maximum age (treated as a plus-group).

B.1.2. BIRTHS

Density-dependence is assumed to act on the female component of the mature population.

$$b_y = BN_y^f \left\{1 + A\left[1 - \left(N_y^f / K^f\right)^z\right]\right\} e^{\varepsilon_y} \qquad \text{(B2)}$$

where

B is the average number of births (of both genders) per year for a mature female in the pristine population,

A is the resilience parameter (see Table A4),

z is the degree of compensation (see Table A4),

$N_y^f = \sum_{a_m} f_a^f N_{y,a}^f$ is the number of mature' females at the start of year y,

a_m is the earliest age-at-first parturition (see Table A4);

f_a^f is the proportion of mature female of age a,

K^f is the number of mature females in the pristine population, and

ε_y from $N(0, (\sigma_R)^2)$ with $\sigma_R = 0.25$.

B.1.3. TOTAL CATCH AND CATCHES-AT-AGE

The catch-at-age is given by:

$$C_{y,a}^{k,g} = F_y^{k,g} v_{y,a}^{k,g} N_{y,a}^{g} \qquad \text{(B3)}$$

where

$C_{y,a}^{k,g}$ is the catch-at-age, i.e. the number of animal of gender *g* and age *a* caught during year *y* in region *k* (where *k* refers to inshore/offshore),

$v_{y,a}^{k,g}$ is the commercial selectivity of an animal of gender *g* and age *a* for year *y* in region *k*; when $v_{y,a}^{g} = 1$, the age-class *a* is said to be fully selected, and

$F_y^{k,g} = \frac{C_y^{k,g}}{\sum_a v_{y,a}^{k,g} N_{y,a}^{g}}$ is the proportion of a fully selected age class that is caught in region *k*.

B.1.4. INITIAL CONDITIONS

For the first year (y_0) considered in the model (here 1930), the numbers-at-age are taken to be at unexploited equilibrium, i.e.:

$$N_{y_0,a}^{g} = \begin{cases} 0.5BK^{f} & \text{if } a = 0 \\ N_{y_0,a-1}^{g} S_{a-1} & \text{if } 1 \leq a < m \\ N_{y_0,m-1}^{g} S_{m-1}/(1 - S_m) & \text{if } a = m \end{cases} \qquad \text{(B4)}$$

B.2. The likelihood function

The model is fitted to estimates of mature female numbers and catch-at-age data to estimate model parameters. Contributions by each of these to the negative of the (penalised) log-likelihood ($-lnL$) are as follows.

Mature female numbers

$$-lnL^{abund} = \sum_j \left\{ \frac{\left(\varepsilon_y\right)^2}{2\sigma_y^2} \right\} \qquad \text{(B5)}$$

with

$$\varepsilon_y = ln\left(I_y\right) - ln\left(\sum_a f_a^{f} N_{y,a}^{f}\right) \qquad \text{(B6)}$$

where

I_y is the estimate of mature female numbers in year *y*, and

$$\sigma_y = \begin{cases} 0.01 & \text{for } y = 2000 \text{ (i.e. sufficiently low to force and exact fit to } I_{2000}\text{)} \\ 0.25 & y \geq 2012 \end{cases}$$

Commercial catches-at-age

The contribution of the catch-at-age data to the negative of the log-likelihood function under the assumption of a multinomial error distribution is given by:

$$-lnL^{CAA} = \sum_{k,y,g,a} -O_{y,a}^{k,g} ln\left(\frac{\hat{O}_{y,a}^{k,g}}{\sum_{a'} \hat{O}_{y,a'}^{k,g}}\right) \quad \text{(B7)}$$

where

$O_{y,a}^{k,g}$ is the observed number of whale of age *a* and gender *g* caught in year *y* in region *k*,

$\hat{O}_{y,a}^{k,g}$ is the model-predicted number of whale of age *a* and gender *g* caught in year *y*in region *k*,

where

$$\hat{O}_{y,a}^{k,g} = \sum_{a'} F_y^{k,g} v_{y,a'}^{k,g} r_{a'}^{g} N_{y,a'}^{g} E_{a,a'} \quad \text{(B8)}$$

with

$E_{a,a}$ being the ageing error matrix (Table A5), and

r_a^g being the age readability at age *a* for gender *g* (Table A6).

The standardised residuals are computed as:

$$\varepsilon_{y,a}^{k,g} = \frac{O_{y,a}^{k,g,k}/\sum_{a'} O_{y,a'}^{g} - \hat{O}_{y,a}^{g}/\sum_{a'} \hat{O}_{y,a'}^{g}}{\sigma_{y,a}^{g,j}} \quad \text{(B9)}$$

with

$$\sigma_{y,a}^{k,g} = \frac{pO_{y,a}^{k,g} \frac{\hat{O}_{y,a}^{k,g}}{\sum_{a'} \hat{O}_{y,a'}^{k,g}}\left(1 - \frac{\hat{O}_{y,a}^{k,g}}{\sum_{a'} \hat{O}_{y,a'}^{k,g}}\right)}{\sum_{a'} O_{y,a'}^{k,g}} \quad \text{(B10)}$$

Female births (recruitment) residuals are defined by:

$$b_y = BN_y^f \left\{1 + A\left[1 - \left(N_y^f/K^f\right)^Z\right]\right\} e^{\varphi_y} \quad \text{(B11)}$$

where φ_y from $N(0, (\sigma_R)^2)$ with $\sigma_R = 0.25$

with the following penalty added to the negative log-likelihood:

$$pen_{birth} = \sum_y \left\{\frac{\left(\varphi_y\right)^2}{2\sigma_R^2}\right\} \quad \text{(B12)}$$

The standard deviations for total numbers are computed as follows, taking account of the estimation bias:

$$\sigma_y^{N_{tot}} = \sqrt{\sum_n \left(\hat{N}_y^{tot} - \beta_y - N_y^{tot}\right)^2/n} \quad \text{(B13)}$$

with the bias computed as:

$$\beta_y = \left(\hat{N}_y^{tot} - N_y^{tot}\right)/n \quad \text{(B14)}$$

and similarly for the female births.

To allow for a better fit, carrying capacity *K* is allowed to change (by a limited amount) every 10 projected years, starting in 2012, but staying constant during each of these 10 year periods:

$$K_y = \begin{cases} K_y = K & \text{for } y \leq 2011 \\ K_{y-1} e^{\varepsilon_y} & \text{for } y = 2012, 2022, 2032 \ldots \\ K_{y-1} & \text{for } y \neq 2012, 2022, 2032 \ldots \end{cases} \quad \text{(B15)}$$

with the following penalty added to the negative log-likelihood:

$$pen_K = \sum_y \left\{ \frac{\left(\varepsilon_y\right)^2}{2\sigma_K^2} \right\} \qquad \text{(B16)}$$

with $\sigma_K = 0.1$.

Thus, aside from selectivity-related parameters, the estimable parameters of the model are *K*, and the 10-yearly ε_y together with the annual recruitment residuals φ_y.

B.3. Harvesting selectivity

Fishing selectivities-at-age in each region *k* are estimated using a logistic form:

$$v_{y,a}^{k,g} = \left(1 + e^{\left(\Delta_{y,a}^{k,g} - a\right)/\delta_{y,a}^{k,g}}\right)^{-1} \qquad \text{(B17)}$$

Pre-1988, the selectivities are taken to be the same for males and females, with the parameters fixed: $\Delta = 4$ and $\delta = 1.2$ (i.e. as for the trials detailed in IWC (2014)).

Post-1988, the selectivities are estimated separately for males and females. Furthermore, ρ is estimated for the female selectivity, so that:

$$v_{y,a}^{f} \rightarrow \rho v_{y,a}^{f} \qquad \text{(B18)}$$

Reference

Fournier, D.A., Skaug, H.J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M.N., Nielsen, A., and Sibert, J. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. *Optim. Methods Softw*. 27:233-249.

Appendix C – Projection methodology

Projections into the future and their evaluation are developed using the following steps.

Step 1: Begin-year numbers-at-age

The components of the numbers-at-age vector for each gender g and at the start of 2012 ($N^{g}_{2012,a}$) are obtained from the MLE of an assessment.

Error is included for all ages, i.e.: $N^{g}_{2012,a} \rightarrow N^{g}_{2012,a} e^{\varepsilon_a}$

$$\varepsilon_a \text{ from } N(0,(\sigma_N)^2) \qquad \text{(C1)}$$

where

σ_N is taken to be 0.2 (independent of age).

Step 2: Catch

These numbers-at-age are projected one year forward at a time given a catch for the year concerned C_y .

This requires specification of how the catch is disaggregated by gender and age and region to obtain $C^{k,g}_{y,a}$, and how future births are generated.

Step 3: Catch-at-age by region, gender and age

Catch by region:

A 60:40 ratio is assumed for the future catches in the inshore:offshore regions.

Catch by gender:

The male/female fishing mortality ratio is taken to stay constant at the 2007-2011 average estimated in the assessment:

$$\rho = \frac{1}{5}\sum_{y=2007}^{2011} F^{k,m}_y / F^{k,f}_y \qquad \text{(C2)}$$

so that:

$$F^{k,f}_y = \frac{C^k_y}{\sum_a v^{k,f}_{y,a} N^f_{y,a} + r \sum_a v^{k,m}_{y,a} N^m_{y,a}} \qquad \text{(C3)}$$

and

$$F^{k,m}_y = \rho F^{k,f}_y \qquad \text{(C4)}$$

The catch by gender is computed by:

$$C^{k,g}_y = F^{k,f}_y \sum_a v^{k,g}_{y,a} r^g_a N^g_{y,a} \qquad \text{(C5)}$$

Catch by age

$C^{k,g}_{y,a}$ is obtained by assuming that the commercial selectivity of an animal of gender g and age a for year y ($v^{k,g}_{y,a}$) stays constant in the future as estimated in the assessment.

$$C^{k,g}_{y,a} = F^{k,f}_y v^{k,g}_{y,a} r^g_a N^g_{y,a} \qquad \text{(C6)}$$

The numbers-at-age can then be computed for the beginning of the following year (y+1):

$$N_{y+1,a}^{g} = \begin{cases} 0.5b_{y+1} & \text{if } a = 0 \\ \left(N_{y,a-1}^{g} - \sum_k C_{y,a-1}^{k,g}\right)S_{a-1} & \text{if } 1 \le a < m \\ \left(N_{y,m-1}^{g} - \sum_k C_{y,m-1}^{k,g}\right)S_{m-1} + \left(N_{y,m}^{g} - \sum_k C_{m}^{k,g}\right)S_m & \text{if } a = m \end{cases} \quad \text{(C7)}$$

Step 4: Births

Future births are obtained assuming a density-dependence acting on the female component of the mature population.

$$b_y = BN_y^f \left\{1 + A\left[1 - \left(N_y^f/K^f\right)^Z\right]\right\} e^{\varepsilon_y} \quad \text{(C8)}$$

Step 5: Generate data

The information obtained in Steps 1 to 4 is used to generate NEWREP-NP catch-at-age data. These data are generated assuming the same multinomial error structure as in the past. The multinomial parameters are the probabilities for each age and the sample size. The probabilities are the expected proportions-at-age for gender g:

$$\hat{O}_{y,a}^{k,g} = \frac{\sum_{a'} v_{y,a'}^{k,g} r_{a'}^{g} N_{y,a'}^{g} E_{a,a'}}{\sum_{a*,a'} v_{y,a'}^{k,g} r_{a'}^{g} N_{y,a'}^{g} E_{a*,a'}} \quad \text{(C9)}$$

while the sample size for the corresponding gender is a fixed proportion of the total sample size:

$$n^g = \gamma^g n \quad \text{(C10)}$$

with

γ^g given in Table A7.

Note that because the purpose of the exercise is to compare estimation performance for different sample sizes for age data, it is desirable that the true numbers-at-age trajectories are the same though these sample sizes differ. This has been done by computing the dynamics using the largest sample size considered (160 in this case), and then scaling down the age-readability vectors to reflect the actual sample size.

In addition, survey estimates of abundance are generated every six years, commencing in year 2012, as follows:

$$I_y = \sum_a f_a^f N_{y,a}^f e^{\varepsilon_y} \quad \text{(C11)}$$

ε_y from $N(0,(\sigma)^2)$ with $= 0.25$.

Step 6: Conduct updated assessment using generated data

The updated assessments follow the procedures set out in Appendix B, incorporating all those historical data in $-lnL$. For the generated data, the catch-at-age data is included as for the historical data. The generated survey estimates of abundance are included using equation B5, with $\sigma_y = 0.25$, i.e. the assessment assumes the same value as used in generating these data.

