Proposed 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; I (iv): Improve RMP trials by incorporating age data in their conditioning; and I (v): Investigation of the influence of regime shift on whale stocks.

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

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): Additional analyses on stock structure in North Pacific sei whale for RMP *Implementation;* II (iv): Specification of RMP *ISTs* for North Pacific sei whale; II (v): Investigation of the influence of regime shift on whale stocks.

Ancillary Objective I: Examination of the effects of pollutants on whale stocks.

Ancillary Objective II: 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 make use of age data of common minke and sei whales to optimize their management under the RMP.

- 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 encouraged and recommended by the IWC SC.

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

- 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 Secondary Objective on regime shift of ecosystem, 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); I (v) and II (v) (sample/data on prey composition/consumption and on nutritional condition indices such as blubber thickness, girth, fat weight and body weight). Lethal sampling is also required for Ancillary Objective I (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 a conclusion that the sample/data listed above can only be obtained 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. Feasibility of biopsy sampling 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 127 animals with the sampling starting in 2017 (see details of the sample size estimates in common minke whale in Annex 12 of the research plan).

- The annual sample size of sei whale is 140 animals (Secondary Objective II (ii)) with the sampling starting in 2017 (see details of the sample size estimates in sei whale in Annex 17 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).

- 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 regime shift investigations) with scientists from other domestic and/or foreign organization. Annex 20 of the research plan shows a list of collaborating research institutions, 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.

CONTENTS

LIST OF ANNEXES

1. INTRODUCTION

[Disclaimer] This document is drafted as a proposed research plan for the New Scientific Whale Research Program in the western North Pacific (NEWREP-NP), and submitted to the Secretary to the International Whaling Commission (IWC) and the Chair of its Scientific Committee in conformity with paragraph 30 of the Schedule to the International Convention for the Regulation of Whaling (ICRW) and Annex P (IWC, 2013a; 2016a). The research plan will be finalized taking into account the comments and suggestions on scientific aspects to be provided by experts inside and outside the IWC SC. This research plan will form 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 in '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), which was 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), meaning 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 valid (see Annex 2) the results of the 2013 RMP *Implementation* are not 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 heavily depleted and; iii) the occurrence of a coastal O stock (so called Ow stock).

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 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 Scientific Committee 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 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 <u>Primary Objective I</u>

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.

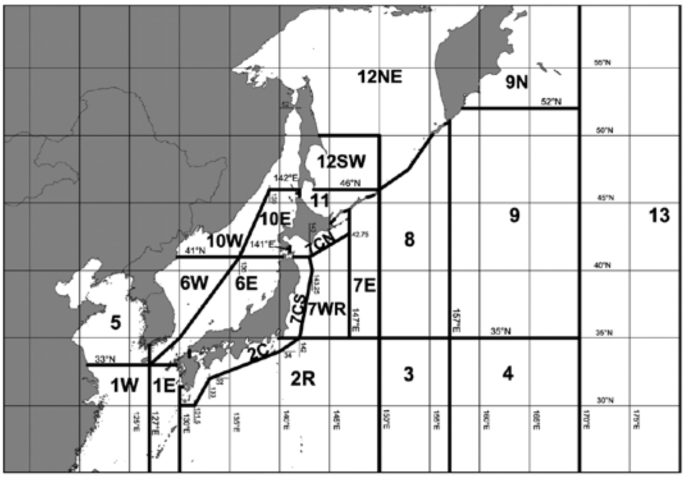


Figure 1. The 22 sub-areas used for the RMP *Implementation* for western North Pacific common minke whale (IWC, 2014b).

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 and research designs identified by the proponents are the following (see more details in Annex 3):

i) The J stock common minke whale is heavily depleted. This assumption 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 trials.

ii) The occurrence of a coastal O stock (Ow) in the Pacific side of Japan as proposed 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 replace these problematic assumptions 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) Distribution and abundance of 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 perception 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 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 trend in 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 be 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 research to verify the existence or otherwise of a coastal O stock (Ow)

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 till 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 till 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 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 a two-O stock hypothesis, we would not expect parent/offspring relationship 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.

Additional age data is also important to further test the hypothesis of the existence of a coastal O stock (the Ow 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 while the single stock scenario seems consistent with the age data, it was difficult to reconcile the two O stock hypothesis with these data particularly because of the relative absence of younger whales in a supposedly separate Oe stock.