Appendix D – Over-dispersion in catch-at-age data

Over-dispersion in the catch-at-age data has been estimated from the fit of the baseline population model to the A01_1 scenario, using the following equation:

$$D = \frac{\sum_{y,A}\left(\sum_{a\in A}(n_{y,a}p_{y,a}) - \sum_{a\in A}(n_{y,a}\hat{p}_{y,a})\right)^2}{\sum_{y,A}\left[\sum_{a\in A}(n_{y,a}\hat{p}_{y,a})(1-\sum_{a\in A}\hat{p}_{y,a})\right]} \qquad \text{(D1)}$$

where the ratio of summations over years rather than the average of yearly ratios was used in the interests of more robust estimation in the face of differing annual sample sizes.

The result of the calculation yielded D = 1.34, i.e. an increase of about one third.

The original intention was to generate future catch-at-age data from an over-dispersed multinomial distribution with this value of 1.34 for the over-dispersion parameter. However for the small samples sizes typical for most of the ages considered here, standard Dirichlet–multinomial generation procedures exhibit large small sample bias, precluding their use.

In these circumstances the assumption has been made that effective sample size scales inversely with variance. Hence, given that the value D = 1.34 reflects an increase of about one third, for an actual intended sample size of *N*, the sample size used when generating catch-at-age data from a multinomial has been set at n =0.75N.

ADJUNCT 4
The selection of sample size North of Hokkaido (sub area 11)

There is limited information on mixing proportion of J stock in sub area 11 (see Annex 7). An examination of the required sample size to estimate the **annual** mixing proportion in this sub area with sufficient precision (e.g. SE (p) is less than 0.1).

In the formula below p is the proportion of J stock in the sub-area and n is the number of the samples in the sub area. Standard error of p, SE($\hat{p}$) is:

$$SE(\hat{p}) = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \qquad (1)$$

Considering overdispersion ϕ (>1), equation (1) becomes:

$$SE(\hat{p}) = \sqrt{\frac{\hat{p}(1-\hat{p})\phi}{n}} \qquad (1)'$$

SE($\hat{p}$) is a maximum when p=0.5 for fixed n. Therefore for this calculation p=0.5 is assumed, without loss of generality. It is desirable to obtain the proportion of the J stock in sub-area 11 with sufficient precision (e.g. SE($\hat{p}$) is less than 0.1). To fulfil this condition:

$$\frac{0.5\sqrt{\phi}}{\sqrt{n}} > 0.1$$
$$n > 25\phi \qquad (2)$$

Considering that the ratio of unassigned samples is 9% in sub-areas 7CS and 7CN (data from the JARPNII coastal component), the required sample size should satisfy the following condition:

$$n > \frac{25\phi}{(1-0.09)} \qquad (3)$$

The overdispersion parameter was estimated by using the samples in sub-area 7CN, assuming a quasi-binomial error in conducting Generalized Linear Model GLM):

$$p = \frac{\exp\{-(a_1 + a_2 y)\}}{1-\exp\{-(a_1 + a_2 y)\}} \qquad (4)$$

where a_1 and a_2 are coefficients to be estimated and y indicates year. The overdispersion parameter ϕ was estimated as 1.689. Substituting the formula (3) for the estimated parameter the resulting sample size is 47.

It should be noted that this estimate is preliminary, and only applies for the first six years of NEWREP-NP. More detailed estimates of sample sizes for the objective of studying yearly trend in the J stock proportion will be made once new data are accumulated after the first six surveys.

Annex 12

Whale sampling survey design under Primary Objective II (sei whale)

Research area

The main study area for lethal sampling of sei whale will be the western North Pacific while non-lethal research such as sighting survey will be conducted in the pelagic region of the North Pacific delimited by 30°N-50°N; 145°E-140°W, which correspond approximately to the area covered by the Japanese DNA survey.

Research period

Annual surveys in this region will be conducted between April and October, which coincide with the migration of the species to the summer feeding grounds.

Target species and sample sizes under Primary Objective II

The target species is the sei whale. The annual sample size in the survey area will be XXX animals (see details of the sample size estimates in Annex 16. The number of samples by month, year and sub-area collected by JARPNII in the period 2002-2016 and the expected samples by NEWREP-NP in the period 2017-2022 are shown in Tables 1 and 2, respectively.

Research vessels

The research base *Nisshin Maru* and two sampling and sampling vessels (*Yushin Maru No. 1* and *3*) will be employed for sampling sei whales. See details of the research vessels in Annex 21.

Survey procedure

The track lines and the allocation of vessels will be set in a similar manner as in previous JARPNII surveys. A zigzag-shaped track line will be set in the research area (see example in Figure 1). The track line consists of one main and two parallel courses, which will be established seven n.miles apart from the main course. Furthermore, in order to secure the sampling of the estimated number of samples, an Adaptive Type Survey (ATS) (e.g. Pollard et al., 2002) and a Special Survey (SS) (Bando *et al*., 2016) may be conducted, when the whale density are expected to be high. ATS will be designed by adding tracks lines over the predetermined track lines. On the other hand, the SS will establish new track lines independently from the original track lines. The track lines of ATS and SS consist of one main and two parallel courses that will be established several n. miles apart from main course.

Survey will be conducted under two main modes, NSC and NSS, depending on weather and sea conditions. The condition to conduct surveys under NSC mode is similar to those established in Japanese dedicated sighting surveys (i.e. visibility of 2 n.miles or more and Beaufort wind scale of 4 or below). The NSS mode will be used under unfavorable weather and sea conditions, though the sampling of whales is still possible. These two survey modes will be recorded separately for future analysis.

Each of the sampling/sighting vessels will change the track line every day to avoid possible sighting bias by a fixed position. The starting position of the day will be set at a point where one of the vessels ended the survey in the previous day in the most advanced position. Other vessels will move to the starting position of the next day after the end of the daily survey. These daily arrangements of vessels will be determined by the cruise leader. The survey is conducted at a speed of 10.5 knots from 1 hour after sunrise to 1 hour before sunset (or maximum from 06:00 to 18:00), with three top men assigned to the barrel.

Sightings of whales will be classified into primary and secondary sightings. The primary sightings are those made in normal searching mode (three observers searched from the top barrel of the vessel on the predetermined trackline). The secondary sightings are those made in modes other than normal searching mode (*e.g.* during confirming or chasing whales, no observer in the top barrel or the vessel engaging in other work).

A researcher on board will record sighting effort and all of the large whale sightings. The sighting record includes date, time, position of the vessel, survey mode (primary or secondary), angle and distance from the vessel at the sighting, species and school size, estimated body length, etc. Weather information (weather, visibility, wind direction and speed, sea surface water temperature) will be recorded every hour.
All sei whales sighted as primary and secondary sightings, excluding cow and calf pairs, will be targeted for sampling. When a sighting consists of more than one animal, the first targeted animal will be selected using tables of random sampling numbers (TRS).

Sampling will be made by a 75mm whaling cannon. Observers on the top barrel will count the number of whales in the school and will estimate the body length of each animal. If a sighting is a solitary whale, it will be sampled immediately after the body length estimation. If a school consists of two or more animals, the researcher will assign a serial number to each individual and the first target whale will be selected using the TRS. When two whales are sampled from a school, the second target will be selected by the same manner after the first animal is sampled. In this case, the remaining individuals will be renumbered according to the latest position in the school. In order to maintain the human safety during the operations, chasing will be usually limited to a maximum of 120 minutes.

When the sampling vessel take a whale, the whale sampled will be pulled onto the upper deck of the research base vessel where it will be biologically examined by a team of scientists.

Details of the field, laboratory and analytical procedures are given in section 3.2 of the main text.

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Table 1. Distribution of available sei whale samples, by year, month and sub-area.

Year-Month	Tot	Sub-areas 7	8	9
2002-5				
2002-6				
2002-7	39		4	32
2002-8				
2002-9			3	
2003-5			3	
2003-6		1	16	11
2003-7	50	4		12
2003-8				3
2003-9				
2004-5				
2004-6			2	9
2004-7	100			36
2004-8				27
2004-9				26
2005-5			12	5
2005-6			3	41
2005-7	100		16	17
2005-8				6
2005-9				
2006-5				
2006-6		1	19	19
2006-7	100	4	29	5
2006-8				23
2006-9				
2007-5			16	22
2007-6		2	2	23
2007-7	100	4	6	16
2007-8				9
2007-9				
2008-5				
2008-6			24	35
2008-7	100		9	15
2008-8				17
2008-9				
2009-5			11	18
2009-6			1	38
2009-7	100		19	13
2009-8				
2009-9				

Year-Month	Tot	Sub-areas 7	8	9
2010-5				
2010-6		10	9	18
2010-7	100		6	29
2010-8				28
2010-9				
2011-5				
2011-6			5	26
2011-7	95		11	11
2011-8		1	13	28
2011-9				
2012-5				
2012-6			31	21
2012-7	100		3	45
2012-8				
2012-9				
2013-5				
2013-6				
2013-7	100			
2013-8			10	36
2013-9				54
2014-5			3	13
2014-6			10	49
2014-7	90		8	7
2014-8				
2014-9				
2015-5				
2015-6			7	
2015-7	90		10	44
2015-8				29
2015-9				
2016-5		4	6	12
2016-6			4	48
2016-7	90		16	
2016-8				
2016-9				

Table 2. Tentative distribution of sei whale samples under the NEWRE-NP, by year, month and sub-area.

Year-Month	Tot	Sub-areas		
		7	8	9
2017-5				
2017-6				
2017-7	134		134	
2017-8				
2017-9				
2018-5				
2018-6				
2018-7	134		134	
2018-8				
2018-9				
2019-5				
2019-6				
2019-7	134		134	
2019-8				
2019-9				
2020-5				
2020-6				
2020-7	134		134	
2020-8				
2020-9				
2021-5				
2021-6				
2021-7	134		134	
2021-8				
2021-9				
2022-5				
2022-6				
2022-7	134		134	
2022-8				
2022-9				

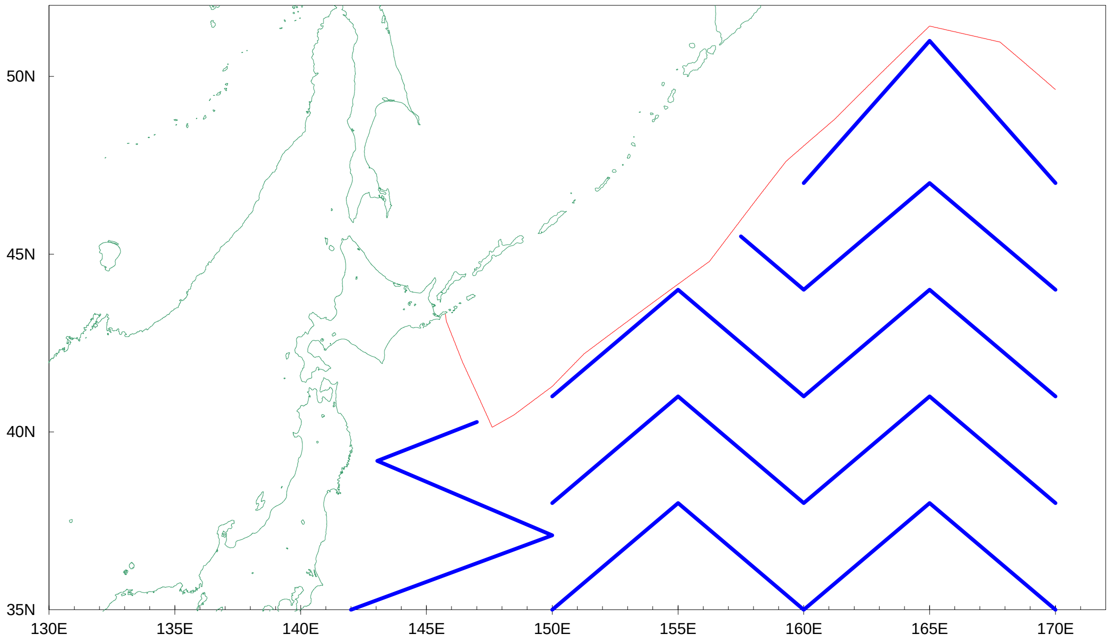

Figure 1. Schematic track line design for whale sampling in the offshore component of the NEWREP-NP.

Annex 13

Secondary Objective II (i)
Abundance estimates for North Pacific sei whales taking account of the additional variance

Field and laboratory work, and analytical procedure

Background
The previous assessment in the IWC/SC performed by Tillman (1977) revealed that the North Pacific sei whales had undergone substantial decline (approximately 20%) from 42,000 in 1963 to 8,600 in 1974 due to intensive pelagic whaling. Forty years has passed since whaling of the sei whales was stopped in the North Pacific.

In JARPN II surveys, dedicated sighting surveys were conducted in sub-areas 7, 8 and 9 excluding foreign EEZ in early and late seasons (Kiwada *et al*, 2009; Matsuoka *et al*., 2016). Since 2010, IWC-POWER surveys have covered the central and eastern North Pacific in longitudinal range between 170ºE and 135ºW, in the south of 20ºN during 2010-2016 (IWC, 2016a). Given that the sei whales are distributed in the north of 40ºN in summer (Horwood, 1987), most of main distribution area of the sei whales were covered except in the east of 135ºW longitudinal line.

Hakamada *et al*. (2009) estimated abundance for the sei whale in sub-areas 7, 8 and 9 in late season as 5,406 (CV=0.300) using design based estimator (i.e. IWC standard methodology) based on JARPNII 2006 and 2007 sighting data. Hakamada and Matsuoka (2016) estimated abundance of 5,086 (CV=0.378) in sub-areas 7, 8 and 9 in late season based on 2008 JARPNII sighting data using the design based estimator and detection functions considering some covariates of detectability. The estimates were presented at the JARPN II review workshop in 2016 and the review Panel recommended that (1) exploration of methods to account for sampling differences between areas and years to obtain measures of short and long-term variation and trends and estimates of the extent of additional variance due to changes over time in spatial distribution and (2) comparison of results from the design-based estimates of abundance with those of model-based estimates, which can be directly obtained from spatial models of distribution and using additional data (IWC, 2016b). Hakamada and Matsuoka (2015) estimated abundance based on IWC-POWER data 2010-2012 using the design based estimator and detection function with covariates. Considering the discussion at the IWC/SC in 2015, Akaike-weighted average of the estimate of 29,632 (CV=0.242) was endorsed for use in the in-depth assessment of the sei whales (IWC, 2016c).

Recommendations (1) and (2) raised by the JARPNII review panel should be addressed to investigate the extent of recovery and the abundance trend of the sei whale stock in the North Pacific.

Field work
Sighting surveys will be conducted by line transect method following the survey protocols set out in the Requirements and Guidelines for Conducting Surveys and analyzing data within the Revised Management Scheme (IWC, 2012) so that sighting surveys are conducted under oversight of IWC/SC. The research plan will be submitted to the IWC/SC before the surveys start. Sighting protocols are the same as those used in the IDCR-SOWER surveys (IWC, 2008). Considering the recommendation from the NEWREP-A expert panel (IWC, 2015), the proponents will consider the following: (a) the survey design and methods will be reviewed to take account previous IWC sighting surveys and spatial model developments; (b) the proponents will work closely with the IWC Scientific Committee before finalizing survey approaches; (c) the proponents will also ensure that future survey plans submitted to IWC SC follow fully the guidelines for such surveys, including the incorporation of planned tracklines.

Survey area and period
Provided that two dedicated sighting vessels will be available for the surveys, survey areas are planned to cover sub-areas 7, 8 and 9 in summer once in three years. For example, sub-areas 7CS, 7CN, 7WR and 7E will be surveyed in the first year, sub-area 8 is planned to be surveyed in the second year and sub-area 9 will be surveyed in the third year. In this case, abundance estimate for sei whales in sub-areas 7, 8 and 9 would be obtained every 3 years. In case dedicated sighting surveys in the Pacific side and other sub-areas will not be conducted simultaneously, sub-areas 6E, 10E and 11 would be surveyed once in other three years. In this case, abundance estimate for sei whales in sub-areas 7, 8 and 9 would be obtained every 6 years.

Areas in the east of 170ºE longitude line, are not planned to be covered in the NEWREP-NP dedicated sighting survey because this area were surveyed in previous IWC-POWER surveys and could be surveyed in future IWC-

POWER surveys. Given that IWC-POWER have been conducted in summer (July and August), the sighting surveys are planned to be conducted in the summer.

Survey mode

Because the use of passing mode in the IWC-POWER would result in very high proportions of unidentified cetaceans, the POWER technical advisory group (TAG) recommended that Passing with abeam closing mode is the most appropriate survey mode, both with respect to confirming species identity and school size (IWC, 2013). This situation would likely occur in sub-areas 7, 8 and 9 because the weather conditions and sea state are not generally good in these sub-areas.

The sighting survey will be conducted using Passing with abeam closing. This survey mode follows the protocol endorsed for the IWC-POWER surveys. Passing with abeam closing mode is in effect passing mode. Two topmen observe from the barrel at all times. There is open communication between the upper bridge and the barrel. The observers on the upper bridge should communicate with the topmen only to clarify information and should not direct the topmen to disrupt their normal search procedure unless directed to do so by the Cruise Leader (Matsuoka *et al*., 2012). Immediately after a sighting is made from the barrel, the topmen inform the upper bridge of their estimate of the distance and angle to the sighting (and also, if possible, the species and number of animals present), but does not change the normal searching pattern in order to keep contact with the sighting. The observers on the upper bridge must attempt to locate the sighting made by the topmen and decide whether it is possible for them to confirm the species and number before the sighting passes abeam of the vessel. The topmen give no further information to the upper bridge unless the whale group happens to surface again within the normal searching pattern of the topmen. A designated researcher on the upper bridge records the species and estimated number of whales in the school when the sighting passes abeam of the vessel, in consultation with other researchers. When the sighting passes abeam of the vessel, the ship then changes course to the appropriate heading to approach the whale, and vessel speed is increased to 15 knots to hasten the closure.

Analytical procedure

Design-based estimator

Assuming that g(0)=1, design based abundance estimator (Thomas *et al*., 2010), which are the standard methodology of line transect surveys, were applied. Covariates related to detectability of the whales are used to estimate detection function (e.g. Hakamada and Matsuoka, 2015; 2016). Estimation procedure will be conducted using DISTANCE program (Thomas *et al*., 2010). Model selection of the detection functions is made using AIC. The estimated abundance for each year and each sub-area can be used as input for models to estimate additional variance.

Inter-annual variance (additional variance)

The approach in Kitakado *et al* (2012) can be used to estimate yearly variation in abundance levels due to inter-annual change in distribution of the sei whale population and abundance trend of the sei whales. By considering the inter-annual variance, underestimating the variance of the abundance estimate can be avoided. This work would respond to the recommendation made at the JARPNII review workshop (IWC, 2016b).

Model-based estimator

Density Surface Modeling (DSM) (Miller *et al*., 2013) will be used, which is one of the packages in the DISTANCE grogram (Thomas *et al*., 2010). But there is a room for trying other options (e.g. smoother, modeling framework, variance estimation method etc.) to improve abundance estimates. For example, an approach presented by Murase *et al*. (2016) would be used as a template of this type of analysis bearing in mind the comments from the JARPNII final review workshop (IWC, 2016b). Sea Surface Temperature (SST), Sea Surface Height anomaly (SSHa) and sea surface chlorophyll-a concentration (Chl-a) recorded by satellites and a digital seafloor depth data would be used as environmental covariates in the models. Data from ocean circulation models such as FRA-ROMS would be used as covariates. It is also planned to compare abundance from model-based estimates with those from the design-based estimates. This work would respond to the recommendation made at the JARPNII final review workshop (IWC, 2016b).

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Annex 14

Secondary Objective II (ii)
Estimation of biological and ecological parameters in North Pacific sei whale for RMP Implementation

Field and laboratory work, and analytical procedure

Background
Under the RMP/*ISTs*, information on biological and ecological parameters is one of key issues for the specification of trials. Although some parameters like the age at sexual maturity are directly obtainable from observations, there are several parameters which can only be derived from the results of stock assessments. The IWC has spent a decade for its discussion and now the SCAA model is recognized as the 'best currently available model for examining stock dynamics for Antarctic minke whales' (IWC, 2014). The SCAA is also applicable to other whale stocks, such as North Pacific sei whales.

In the age-structured population dynamics model, parameters such as the 'natural mortality rate (M)', the 'MSYR', recruitment relationship and time-varying carrying capacity are influential to the results. The estimated changes in the recruitment rate (the number of recruited whales divided by that of mature females) and carrying capacity over years were clear so far, but estimating and monitoring such likely changes in the future has scientific importance given consideration of various changes in the ecosystem and environment in the North Pacific. Therefore, the biological parameters including these which will be estimated from data collected by this program, will contribute to the trials structure in the RMP *ISTs*. Biological information required for SCAA analysis will be collected during this program (see Adjunct 1).

Methods
Field and laboratory work
Biological information required for SCAA analysis will be collected from all of the sampled animals. Age data will be collected by ear plug reading and aspartic acid racemization technique in eye lens. As in the case of common minke whales, earplugs of small individuals will be collected using the method of gelatinized extraction. Ages of whales with unreadable earplugs are estimated applying age-length-key from body length data to be tentatively incorporated into the SCAA (Punt *et al.*, 2014). Body length will be measured straight line from tip of snout to notch of flukes for all animals. Maturity of females is determined by presence or absence of corpora lutea/albicantia in both ovaries. Presence of fetus is examined by cutting both side of uterine horn. Maturity of males is preliminary determined by testis weight at the field, and confirmed by examination of histological testis sample. Testis weight (heavier side) of more than 1,090g is defined as sexually mature (Bando unpublished data) (see Annex 7 for details of field and laboratory works for biological information).

Analytical procedure
Models used in this Secondary Objective are mostly similar with the current SCAA models developed in Punt (2014). The basic assumption is same as that in Punt (2014). The following basic population dynamic is assumed.

<u>1) Basic structure of underlying population dynamics)</u>

$P^g_{t,a}$: the number of animals of age a and sex g at the beginning of year t

R_t : the number of birth in year t

$$P^g_{t,a} = \begin{cases} 0.5R_t & \text{for } a=0 \\ (P^g_{t-1,a-1} - C^g_{t-1,a-1})\, S^g_{a-1} & \text{for } 1 \le a \le m-1 \\ (P^g_{t-1,m-1} - C^g_{t-1,m-1})\, S^g_{m-1} + (P^g_{t-1,m} - C^g_{t-1,m})\, S^g_m & \text{for } a=m \end{cases}$$

$S_a = \exp(-M_a)$: annual survival probability of animals age a

M_a : natural mortality rate of animals age a

2) Recruitment function

$$R_t = \frac{\exp\left[\text{logit}(\tilde{f}_t) + \varepsilon_t\right]}{1+\exp\left[\text{logit}(\tilde{f}_t) + \varepsilon_t\right]} \tilde{P}_t^F$$

$$\tilde{f}_t = f \exp\left[A \left\{1-\left(\frac{P_{t,1+}}{K}\right)^z\right\}\right]$$

$$\varepsilon_t \sim N(0, \sigma_R^2)$$

f : pregnancy rate at the carrying capacity

A : resilience

K : carrying capacity for 1+ population

$\tilde{P}_t^F = \sum_{a=1}^{m} \beta_a P_{t,a}^F$: the number of mature female animals at the beginning of year t

$P_{t,1+} = \sum_{a=1}^{m} (P_{t,a}^M + P_{t,a}^F)$: 1+ population size

β_a : maturity rate for animals of age a

3) Catch and selectivity

C_t : catch in year t

$C_{t,a}^g = \frac{\gamma_a^g P_{t,a}^g}{\sum_{a=0}^{a_{\max}} \gamma_a^g P_{t,a}^g} C_t^g$: expected catch of animals of age a and sex g

$\gamma_{t,a}^g = \left(1+e^{\left(\mu_y^g - a\right)/\delta_y^g}\right)^{-1}$: selectivity specific to age, sex and period (Commercial/Scientific)

4) Likelihood function

Log-normal distributions are assumed for abundance estimates. Also, multinomial distributions are used for describing stochastic nature of sex-specific catch-at-age data. Also, likelihood for recruitment deviations contributes to the total likelihood as a penalty function given σ_R or as an integrand for an integrated likelihood. Codes written in ADMB or TMB will be employed for optimization.

5) Expected outcomes

The results of SCAA analyses will provide improvement in the precision of key biological and ecological parameters. Also, the outcomes will contribute to the specification of the *ISTs*.

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Table 1. Key assumption in the model specification

Parameter/Structure in the model	**Assumption**
Stock structure	Single stock
$MSYR_{1+}$	0.01 and 00.25 (given)
$MSYL_{1+}$	0.6 (given)
Mortality rate (M)	To be estimated
Initial year and initial depletion	D (=1) at 1906
Carrying capacity K_{1+}	To be estimated
Recruitment	Densitity dependence with a fixed MSYR Deviation in the recruitment
Selectivity	Estimated (commercial, scientific, by sex)
Additional variance in abundance estimates (inter-annual distributional change)	To be estimated and incorporated into the model

ADJUNCT 1

Further reasons for improving the estimates of M

The views was expressed by the Review Panel for NEWREP-NP about the likely poor precision of attempts to simultaneously estimate the values of *M* and MSYR for North Pacific sei whales given the information currently available and planned to be obtained under NEWREP-NP.