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 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.

iv) 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 a same time period. Systematic sighting survey under the Line Transect Method as well genetic mark-recapture methods are proposed to address this research topic.

v) The regime shifts in the western North Pacific

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 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 *et al*., 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 regime shift on whale stocks. For example, changes are being observed in migration timing and nutritional condition that may be caused by changes in prey availability because of regime shift. Data are required to examine this.

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*

- Secondary Objective I (v): *Investigation of the influence of regime shift on whale stocks*

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 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 an 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 only requires historical catch data and abundance estimates (with their CV) when it calculates catch limits. However, RMP 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 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 employed (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, 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 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 ・ Possible contribution from ecosystem modelling (JARPNII) (Secondary Objective II (iv) and (v))

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 five 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): Additional analyses on stock structure in North Pacific sei whale for RMP *Implementation*

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

- Secondary Objective II (v): Investigation of the influence of regime shift on whale stocks

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

Examination of the effects of pollutants on whale stocks

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

2.2.2 Ancillary Objective II

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.

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.

Ecological aspects will be investigated for both species under both Primary Objectives. As noted earlier the effect of the regime shift on whales is not well understood. Changes in distribution could be related to change in prey availability, and this could be related in turn to regime shift. An understanding of this will assist greatly in the design of sighting surveys for abundance estimates and for the interpretation of this information, which is an important piece of the information for the application of the RMP.

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).

- Secondary Objective I (v): *Investigation of the influence of regime shift on whale stocks*

Non-lethal (sighting data for abundance estimates; satellite tracking for studies on movement and distribution of whales; prey information from other sources; oceanographic information from other sources); and lethal (stomach contents for prey composition and consumption analyses; body weight, blubber thickness, fat weight and girth for nutritional condition analysis; earplug and eye lens for age determination; ovaries and testis for sexual maturity determination).

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): *Additional analyses on stock structure in North Pacific sei whale for RMP Implementation*

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.

- Secondary Objective II (v): *Investigation of the influence of regime shift on whale stocks*

Non-lethal (sighting data for abundance estimates; satellite tracking for studies on movement and distribution of whales; prey information from other sources; oceanographic information from other sources); and lethal (stomach contents for prey composition and consumption analyses; body weight, blubber thickness, fat weight and girth for nutritional condition analysis; earplug and eye lens for age determination; ovaries and testis for sexual maturity determination).

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 the whale stocks 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 Secondary Objective on regime shift of ecosystem, 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.

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 ecosystem modeling and regime shift. 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 following the same format. 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 regime shift 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 <u>Primary Objective I</u>

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 of common minke whale 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 of common minke whale in sub-areas 7-9 in the Pacific side of Japan is 127 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*. Details of the sampling procedure are given in Annex 6.

All whales sampled will be transported to a land station and biologically examined by a team of scientists.

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 13.

- 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 *et al.* (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, Mogoe *et al.* (in prep) reports 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 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 (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.

<u>Sexual maturity</u>

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 Mogoe *et al*., in prep).

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, 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.

<u>Body length</u>
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.

<u>Tissues for genetic analysis</u>
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. Mogoe *et al*. (in prep) 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*. (in prep) 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*., in prep).

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 biopsy sampling in common minke whales will be conducted (Figure 2), and results will be presented to future IWC SC meetings.

<u>Utility of historical data and samples</u>
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.

The following Secondary Objective also requires lethal sampling

Secondary Objective I (v): Investigation of the influence of regime shift on whale stocks

Stomach contents
It should be noted here that the proponents will examine stomach contents with the main aim to investigate the influence of regime shift on whales stocks. From this perspective, changes in the proportion of different prey items are important. Information on the amount of prey consumed is also important for the spatial modeling approach to be used under this Secondary Objective (see below).