It has already been pointed out by the Proponents in their responses during the Review that such joint estimation was not the purpose of the proposal (see their morning papers of 1 and 2 February, 2017) submitted to the Panel. Note also that the Panel seems not to have taken certain important comments in these morning papers into account in its report (SC/67a/SCSP01).

It is also certainly true that in the case on North Pacific sei whales, the limited data available (either now or in the short term future) would be insufficient to allow reliable direct estimation of MSYR, either on its own or in combination with *M*. However this last point has little immediate pertinence, as at present the standard practice for *IST*s is to consider trials for fixed values of MSYR, and as explained in those morning papers, the NEWREP-NP proposal related to estimation of *M* conditional on a value for MSYR to secure *IST*s that more realistically reflected stock dynamics, as always needs to be the aim for such trials.

Those morning papers explained that the utility of having such an estimate of *M* related to transient effects in the stock dynamics. The higher the value of *M*, the more rapidly population abundance will respond to changes (for example in recruitment). Annex 16, Figure 5 reports that present data do not exclude values of *M* for North Pacific sei whale within the range of about [0.02; 0.10]. This corresponds to a multiplicative range of a factor of five, about the same as typical for a cod compared to a sardine, for which fisheries management approaches certainly differ in consequence.

One example of the differential consequences of the value of *M* as a result of such transients emerges from projections based on the set of assessments for North Pacific sei whales presented in Annex 16. The conditioning is simple given that this example is intended to purely as a simple illustration: commercial and research selectivities are taken to be fixed at their values for the *M*=0.04 and MSYR(1+)=1% case of the four scenarios considered in that Annex 16 (in any case those selectivities do not differ greatly across those scenarios), and the resilience parameter *A* is adjusted for compatibility with MSYR(1+)=1% and a range on *M* values from 0.02 to 0.10. For each value of *M*, a value of *K* for the mature female component of the population is found to secure the population trajectory passes through the abundance estimate for the stock as a whole for 2010. Finally projections are used to establish what constant future annual catch would result in the population reaching a depletion of 0.72 (the CLA equilibrium) of that component of *K* after 50 years.

Table 1 lists the values of this catch for each of the values of *M* considered. What is evident is that despite all these calculations being conducted for the same value of MSYR, the value of the annual catch changes by relatively substantial amounts as the value of *M* is changed. Such differences would certainly be of interest to managers. Thus even if the value of MSYR is known/assumed, knowledge of the value of *M* remains important.

Table 1: Values of a fixed annual catch that secures a depletion of 0.72 in terms of the mature female population of North Pacific sei whales after 50 years in relation to the value of natural mortality *M*.

M	**Catch**
0.02	153
0.04	93
0.06	57
0.08	30
0.10	6

Moving beyond the current typical *IST*s, there is of course the general relationship evident for marine species that values for productivity and *M* across resources tend to be positively correlated (e.g. Andersen *et al*. 2009), so that information on the value of *M* adds qualitatively at least to an evaluation of the plausibility of different values for MSYR.

But as SC/67a/SCSP01 states, the NEWREP-NP proposal considers the RMP not only in its current form, but as it will need to be modified for future improvement, particularly given the availability of age data. This allows for much improved estimation of annual recruitments and their changes over time, and moves the situation for the whale stock concerned much closer to that typical for the management (including under MPs) of fish populations. The calculation basis underlying SC/67a/SCSP08 is a class of assessment models (sometimes called age-structured production models) used in a "data-limited" situation (as has applied in the past for most whale populations), and in particular relies heavily of an assumed stock-recruitment function and the assumption of a resource at equilibrium prior to the onset of exploitation. In contrast, the greater data set (particularly including age data) that is available for many fish stock assessments sees much less reliance on such assumptions to obtain more reliable results. The associated projections (including for MP testing purposes) are typically much more heavily based on estimates over a recent period of annual recruitments in relation to the reproductive component of the population. In these circumstances, the value of *M* has a much greater influence on assessment outputs and on the estimation of target levels for abundance. For whales there are already cases such as the Eastern North Pacific gray whale and the Indo-Pacific Antarctic minke whale which provide examples of violations of those assumptions regarding pre-exploitation equilibrium and standard stock-recruitment relationships. This adds weight to the desirability of moving whale stocks closer to the typical fish stock assessment situation, given especially the availability of age data; this process is likely to see the value of *M* start to play a more important role in the manner in which *IST*s are developed in the future.

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Annex 15

Secondary Objective II (iii)

Study of the pattern of movement of whales of the 'pelagic stock' within the feeding grounds and between feeding and breeding grounds

Field and laboratory work, and analytical procedure

Background

The *in-depth assessment* of North Pacific sei whale started at the 2015 IWC SC meeting. The IWC SC agreed to proceed with two initial alternative stock structure hypotheses: i) a single stock in the entire North Pacific as proposed by Kanda *et al*. (2015a;b), based on several pieces of evidences included the genetics; and ii) a five-stock hypothesis proposed in Mizroch (2015), based mainly on the interpretation of mark-recapture data: Japan coastal; North Pacific pelagic; Aleutian Islands and Gulf of Alaska; eastern North Pacific migratory; and Southern North American coastal stock (coastal California) (IWC, 2015a). The IWC SC agreed that discriminating between these two hypotheses is difficult in the absence of genetic data from the potentially extirpated stocks, and thus both hypotheses are plausible (IWC, 2015a). The IWC SC agreed that the oceanic regions of the North Pacific are composed by a single stock (IWC, 2015a).

Under this new research program both satellite tracking and routine genetic analyses will be used to address this Secondary Objective. Under the single pelagic stock hypothesis it is expected random movement of whales in the feeding grounds. Satellite tracking experiments have also the potential to provide information on movement of whales from the feeding grounds to breeding grounds. The method of satellite tracking is widely used by IWC SC and was also useful to track the movement of two Bryde's whales in the North Pacific (Murase *et al*., 2016).

All samples obtained from the surveys of JARPNII, IWC-POWER, past commercial whaling and additional new samples from the new research will be analyzed to further examine the spatial population genetic structure of sei whale in the North Pacific, in particular to examine the plausibility of the 'North Pacific pelagic' stock.

Methods

Field works

Satellite tagging

Feasibility trials for satellite tracking will be conducted to address the question of movement to the north of the tentative limit of the 'pelagic stock' under one of the stock structure hypothesis (see item 4.2 in the main text), and to the south of the tentative limit. The former will be conducted early in the feeding season and the experiment will be useful to understand the northern distribution of the stock and at the same time the plausibility of some proposed stocks under one of the stock structure hypotheses (see section 4.2). The latter will be conducted late in the feeding season and the experiment will be useful to investigate migratory routes of whales to lower latitude areas. Trials will be conducted during the dedicated sighting surveys or by the sighting and sampling vessels. On such occasions a total of five trials will be attempted during the research period.

With regard to field methods as well as tag types, ICR scientists will collaborate and consult with experienced foreign and Japanese colleagues.

The study will be based on a pneumatic tool (e. g. the whale tag launcher: Aerial Rocket Tag System (ARTS), Lars Kleivane and Restech Norway A/S, Norway and satellite tag: SPOT6, Wildlife computers, WA, USA) (Isoda *et al*., 2016). Satellite tags are shot by this tool from the bow deck with a blubber penetration-type mount system. The tagged whales will be also target of biopsy sampling using the Larsen-gun system.

In addition a member of the proponents will attend the IWC-ONR Joint Workshop on Tag Development, Follow-Up Studies and best Practices to be held in September 2017 in Silver Spring, MD (USA) to become acquainted with the most current tagging technologies and deployment methods.

Genetic samples

Skin tissues of sei whales will be taken during NEWREP-NP and stored in 99% ethanol until DNA extraction. In the case of biopsy sampling, the details of equipment and sampling procedure are described in Annex 19.

Laboratory works

Genetics

Laboratory work and data analyses described in this Annex will follow the IWC SC's guidelines for DNA data quality (IWC, 2009) as much as possible. Sampling and laboratory procedures of the genetic laboratory of the Institute of Cetacean Research were summarized by Kanda *et al*. (2014), and the IWC SC agreed that the paper had responded appropriately to some relevant recommendations on DNA data quality from the JARPAII review workshop (IWC, 2015a, b). In 2016 additional information was provided by the proponents on estimates of microsatellite genotyping error rates and again, the IWC SC agreed that the work presented had addressed a recommendation on DNA data quality from the JARPNII final review workshop (IWC, 2016a).

Details of the laboratory procedure for microsatellite marker can be found in Annex 7. However, a different set of microsatellite loci are used in the present analyses: EV1, EV14, EV21, EV94, EV104 (Valsecchi and Amos, 1996), GT011 (Bérubé *et al*., 1998), GT23, GT211, GT271, GT310, GT575 (Bérubé *et al*., 2000), GATA28, GATA53, GATA98, GATA417, GGAA520 (Palsbøll *et al*., 1997), and DlrFCB17 (Buchanan *et al*., 1996).

Analytical procedure

Genetics

Following recommendations from the IWC SC further analyses based on STRUCTURE and DAPC will be conducted (IWC, 2016b).

The Bayesian clustering approach is conducted in the program STRUCTURE version 2.0 (Pritchard *et al*., 2000) to determine the most likely number of genetically distinct stocks using all available genotype data. The program implements a model-based clustering method for inferring stock structure (K, the number of stocks in the model) using multilocus genotype data with and without information on sampling locations. The program STRUCTURE allows for the analyses of the samples without choosing sample units. In the present analysis, posterior probabilities for each K are estimated from ten independent runs for K = 1-3 without information on sampling locations. All runs are performed with 100,000 Markov chain Monte Carlo repetitions and 10,000 burn-in length using the admixture model which assumes individuals may have mixed ancestry, with correlated allele frequencies which assumes that frequencies in the different stocks are likely to be similar due to migration or shared ancestry.

The Discriminant Analysis of Principal Components (DAPC) is performed to identify and describe clusters of genetically related individuals (Jombart *et al*., 2010). DAPC relies on data transformation using PCA as a prior step to DA which ensures that variables submitted to DA are perfectly uncorrelated, and that their number is less than that of individuals analyzed. Along with the assignment of individuals to clusters, DAPC provides a visual assessment of between-population genetic structures, permitting to infer complex patterns such as hierarchical clustering or clines (Jombart *et al*., 2010). Following these authors, the K-means clustering of principal components is used to identify groups of individuals. K-means relies on the same model as DA to partition genetic variation into a between-group and a within-group component, and attempts to find groups that minimize the latter (Jombart *et al*., 2010). K-means is run with different numbers of clusters, each of which gives rise to a statistical model and an associated likelihood.

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Annex 16

Estimates of sample size for Primary Objective II (sei whale)

Introduction

This annex introduces an approach to estimate the proposed sample size for the North Pacific sei whales to meet the Primary Objectives II, especially the Secondary Objective II (ii). The approach followed is based on the age- and sex-structured model applied to this stock for conditioning and generating future data in a simulation. The target is to estimate the natural mortality rate, *M*, by using the SCAA methodology.

Materials and methods

Data for conditioning

The data used for the conditioning are as follows:

i) Catch series since 1906 (aggregated over ages and sexes) (Figure 1).

ii) Sex-specific catch-at-age data for commercial period (1966-1973) and those from JARPNII (2002-2013) (Figures 2 and 3).

iii) An abundance estimate of the sei whales, 34,718 (CV=21.4%) in the whole North Pacific area (Hakamada and Matsuoka, 2015; 2016). Note that this estimate adds the contributions from the IWC-POWER and JARPNII cruises which covered non-overlapping areas

Model assumed for conditioning

The population dynamics assumed for the conditioning is the same as the model shown in Annex 14 except for the recruitment as

$$R_t = f\ \tilde{P}_t^F \exp\left[A \left\{ 1 - \left(\frac{P_{t,1+}}{K} \right)^z \right\} \right]$$

The plus group age is set at *m*=40, and in the maturity ogive, age at 50% maturity is fixed at 7.5 with scale parameter 1.2. The natural mortality is assumed to be age-independent as *M*=0.04 and 0.05 (/year) (the reasons for these choices are explained below), and the MSYR(1+) is set at 1 and 2.5%. These values are used not only for conditioning but also for generating future data in the simulation context to assess the estimation performance of the natural mortality coefficient.

For the estimation process, given the single abundance estimate available, a procedure like 'Hitter' was applied, which means the standard deviation of abundance estimate was intentionally set at a tiny value (here at 0.01) while naive multinomial distributions were assumed for the catch-at-age data. Unknown parameters to be estimated in the model fitting process) are the carrying capacity, sex- and fleet- (same as period-) specific selectivity parameters given the values of *M* and as well as MSYR (equivalently given A). The fecundity is solved internally assuming that population in the start year 1906 is at equilibrium.

Conditioning gave rise to some problems because the historical catch-at-age data for the commercial period show substantial variability and are in fact made available only as ages rounded to odd integers. The likelihoods obtained did, however, indicate a preference for *M* values close to the 0.04 to 0.05 range.

Model assumed for simulation

Based on the conditioned models, projections were conducted to generate future abundance estimates and catch-at-age data. Given the somewhat questionable nature of the historical age data from commercial whaling, it was decided not to use these when fitting the model given additional data generated in the future; furthermore commercial and research selectivities (the same for the past and the future) were fixed at their values estimated for the MSYR/*M* scenario concerned. For 12 years research period, it was assumed that an abundance estimate is available twice though not for the whole area of the North Pacific but only the survey area covered under NEWREP-NP. These abundance estimates are subject to the process error due to inter-annual variations in spatial distribution, and therefore it was assumed that the abundance estimates generated when inflated to the whole area for use in the simulations have a larger CV (30%) than CV=21.4% for the actual survey to take additional variance into consideration.

In the projection and generation of future data, log-normal deviations are incorporated into the recruitment although these recruitment deviations were turned off in the estimation process. The projection starts from 2014 because the model was conditioned data up to 2013. In the 3-year gap, the actual catch was allocated to age composition using estimated selectivity and numbers-at-age. For future catch-at-age data, multinomial distributions were used without assuming any overdispersion and age-reading error. Age-readability was assumed to be 70% across all the ages based on a coarse analysis. The various annual sample sizes for the 12 years of the research program generated for the evaluation were 40, 60, 80, 100, 120 and 140. For each sample size, data generation and estimation were repeated 100 times (i.e. n=100 for the measures defined below). Estimation assumed the true selectivities, so that only carrying capacity K and natural mortality M were estimated estimated. The existing JARPNII age data were not included in the likelihood for these fits because of 'double usage' concerns since they had been used to fix the research selectivity; including them would not have a large effect on results as they total only 100, which is small compared to the sample numbers to be accumulated over the research period.

Performance measures

The parameter of interest is the natural mortality (M), and therefore the following three measures are used for evaluation of estimation performance by sample size.

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\hat{M}_i - M\right)^2}$$

$$\text{CV} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\hat{M}_i - \bar{M}\right)^2} \,/\, M$$

$$\text{Relative Bias} = 100\left[\frac{1}{n}\sum_{i=1}^{n}\hat{M}_i - M\right] / M$$

Results and conclusion

Figure 4 shows the performance measures for the four scenarios (true M/MSYR combinations) considered. Robust results across these scenarios are that for an annual sample size n of 100 or above, bias reduces to close to zero, and RMSE stabilises at about 0.005. Figure 5 illustrates how the variance of the distribution of M estimates narrows considerably as the sample size is increased from 40 to 100.

This value makes no allowance for possible over-dispersion in the age data, and the sample sizes available are too small to estimate this reliably. Consequently the assumption has been made that this is the same as for minke whales, corresponding to a need to increase the sample size by a multiplicative factor of 1.34 (see Appendix D of Adjunct 3 of Annex 11).

Consequently the proposed annual sample size for sei whales is 134.

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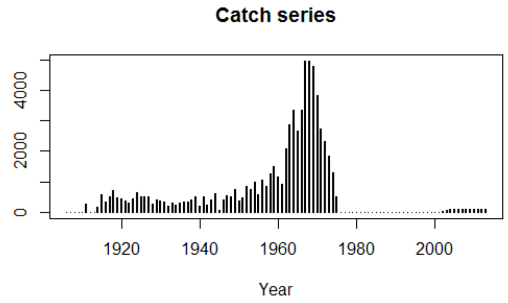

Figure 1. Catch series for the North Pacific sei whales.

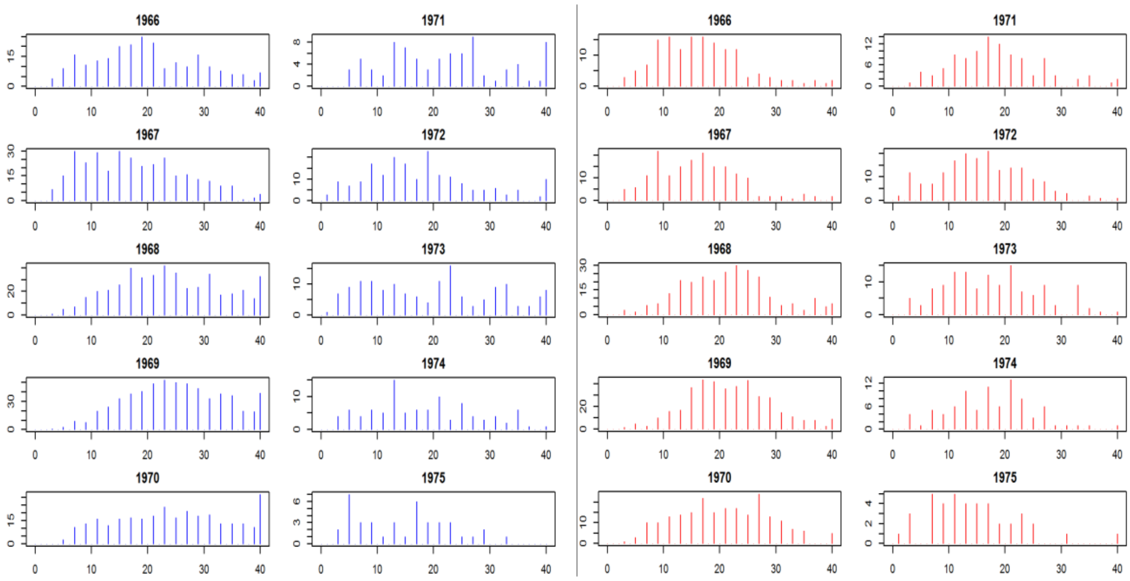

Figure 2. Catch-at-age data for male (left) and female (right) in commercial period (1966-1975)

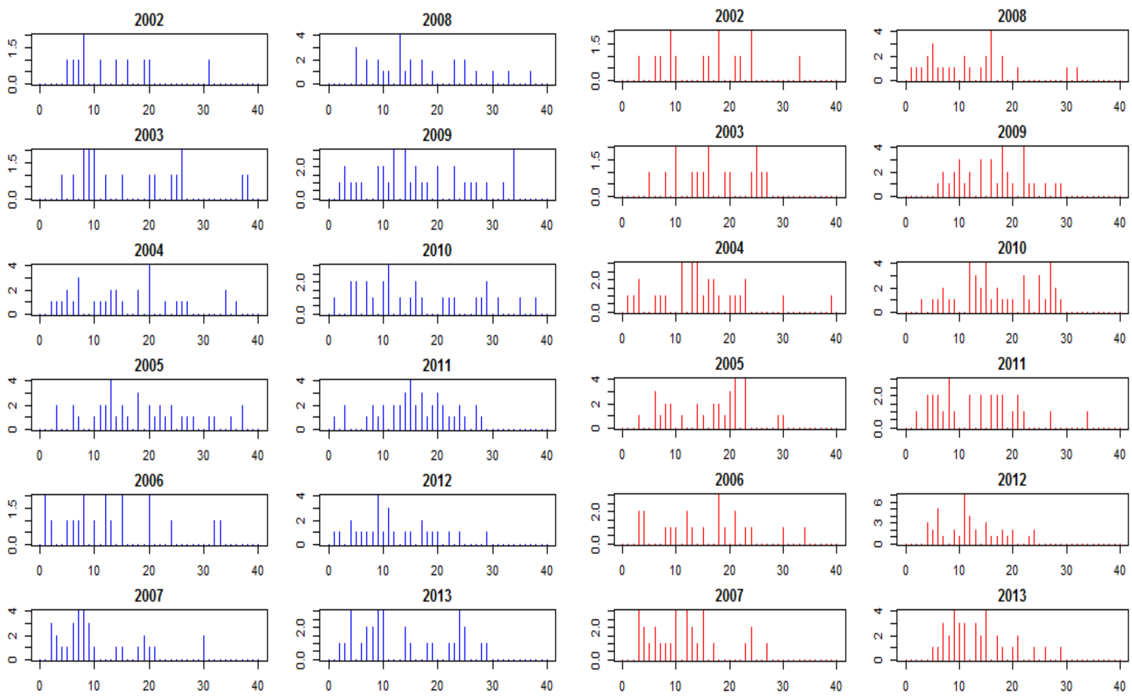

Figure 3. Catch-at-age data for male (left) and female (right) in JARPN-II period (2002-2013).

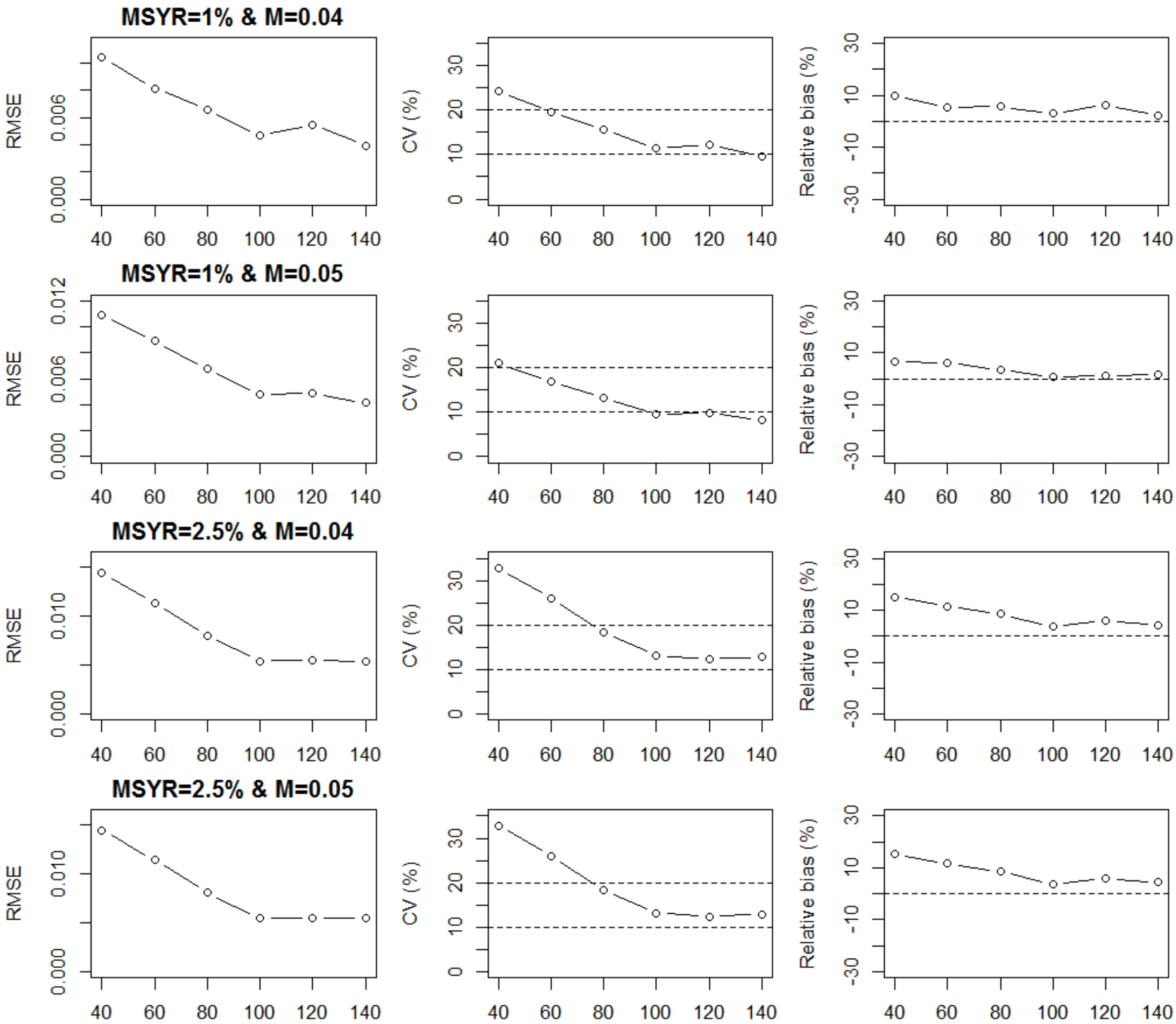

Figure 4. Summary of estimation performance for the true values of *M* at 0.04 and 0.05 under MSYR(1+)=1.0 and 2.5%.