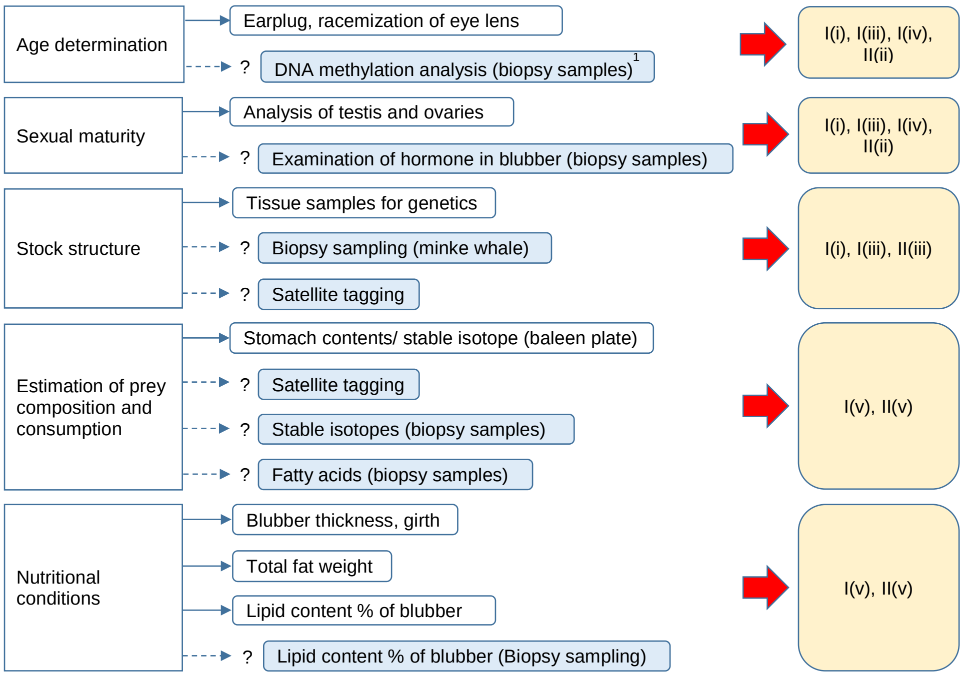
The JARPNII review workshop noted that 'the primary rationale for stomach sampling, which requires killing the animal, is the qualitative and quantitative information on prey consumption (e.g. species, age) functional relationships between marine mammals and their prey…The Panel recognized that at present, certain data, primarily stomach content data, are only available via lethal sampling' (IWC, 2010).

There are some non-lethal approaches proposed to study the feeding ecology of whales. For example the DNA-based method allowing identification of prey species in whale's faeces (Jarman *et al*., 2002). Another method compares fatty acids in whale blubber with fatty acids profiles of potential prey species to investigate if fatty acids can be used to predict the diet of common minke whale and how the fatty profiles of the blubber reflect the regional ecosystem in which the whales were caught (Meier *et al*., 2016). A third method is based on stable isotope analyses (Newsome *et al*., 2010). However unlike the direct analysis of stomach contents, none of them provides quantitative information on stomach contents, which is important for the spatial modeling approach mentioned above. Also the time scale of the latter two methods is different from that of direct analysis of stomach content, which reveals information of contents at the time the whale was caught.

Based on this review, the proponents concluded that for investigating the prey composition and consumption of common minke whales in the actual time, the lethal technique is required.

Feasibility studies on DNA-based identification of preys in faeces was carried out in JARPNII between 2014 and 2016, and results are summarized in Mogoe *et al* (in prep). One of the results is that the frequency of observation of faeces at sea is very low. Given these results, the proponents consider that additional feasibility studies on DNA prey identification in whale's faeces is not required. However the proponents will investigate the utility of stable isotopes and fatty acids for feeding ecology studies relevant to this objective (Figure 2), in a similar manner as in the Icelandic whale research program under special permit (IWC, 2014d).

Blubber thickness, girth, fat weight, body weight
These data can be only collected by lethal means. Under NEWREP-NP a feasibility study to investigate the lipid content % of blubber (blubber can be obtained by biopsy), will be carried out (Figure 2)



[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

Figure 2. Use and evaluation of new non-lethal techniques on common minke and sei whales in NEWREP-NP (white: lethal methods; blue: non-lethal methods that will be evaluated in this research).

<u>Utility of historical data and samples</u>
Data on stomach contents available from commercial whaling are limited and are of a qualitative nature. Quantitative data are also required. Past data on diet composition will be examined with new data to see temporal changes in diet.

- 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.

<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 II). 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 3.5.