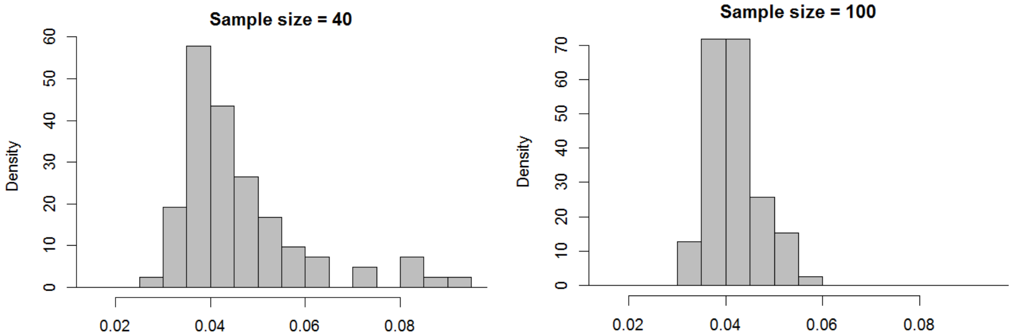

Figure 5. Histogram of estimates of *M* for the sample sizes 40 and 100 under *M*= 0.04 and MSYR= 2.5%

Annex 17

Ancillary Objective I

Investigation of the influence of environmental changes on whale stocks

Field and laboratory work, and analytical procedure

Background and objectives

There have been many studies on regime shift of the marine ecosystem in the western North Pacific around 1925, 1947, 1977 and 1998 (King, 2005, Overland *et al*., 2008, Takasuka *et al*., 2008; Tian *et al*., 2004; Yatsu *et al*, 2001, 2008). It is well known that the regime shift triggered fish replacement: dominant pelagic fish species changed from Japanese sardine (*Sardinops melanosticus*) in the 1980s and 1990s to mackerels in the 2000s, and recent data indicates the recovery of Japanese sardine. It is important to elucidate the effect of environmental change on baleen whales from both ecological and management points of view. On the latter, possible changes in the geographical and temporal distribution of baleen whale stocks will affect the interpretation of abundance estimates and trends based on systematic sighting surveys. Abundance estimates and trends are important pieces of information for management under the RMP.

The results suggested that JARPNII from 2000 to 2013 was conducted in relatively stable oceanographic conditions on a broader scale while oceanographic conditions on a local scale (*i.e*. off Kushiro) in the same period were highly variable. However, it has been pointed out that further monitoring of oceanographic conditions would be required to determine whether the climatic regime for the period of JARPNII had changed or not (Tamura *et al*., 2016a).

In recent years, yearly changes in the prey species of common minke whales were not observed in coastal water off Sanriku (Tamura *et al*., 2016b). On the other hand, in the Pacific coastal water off Kushiro, the dominant prey species shifted from Japanese anchovy (*Engraulis japonicus*) and Pacific saury (*Cololabis saira*) to Japanese sardine and mackerels after 2011. Similarly, the yearly changes in the dominant prey species of sei whales shifted from Japanese anchovy to Japanese sardine and mackerels after 2014 (Tamura *et al*., 2016c). These phenomena could be associated with pelagic fish regime shift as described in Yatsu *et al*., (2001) and Takasuka *et al*. (2008). As with past studies (*e.g.* Kasamatsu and Tanaka, 1992), this suggests that the feeding strategy of common minke and sei whales are adaptive to optimize their feeding strategy in their environments.

This aspect of the NEWREP-NP will be focused on following two issues.

i. Contribution to the understanding of the environmental change based on phenomenon such as the change in distribution of whales and their prey species.
ii. Data collection for elucidation of the cause of the change in distribution of whales and their prey species.

The research will contribute to the scientific understanding of the impact of prey change on common minke and sei whales and their geographical movements in the western North Pacific during the long-term research activity of NEWREP-NP. For example, NEWREP-NP could see changes in migration timing of common minke and sei whales that may be caused by environmental change. Such ecological changes related to common minke and sei whales and the possible effects on management under the RMP should be further investigated through the examination of data on distribution, abundance and feeding habits of common minke and sei whales and environmental variables. For a better understanding of this Secondary Objective Figure 1shows a flow chart indicating the data to be collected, analyses and expected outputs.

Field work

Sighting surveys

Dedicated sighting surveys will be conducted in the coastal waters of Japan to understand the distribution patterns of common minke and sei whales. Survey protocols will follow the 'Requirements and Guidelines for conducting surveys and analyzing data within the Revised Management Scheme' (IWC, 2012). Sighting protocols are described in Annexes 8 and 14.

Trawling and acoustic survey for prey species

One of the key elements of this aspect of NEWREP-NP is to monitor the pelagic fish replacement since baleen whales are highly depend on pelagic fishes.

In the Sanriku region, the prey survey will be conducted by the Miyagi Prefecture Fisheries Technology Institute. Survey protocols will be applied as in Wada *et al* (2016). Acoustic, trawl, and oceanographic surveys will be conducted using a trawler-type R/V, "*MIYASHIO*" (Miyagi prefecture, 199 GT). Data on the distribution and abundance of the prey species will be recorded by a quantitative echosounder, EK60 (Simrad, Norway) with operating frequency at 38, 120 and 200 kHz. The RV will steam at 9-10 knots along the track-lines. Acoustic data will be stored with the aid of software, Echoview (Sonar Data, Australia). Calibration will be carried out in the survey area using the copper sphere technique described in the EK 60 manual. Vertical oceanographic observations will be conducted with CTD. Subsurface (approximately 5m water depth) temperature, salinity and chlorophyll-*a* index will be recorded every minute (in time) along the track-lines. Trawl sampling will be conducted to identify the species and size compositions of targeting echo signs. The trawl net will have a mouth opening of 7 m (width) by 3.5 m (height) and a 3 mm liner cod end. The depth and the height of the mouth of the net will be monitored with a net recorder. The towing speed of the trawl net will be 2-4 knots. Catches will be identified to the species level and weighed aboard the vessel.

The prey survey will not be conducted at this stage in the Kushiro, Okhotsk and offshore regions (sub areas 8 and 9). However, the information on abundance and occurrence of prey species in these regions will be obtained from the Japan Fisheries Research and Education Agency (FRA), Kushiro Fisheries Research Institute and Abashiri Fisheries Research Institute in the Hokkaido Research Organization.

Whale sampling for common minke whales
Sampling procedure for common minke whales is described in Annex 6.

Whale sampling for sei whales
Sampling procedure for sei whales is described in Annex 12.

Measurement of nutritional condition indexes and stomach contents
The measurement of nutritional condition indexes and stomach contents will be applied as described by Tamura *et al*. (2016b, c) and Konishi (2016). After capture, the stomach contents will be removed from each compartment and weighed to the nearest 0.1kg on the ship's flensing deck. The analysis of prey consumption in this study will be based on data collected from the first compartment (forestomach) and second compartment (fundus). To examine the daily feeding rhythms of the whales, the freshness of prey in the forestomach will be categorized into four digestion levels. An estimate of the daily prey consumption requires the use of some additional biological and morphometric data. Body length of the whales will be measured to the nearest 1cm from the tip of the upper jaw to the deepest part of the fluke notch in a straight line. Body weight will be measured using large weighing machine to the nearest 50kg. Energy requirements are different for sexual maturity classes; therefore, estimations of the daily prey consumption in this study will take into consideration information on sexual maturity. Sexual maturity of each whale will be defined by testis weight and observation of the ovaries. Nutritional condition will be measured as a part of routine measurements of marine mammals such as blubber thickness, girth, body weight in combination with lipid contents (%) of blubber.

Stomach contents/tissue sampling
The analysis of prey composition and consumption will be based on data collected from the first compartment (forestomach) and second compartment (fundus). First stomach content will be removed from each stomach component and will be weighed to the nearest 0.1kg. Then all contents will be classified to major prey groups such as euphausiids, copepods, fish and others. Basically, a sub-sample (1-5kg) of stomach contents will be obtained and frozen and/or fixed with 10% formalin for later analyses. The sub-sample volume will depend on the whole stomach volume and on the prey's size. When stomach contents are prey-diverse, more sub-samples of stomach contents will be obtained and frozen. This methods will ensure that the samples is representative of the whole stomach contents.

At the laboratory prey species in the sub-samples will be identified to the lowest taxonomic level as possible. Undigested prey will be identified using morphological characteristics, based on different reference sources. The stomach will be transferred to a system consisting of three sieves (20mm, 5mm and 1mm), which was applied in the Norwegian scientific research to filter off liquid from the rest of the material (Haug *et al*., 1995).

To measure the lipid content %, the blubber, ventral groove and intestinal fat of all whales will be sampled.

Attachment of satellite tagging and data logger
To understand seasonal migration and reaction to prey environment, satellite tagging and data logger experiments for the common minke and sei whales will be conducted. As in the past survey, the study will be based on a pneumatic tool (the whale tag launcher: ARTS Aerial Rocket Tag System, Lars Kleivane and Restech Norway A/S, Norway) and satellite tag (SPOT6, Wildlife computers, WA, USA). Satellite and dummy tags will be shot from the bow deck by the pneumatic tool carrying a blubber penetration-type mount system for whales. The harpoon heads function to anchor under the skin.

Oceanographic observation
Oceanographic conditions in the NEWREP-NP will be investigated using data from ocean circulation models such as FRA-ROMS (Okazaki *et al.*, 2016a, b) and other resources.

Laboratory work
Prey species identification
In the laboratory prey species in the sub-samples will be identified to the lowest taxonomic level as possible. Undigested prey will be identified using morphological characteristic, based on different sources: copepods (Brodskii, 1950), euphausiids (Baker *et al*., 1990), squids (Kubodera and Furuhashi, 1987) and fish (Masuda *et al*., 1988; Chihara and Murano, 1997). The otoliths and jaw plate will be used to identify the fish with advanced stage of digestion (Morrow, 1979; Ohe, 1984; Kubodera and Furuhashi, 1987; Arai, 1993).

When undigested fish and squid are found, fork length, mantle length and the weights will be measured to the nearest 1mm and 1g, respectively. This data will be used for restoring stomach contents with advanced stage of digestion.

The total number of each fish and squid species in the sub-sample will be calculated by adding to the number of undigested fish or squid, undigested skulls and half the total number of free otoliths. The total weight of each prey species in the sub-sample will be estimated by multiplying the average weight of fresh specimens by the number of individuals. The total number and weight of each prey species in the stomach contents will be estimated by using the figures obtained from the sub-sample and the total weight of stomach contents.

Feeding period estimation
Stable isotope analyses from the edge of baleen plates will also be conducted under the NEWREP-NP program to estimate the time spent and dive time by common minke and sei whales in feeding grounds. Stable isotopes in baleen plates (n=10-20) of common minke and sei whales sampled under NEWREP-NP will be analysed early in the research program, as an initial step. At the same time, in order to obtain further information on time spent by common minke and sei whales in the feeding grounds, tagging methods for data loggers (TDR) and satellite tagging transmitters will be developed.

Nutritional condition
Dermal and hypodermal layers will be removed from blubber samples and their lipid content % of blubber will be measured with Near-Infrared Spectroscopy using *CA-HN* (Joy World Pacific Co. Ltd).

Analytical procedure
Abundance estimation of whales
The standard methodology of line transect surveys (*e.g*. Branch and Butterworth, 2001) will be applied to estimate abundance of common minke and sei whales in sub areas 7, 8, 9 and 11. Abundance estimation protocols are described in Annexes 8 and 14.

Prey composition (W %) in each individual
In order to simplify the comparison of feeding indices, prey species will be divided as follow: copepods (*Neocalanus cristatus*, *N. plumchrus*, *Calanus* sp.), krill (*Euphausia pacifica*, *E. similes*, *E. gibboides*, *Thysanoessa gregaria*, *Nematoscelis difficilis*), Japanese anchovy, Japanese sardine, Pacific saury, walleye pollock, oceanic lightfishes (*Vinciguerria nimbaria*; *Maurolicus japonicus*), other squids (Japanese common squid, minimal armhook squid (*Berryteuthis anonychus*)), and other fishes (Japanese pomfret (*Brama japonica*), Atka mackerel (*Pleurogrammus monopterygius*), Salmonidae).
The relative prey composition (%) by weight of each prey species (*RW*) in each individual will be calculated as follows:

$RW = (W_i / W_{all}) \times 100$
W_i = the weight of contents containing prey group *i*.

W_{all} = the total weight of contents analyzed.

Feeding period estimation

To consider the uncertainties such as feeding period in the calculation of prey consumption, stable isotopes analyses from the edge of baleen plates will also be conducted under the NEWREP-NP program to estimate time spent by common minke and sei whales in the feeding grounds. The analyses will be conducted based on Mitani *et al* (2006). At the same time, the tagging and satellite tracking that records the position of whales for a long period will be conducted for the common minke and sei whales to examine the migration patterns and duration of stay in the western North Pacific. The tagging of sensor data logger (depth and acceleration) will be conducted for the common minke and sei whales to examine daily feeding patters.

Feeding habits, estimation of daily and seasonal prey consumption

The amount of prey consumed by common minke and sei whales in each area and period will be estimated using theoretical energy requirement calculations. The uncertainties associated with the relevant parameters will be treated by Monte Carlo simulations.

The daily prey consumption (D_{kg}) in each sexual maturity class will be estimated from the standard metabolic rate (SMR_{kJ}) and energy deposit according to the following equation:

$$D_{kg} = SMR_{kJ} / (E_{KJ} * AE)$$

Where D_{kg} is daily prey consumption (kg day^{-1}), SMR_{kJ} is the standard metabolic rate (kJ day^{-1}), E_{kJ} is the caloric value of prey species (kJ kg^{-1}), and AE is assimilation efficiency (%).The details of these items are described in Tamura *et al*. (2016b, c). Nutritional condition will be used when serious depletion of prey environments or drastic change in amount of prey are observed.

Spatial modelling

A hierarchical structure with two levels of Generalized Additive Models (GAMs) based spatial distribution models will be considered: (1) daily prey consumption by common minke and sei whales and (2) relative abundance of these species. The product of two levels of models are prey consumption by these species. For the second level, Density Surface Modeling (DSM) (Miller *et al*., 2013) would be one of the options (see also Appendices 10 and 14). Environmental variables such as Sea surface temperature (SST), sea surface height anomaly (SSHa) and sea surface chlorophyll-a concentration (Chl-a) will be used as covariates of these models. Data from ocean circulation models such as FRA-ROMS would also be used as covariates. The models presented by Tamura *et al*. (2016d) would be used as a template bearing in mind the comments from the panel of the final review of JARPNII (IWC, 2016).

Abundance of prey species and fisheries catch statistics

In the Sanriku region information on abundance and occurrence of prey species will be obtained from the Miyagi Prefecture Fisheries Technology Institute. In Kushiro, Abashiri regions and offshore areas (sub areas 7, 8 and 9), the information on abundance and occurrence of prey species will be obtained from Japan Fisheries Research and Education Agency (FRA), Kushiro Fisheries Research Institute and Abashiri Fisheries Research Institute of the Hokkaido Research Organization.

3. Distinctive features and expected outcome

The abundance estimates of common minke and sei whales will be used as an important input parameter for the estimation of prey composition and consumption by whales. It should be noted that the proponents will examine stomach contents with the main aim to investigate the influence of environmental change on the whale stocks. From this perspective, changes in the proportion of different prey items is important. Information on the amount of prey consumed is important for the spatial modelling approach to be used under this Secondary Objective. The outcome of the NEWREP-NP could contribute more reality to the management and stock assessment of common minke and sei whales. The estimated abundance, prey composition, consumption and any observed nutritional change of whales will be reported to the IWC/SC and other scientific organization such as PICES. The obtained data by the NEWREP-NP could contribute to not only management of common minke and sei whales but also to the management of several commercial fish species such as sandlance, Japanese anchovy, Japanese sardine and Pacific saury in the around of Japan.

The proponents will monitor spatial distribution, prey species compositions and body conditions of target whales and they will investigate potential influential factors (e.g. available prey), if temporal changes (which could ultimately be related to major changes) in whales are observed. Such monitoring and investigation will contribute to future *in-depth assessment* (IA) of whales as in the case of Antarctic minke whales

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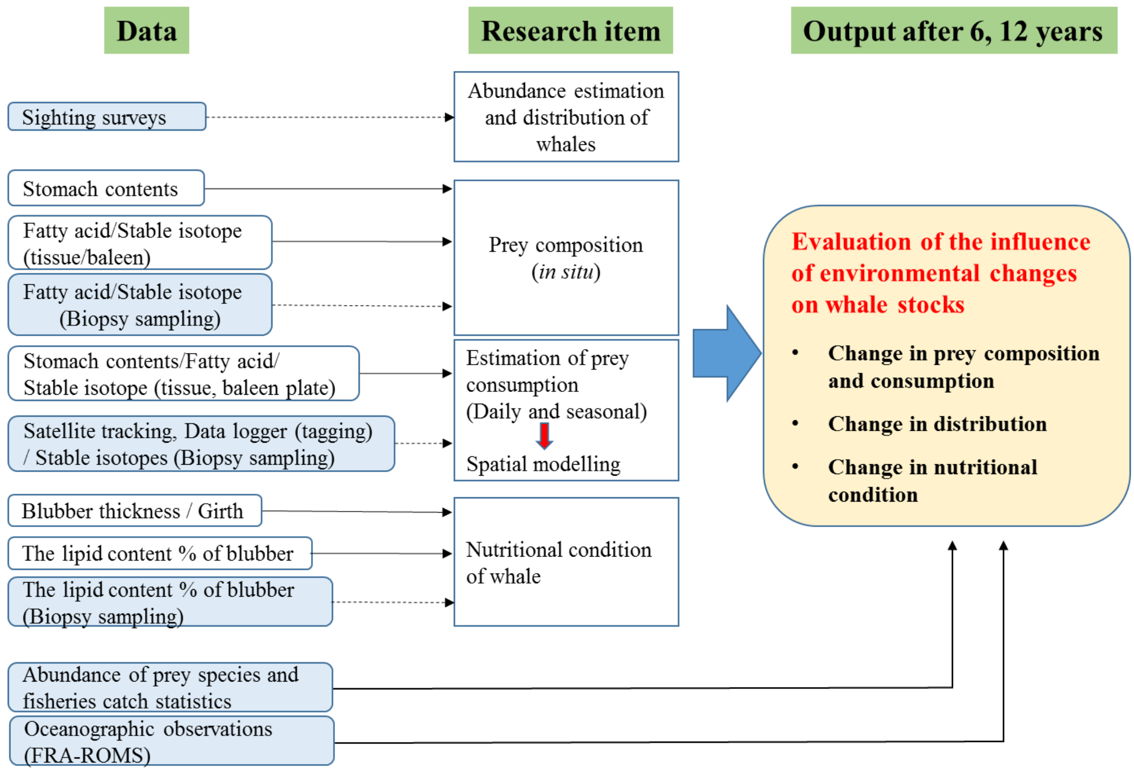

Figure 1. Flow chart with data, analyses and outputs of the research related to Ancillary Objective I.

Annex 18

Ancillary Objective II
Examination of the effects of pollutants on whales

Field and laboratory work, and analytical procedure

Background and Objectives

In 1980, the Special Scientific Committee Working Group on Management Procedures identified that "Management measures should take into account the effect on whale stocks of environmental changes due either to natural causes or to human activities" (IWC, 1981) as one of principles for whale management.

In response to this suggestion, the JARPNII conducted environmental studies under one of its objectives ('Monitoring environmental pollutants in cetaceans and the marine ecosystem'). It was observed that PCB levels in common minke whales (Yasunaga *et al.*, 2016a) and total mercury (Hg) levels in common minke, Bryde's and sei whales (Yasunaga *et al.*, 2016b) did not change during the research period, and were sufficiently below their thresholds in other species. It was suggested that adverse effects of pollutants such as PCB and total Hg to the whale health could be low in the area.

On the other hand, it was recognized that further work was required including, i) Examination of possible adverse effects of pollutants with adjustment for confounding factors such as nutritional condition and ages, ii) Species differences of sensitivity and response to pollutants, iii) Investigation of possible adverse effects of novel compounds. These tasks are set as sub-objectives, in order to clarify the effects of pollutants on the stock levels of marine mammals.

Research item (i): *Examination of possible adverse effects of pollutants with adjustment for confounding factors such as nutritional condition and ages*

A major toxicological effect of PCBs, one of the major persistent organic pollutants (POPs), in marine mammals is immunosuppression (Loseto and Ross, 2011). Immunosuppression might be induced in whales, even if their PCBs levels are lower than the threshold of other animals. This is because, immunosuppression in marine mammals could be induced by not only pollutants but also nutrient depletion, stress and aging (Alam and Pawelec, 2012). Accordingly, it is necessary examine confounding factors, such as nutritional condition, stress and age in order to clarify the possible adverse effects of pollutants to immune functions in marine mammals.

Research item (ii): *Species differences of sensitivity and response to pollutants*

There are inter species differences of genotype related to the sensitivities and response to organochlorine pollutant levels (Curran *et al.*, 2011), however, uncertainty factors have to be applied when extrapolating the differences in response and sensitivity of experimental model animals to individual non-model species. Accordingly, it is necessary to examine the factors underlying the susceptibility that cause species differences using OMICS approach.

Research item (iii): *Investigation of possible adverse effects of novel compounds*

Polybrominated diphenylethers (PBDEs) are one of the flame retardants used in plastic materials for electric devices and automobile interior articles etc. These are listed in the Stockholm Convention on POPs (UNEP, 2011), because PBDEs are lipophilic and bioaccumulate in wildlife through the food chain in the marine environment (Burreau *et al.*, 1999). In addition, plastic marine debris ingested by marine mammals are possibly one of the sources of flame retardants such as PBDEs (Derraik, 2002). A major effect of these compounds is neurological dysfunction related to thyroid hormone depletion in utero (Chevrier *et al*., 2010). Accordingly, PBDE levels in whales and their sources including ingested marine debris will be investigated for understanding of their pathway and the possible impact on whale stocks.

Methods

Field work
Research items (i, ii & iii): Blubber, plasma and other tissues from common minke and sei whales will be collected onboard the research base vessel. Blubber and other samples will be frozen and shipped to the laboratory and stored -20˚C until chemical analysis, and plasma samples for specific analyses such as immunoassay will be stored -80˚C until each analysis is conducted. Prey items and plastic marine debris ingested by whales will be collected onboard the research base vessel. The tissues and samples will also be frozen and shipped to the laboratory and stored -20˚C until chemical analyses are conducted.

Laboratory and analytical works
Research item (i):
Concentrations (expressed as lipid weight) of POPs (PCBs, DDTs, HCHs, HCB and CHLs) will be measured in 10 blubber samples from each of J- and O-stock minke and sei whales every year using gas chromatography-mass spectrometry (Yasunaga *et al.*, 2015), and biomarkers such as ethoxyresorufin-O-deethylase (EROD) activity (Fossi *et al.*, 2007), total and free thyroxin in plasma (Schwacke *et al.*, 2009), cortisol in plasma (Romano *et al.*, 2004) and retinol in liver (Simms and Ross, 2000).
.
The changes of biomarkers relating immune functions of whales will be assessed by multiple regression in the context of other factors (R Development Core Team, 2006).

Research item (ii):
Changes at multi-ome levels through intracellular receptors will be measured to examine the disruption of intracellular receptor signaling by chemical exposure in whales (Hirakawa *et al.*, 2011).

Research item (iii):
Concentrations (expressed as lipid weight) of flame retardants such as PBDE will be measured in 10 blubber samples of the same sei whales collected for item i) above, 10 prey items and 10 plastic marine debris samples every year using the high-resolution mass spectrometry (Kajiwara *et al.*, 2006), and materials contained in the plastic marine debris will be determined using the Fourier transform infrared spectroscopy.

Expected outcome and future plan
These studies could be helpful to predict the potential risk of infectious disease in each stock due to pollutants. Pollutants and the other items measured, and the next themes of basic research will be re-examined every sixth year based on progress and results from this study.

The proponents will collaborate with a wildlife immunotoxicologist from Ehime University (research item ii) above).

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Annex 19

Ancillary Objective III
Study on distribution and stock structure of large whales with particular emphasis on blue and North Pacific right whales

Protocol for biopsy sampling and photo identification

Biopsy sampling

Equipment
The Larsen systems will be used for biopsy sampling (Larsen, 1998). Biological samples (skin/blubber) will be collected by projectile dart which will be shot from sighting and sampling vessel, and the procedure below will be followed.

Sampling procedure

1) During any single encounter, no more than five biopsy sampling attempts per individual will be made.
2) The projectile biopsy sample will be collected from animals within approximately 5 to 30m of the bow of the vessel. When the vessel approaches to the whales, she must avoid rapid engine and direction changes and follows a path convergent with the direction of travel of the whale. While it is possible to collect samples at ranges of up to 50m - normally do not shoot at distances less than 10m. Care should be taken to avoid the head region.
3) For large cetaceans, small samples (<1 gram) will be obtained from free-ranging individuals using a biopsy dart with a stainless steel tip measuring approximately 4 cm in length with an external diameter of 9mm and is fitted with a 2.5 cm stop to ensure recoil and prevent deeper penetration (so that only 1.5cm of the tip is available to penetrate the animal).
4) During sampling, the biopsy tips are thoroughly cleaned and sterilized with bleach. Biological samples may be collected from adults, juveniles, females with calves and calves. The same size biopsy dart would be used for calves as for adults. No biological samples will be taken from newborn calves.
5) All collected samples will be frozen at -20°C until use for analyses.