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 7-11 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; 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.

- Stomach contents (I (v))

At the field stomach contents will be removed from each stomach compartment and weighted to the nearest 0.1kg. The analysis of prey composition and consumption will be based on data collected from the first compartment (forestomach) and second compartment (fundus). A sub-sample (1-5kg) of stomach contents will be obtained and frozen and/or fixed with 10% formalin for later analyses. At the laboratory prey species in the sub-samples will be identified to the lowest taxonomic level as possible. Undigested preys will be identified using morphological characteristics, based on different reference sources. See details of the laboratory work in Annex 11.

3.1.3 Analytical methods

Annexes 7-11 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

<u>Common minke whale in sub-areas 7-9</u>

Annex 12 provides the details of the implications of different sample size choices for O-stock common minke whale in sub-areas 7-9 for assessing stock dynamics, as well as of the basis upon which these implications have been evaluated.

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, 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 12 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 of regime shift of marine ecosystem that should affect population dynamics of whale populations. It is thus very important for resource manager to detect possible change in population trends 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, the 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 the annual sample size of 120 whales. The annual sample size of 40 whales was found to be incapable of detecting crucial changes in the recruitment rates. The 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. A 75% of the sample size would be taken in coastal sub-areas (7CS and 7CN) and 25% in offshore sub-areas (7WR, 7E, 8 and 9) (Annex 12). Therefore 80 animals will be sampled in coastal sub-areas and 27 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 should be adjusted to 100 animals. Then the total sample size in the Pacific side of Japan becomes 127 animals.

<u>Common minke whale in sub-area 11 (I (i))</u>

Annex 12 also provides the details of sample size estimates for common minke whale in sub-area 11. As shown in Annex 7, unlike the case of sub-areas 7CS and 7CN, there is only limited and dated data on mixing proportion 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 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 stock mixing by age and sexual maturity classes. This ultimately will be 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 a thoroughly estimates of sample size for the objective of studying yearly trend in the proportion of the J stock in this sub-area. Therefore the estimate of samples size in Annex 12 is preliminary. Basically the proponents conducted an examination of the required sample size to estimate the mixing proportion itself, rather than 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 essential for achieving the objective here. The resulting annual sample size was 47 animals.

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. 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 will be made.

- 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 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, 2014e). Details of the model are presented in Annexes 10 and 12.

- 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 is provided in Annex 9.

- Estimate of prey composition and consumption (I (v))

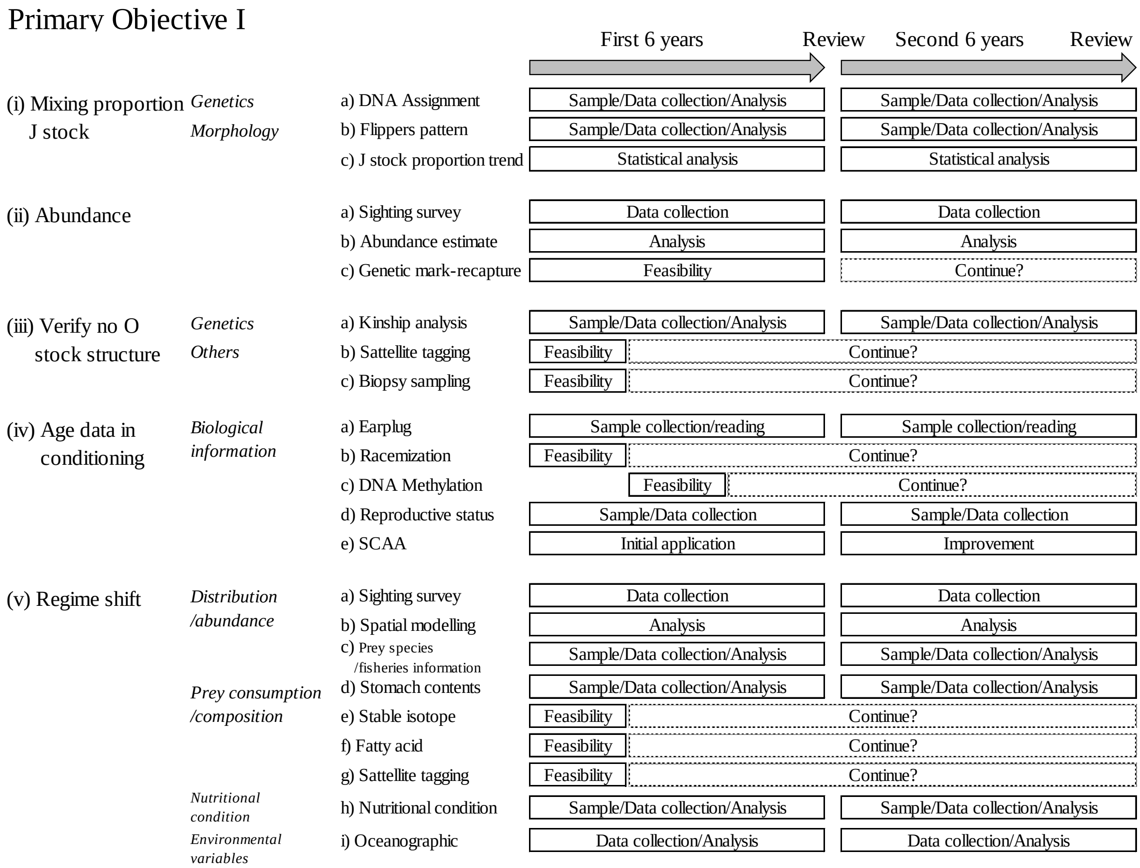
The relative prey composition (%) in weight of each prey species (RW) in each individual whale will be calculated (see details of the analytical procedure in Annex 11). The prey consumption by common minke whales in each area and period will be calculated using theoretical energy requirement approaches. The uncertainties associated to the relevant parameters will be treated by Monte Carlo simulation. This approach was welcomed by the JARPNII review workshop (IWC, 2016c). See details in Annex 11.