Laboratory analyses of biopsy samples are similar to those described for minke and sei whales in Annex 7.

Photo-identification

Procedures are similar to those used in the IWC-POWER surveys.

Equipment
Digital single-lens reflex (SLR) cameras (e.g. 300mm lens, Canon Co., Ltd., Japan) will be the primary equipment for this study. It should be shot as raw files (if the camera permits researcher can simultaneously also shoot fine jpegs).

Procedure for blue whales

- It is preferable to take photographs perpendicular to the whale.
- As the identification pattern can be different on both sides of the animal, it is important to try and photograph both sides, but priority should be given to the left hand side, i.e. that side should be attempted first whenever possible.
- If working with a group, try to concentrate on one whale before starting on another and use 'marker frames' between animals in order to avoid ambiguities in analysing photographs. From the viewpoint of the development of a visual key, it is particularly important to try to also obtain photographs from behind the animal.
- The aim is to photograph as much of the flanks as possible. It is important to try to avoid both glare reflecting off the body and backlighting, both of which can result in useless (if artistic) pictures.
- If the animal is one that shows its flukes on diving then try to photograph this, but only after you are satisfied that the flanks have been adequately photographed.

- In closing to the animals, it is important not to approach too fast nor change direction or speed frequently. It has been most productive to follow a course almost parallel to the whale but converging slowly with it.

Procedure for right whales

- The key area for identification is the head (callosities and lip patches) and where possible from the top - failing that both sides of the head should be photographed. If only one side is possible, it should be the left hand side.
- Head photographs should be taken as vertically as possible, i.e. from the barrel
- Other distinguishing or unusual marks or scars should also be photographed, including the flukes of fluking animals.
- If working with a group, try to concentrate on one whale before starting on another and use 'marker frames' between animals in order to avoid ambiguities in analysing photographs.
- A similar approach and methods that are described for blue whales is recommended.

Satellite tracking

Satellite tracking experiments will be conducted as feasibility studies on an opportunistic basis. Technical details of the equipment are given in Annexes 9 and 15.

References

Larsen, F. 1998. Development of a biopsy system primarily for use on large cetaceans. Paper SC/50/O15 presented to the IWC Scientific Committee, May 1998 (unpublished). 8pp

Annex 20

List of collaborating and data providing research institutions

Research activities under the NEWREP-NP will be carried out by the Institute of Cetacean Research (ICR) in collaboration and coordination with several research institutions. Furthermore relevant data will be acquired from other research institutions and research programs. This annex provides a list of collaborating research institutions, and a list of institutions and research programs from where data will be obtained, by NEWREP-NP objectives.

Primary Objective I

Contribution to optimize the establishment of a sustainable catch limit for common minke whales in the coastal waters of Japan

- Secondary Objective I (i): *Investigate the spatial and temporal occurrence of J stock common minke whales around Japan, by sex, age and reproductive status* (Annex 7)

a) Collaborating research institutions/projects

- Tokyo University of Marine Science and Technology (morphological characterization of J stock; assignment analysis based on genetic data; estimates of J stock mixing proportion trend).
- National Research Institute of Far Seas Fisheries (age determination based on earplug, genetic characterization of J stock).
- Azabu University (feasibility study on DNA methylation).
- Riken Genesis Co. (feasibility study on DNA methylation).

- Secondary Objective I (ii): *Estimate the abundance of the J and O stocks in coastal waters of Japan* (Annex 8)

a) Collaborating research institutions/projects

- Tokyo University of Marine Science and Technology (estimate of whale abundance based on Line Transect Method and spatial modelling, g(0) estimates; additional variance).
- National Research Institute of Far Seas Fisheries (survey in IO mode; spatial modeling).

- Secondary Objective I (iii): *Verify that there is no structure in the O stock common minke whale in the Pacific side of Japan* (Annex 9)

a) Collaborating research institutions/projects

- National Research Institute of Far Seas Fisheries (consultation on satellite tracking techniques).
- Lkarts Norway (consultation on satellite tracking technique).

- Secondary Objective I (iv): *Improve RMP trials by incorporating age data in their conditioning* (Annex 10)

a) Collaborating research institutions/projects

- Tokyo University of Marine Science and Technology (SCAA).
- National Research Institute of Far Seas Fisheries (age determination based on earplug, consultation on satellite tracking techniques).
- Azabu University (feasibility study on DNA methylation).
- Riken Genesis Co. (feasibility study on DNA methylation).

Primary Objective II

Contribution to the RMP/IST for North Pacific sei whale

- Secondary Objective II (i): *Abundance estimates for North Pacific sei whales taking of the account additional variance* (Annex 13)

  a) Collaborating research institutions/projects

  - Tokyo University of Marine Science and Technology (estimation of whale abundance based on Line Transect Method and spatial modelling, additional variance).
  - National Research Institute of Far Seas Fisheries (survey in IO mode; spatial modeling).

  b) Research institutions/projects providing data and samples

  - IWC-POWER (sighting survey).

- Secondary Objective II (ii): *Estimation of biological and ecological parameters in North Pacific sei whale for RMP Implementation* (Annex 14)

  a) Collaborating research institutions/projects

  - Tokyo University of Marine Science and Technology (SCAA).
  - National Research Institute of Far Seas Fisheries (age determination based on earplug).
  - Azabu University (feasibility study on DNA methylation).
  - Riken Genesis Co. (feasibility study on DNA methylation).

- Secondary Objective II (iii): *Study of the pattern of movement of whales of the 'pelagic stock' within the feeding grounds and between feeding and breeding grounds* (Annex 15)

  a) Collaborating research institutions/projects

  - National Research Institute of Far Seas Fisheries (consultation on satellite tracking technique).
  - Lkarts Norway (consultation on satellite tracking technique).
  - Tokyo University of Marine Science and Technology (genetic analyses based on DAPC).

  b) Research institutions/projects providing data and samples

  - IWC-POWER (biopsy sampling).

- Secondary Objective II (iv): *Specification of RMP ISTs for North Pacific sei whales*

  a) Collaborating research institutions/projects

  - Tokyo University of Marine Science and Technology (RMP *ISTs* specifications).

Ancillary Objective I (Annex 17)

a) Collaborating research institutions/projects

- National Research Institute of Far Seas Fisheries (spatial estimation of prey consumption; consultation on satellite tracking technique).
- Lkarts Norway (consultation on satellite tracking technique).
- Hokkaido University (stable isotope analyses).
- Miyagi Prefecture Fisheries Technology Institute (prey survey).

b) Research institutions/projects providing data and samples

- National Research Institute of Fisheries Science (oceanographic data and oceanographic data analyses based on FRA-ROM).

- Hokkaido National Fisheries Research Institute (information on fisheries).
- Hokkaido Research Organization (information on fisheries).
- Japan Chemical Analysis Center (stable isotope analyses).
- Japan Food Research Laboratories (fatty acid analyses).

Ancillary Objective II (Annex 18)

a) Collaborating research institutions/projects

- Ehime University (immunotoxicology study).

Ancillary Objective III (Annex 19)

a) Research institutions/projects providing data and samples

- IWC POWER (biopsy samples; photo-identification data.

Annex 21

Research vessels

<u>Research Base vessel</u>
Vessel engaged in the biological and ecological surveys of whales sampled.

Nisshin Maru

Length overall: 129.58m
Molded breadth: 19.40m
Gross tonnage: 8,145GT
Engine power: 7,320PS
Speed: 14.30kt

<u>Sighting/sampling vessels</u>
Vessels engaged in whale sighting and sampling, and experiments.

Yushin Maru No.1

Length overall: 69.61m
Molded breadth: 10.40m
Gross tonnage: 724GT
Engine power: 5,280PS
Speed: 12.00kt

Yushin Maru No.3

Length overall: 69.61m
Molded breadth: 10.80m
Gross tonnage: 742GT
Engine power: 5,280PS
Speed: 12.00kt

Dedicated sighting vessel
Vessel engaged exclusively in whale sighting and experiments.

Yushin Maru No.2

Length overall: 69.61m
Molded breadth: 10.80m
Gross tonnage: 747GT
Engine power: 5,280PS
Speed: 12.00kt

Sighting/sampling vessels (Coastal component)

Sumitomo Maru No.51 (51S)

Length overall: 21.31m
Molded breadth: 4.45m
Gross tonnage: 30.00GT
Engine power: 987PS
Speed: 10.00kt

Taisho Maru No. 3 (3T)

Length overall: 20.25m
Molded breadth: 4.24m
Gross tonnage: 19.00GT
Engine power: 1,210PS
Speed: 13.00kt

Koei Maru No.8 (8K)

Length overall: 19.96m
Molded breadth: 4.30m
Gross tonnage: 32.00GT
Engine power: 330PS
Speed: 10.00kt

Katsu Maru No.7 (7K)

Length overall: 19.97m
Molded breadth: 4.30m
Gross tonnage: 32.00GT
Engine power: 400PS
Speed: 11.00kt

Seiwa Maru

Length overall: 15.10m
Molded breadth: 3.20m
Gross tonnage: 15.20GT
Engine power: 160PS
Speed: 11.00kt

<u>Prey survey vessel (Coastal component)</u>

Miyashio

Length overall: 44.50m
Molded breadth: 7.6m
Gross tonnage: 199GT
Speed: 13.0kt

Equipment
* Echo sounder: EK60 (38kHz, 120kHz and 200kHz)
* CTD
* Water sampling gear (12L)
* Trawl net (mouth area $7m^2$)

Potential dedicated sighting vessel (Offshore component**)**

Kaiyo Maru No. 7

Length overall: 60.02m
Molded breadth: 10.6m
Gross tonnage: 649GT
Engine power: 1,600PS
Speed: 12.50kt

Annex 22

Protocol for participation of foreign scientists in field and analytical research under the NEWREP-NP

Field surveys

Participation of foreign scientists in the field surveys of NEWREP-NP will be welcomed, so long as they meet the following qualifications established by the Government of Japan: i) costs for participation, travel expenses to and from the home ports, subsistence on board the research vessels and any other ancillary cost, will be covered by the participant; ii) indemnification and insurance for any casualty or personal injury while on board the research vessels, will be covered by the participant; iii) participation of those who are found to have intentionally sabotaged the implementation of the research in the field shall be terminated.

PROTOCOL

Scientists interested in participating in field surveys of NEWREP-NP should:

1. Complete the application form below.

2. Send the application form electronically to the director of the Survey and Research Division of the Institute of Cetacean Research (ICR) (tamura@cetacean.jp) at least five month before the start of the survey.

An *ad-hoc* team in ICR will examine applications and communicate its resolution to applicants at least three months before the start of the survey.

APPLICATION FORM

Family name:	First name:
Research institution, postal address and E-mail address:	
Field expertise:	
Explain briefly the reasons of why you want participate in the NEWREP-NP field survey:	
Past field experience:	
Indicate the field survey of your interest ☐ : Whale biological survey ☐ : Cetacean dedicated sighting survey ☐ : Whale’s prey survey ☐ : Oceanographic survey ☐ : Other (ex: satellite tracking:)	
Medical check to see if you fit for long-period field surveys at sea : Y ☐ N ☐ If yes, attach certificate	
Remarks:	
Date: Signature:	

Research collaboration

As in the case of JARPN and JARPNII, data obtained by NEWREP-NP will be shared with members of the IWC SC in accordance with the IWC SC Data Availability Agreement (DAA) (IWC, 2004). Data and samples from the research will be available for other accredited scientists and research organizations in accordance with the protocol for access to samples/data from the ICR (http://www.icrwhale.org/pdf/appendix2.pdf).

To facilitate the collaboration and analyses, databases will be created after each annual survey, which will specify the kind of samples and data collected during the research activities, and the list will be posted on the ICR Home Page.

PROTOCOL

Scientists interested in conducting a particular research based on data and/or samples collected by NEWREP-NP should follow two steps:

1. Complete the application form below.

2. Send the application form electronically to the director of the Survey and Research Division of the Institute of Cetacean Research (ICR) (tamura@cetacean.jp).

An *ad-hoc* team in ICR will examine research proposals and communicate its resolution to applicants within two weeks after receiving the proposal.

APPLICATION FORM

RESEARCH PROPOSAL TO THE INSTITUTE OF CETACEAN RESEARCH

Title of the research	
Principal Investigator	
Institution and Address of Principal Investigator	
Co-Investigators	
Institutions and Addresses of Co-Investigators	
Objective of the research and rationale	
Data requested	
Methods	
Research plan and schedule	
Output of the research (oral presentations, publications)	
Other remarks	

Reference

International Whaling Commission. 2004. Report of the Data Availability Working Group. Annex T. *J. Cetacean Res. Manage*. 6 (*Suppl.*): 406-408.