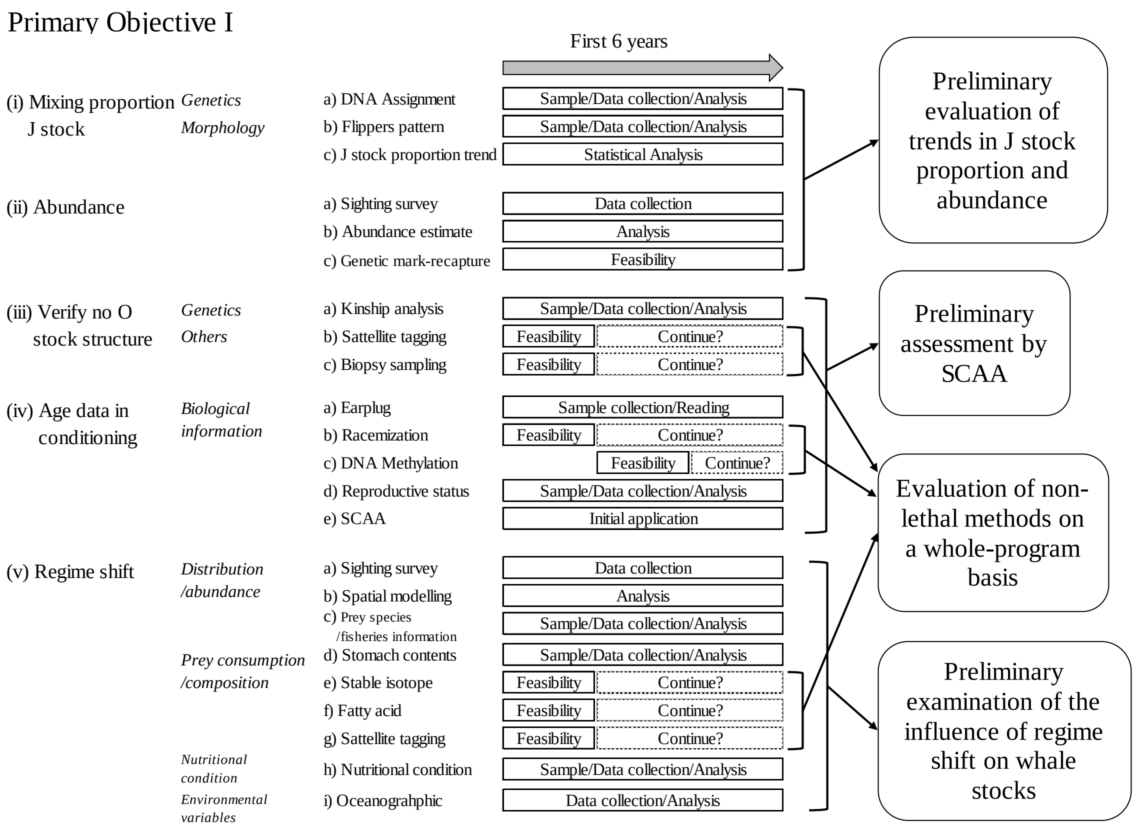
- Spatial modelling (I (v))

A hierarchical structure with two levels of Generalized Additive Models (GAMs)-based spatial distribution models will be considered: i) daily prey consumption by common minke and sei whales, and ii) relative abundance of these species. The product of two levels of models are prey consumption by these species. For the second level, DSM (Miller *et al*., 2013) will be one of the options. Environmental variables such as SST, SSHa and CHL-a will be used as covariates in these models. Data from ocean circulation models such as FRA-ROMS will also be used as covariates. The models presented by Tamura *et al*. (2016c) will be used as a template bearing in mind the comments from the JARPNII final review workshop (IWC, 2016c).

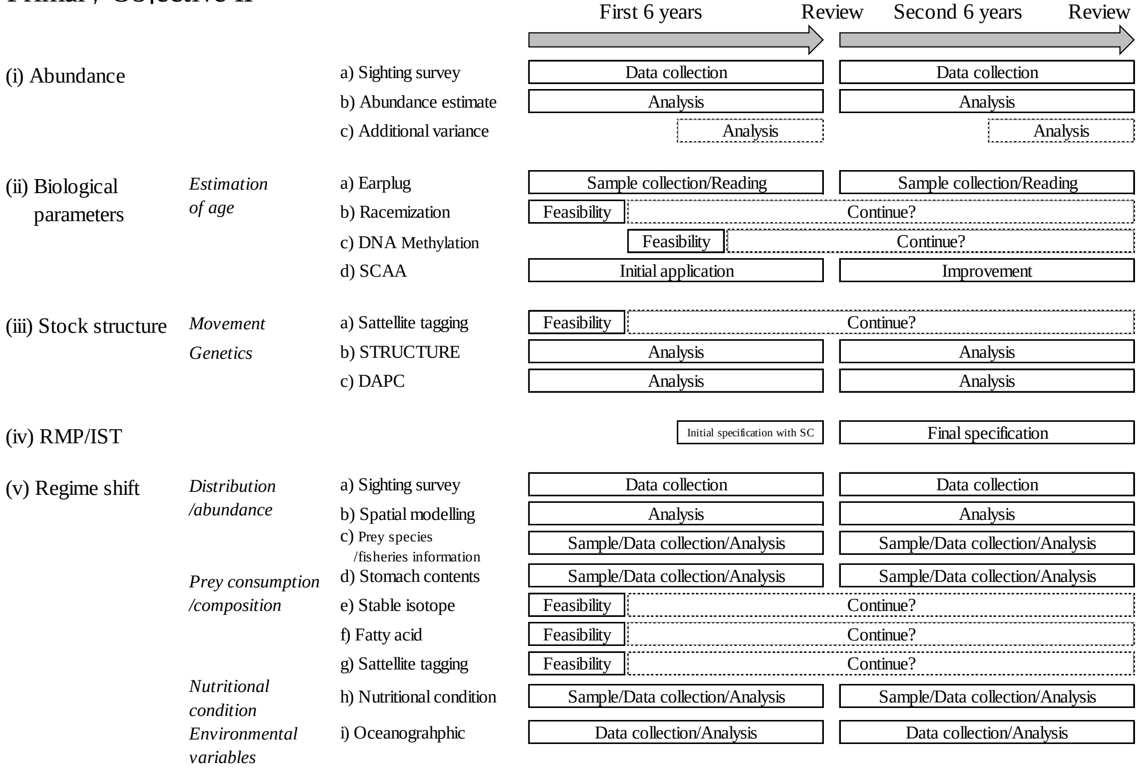
3.1.4 Time frame with intermediate targets

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 and II. 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.

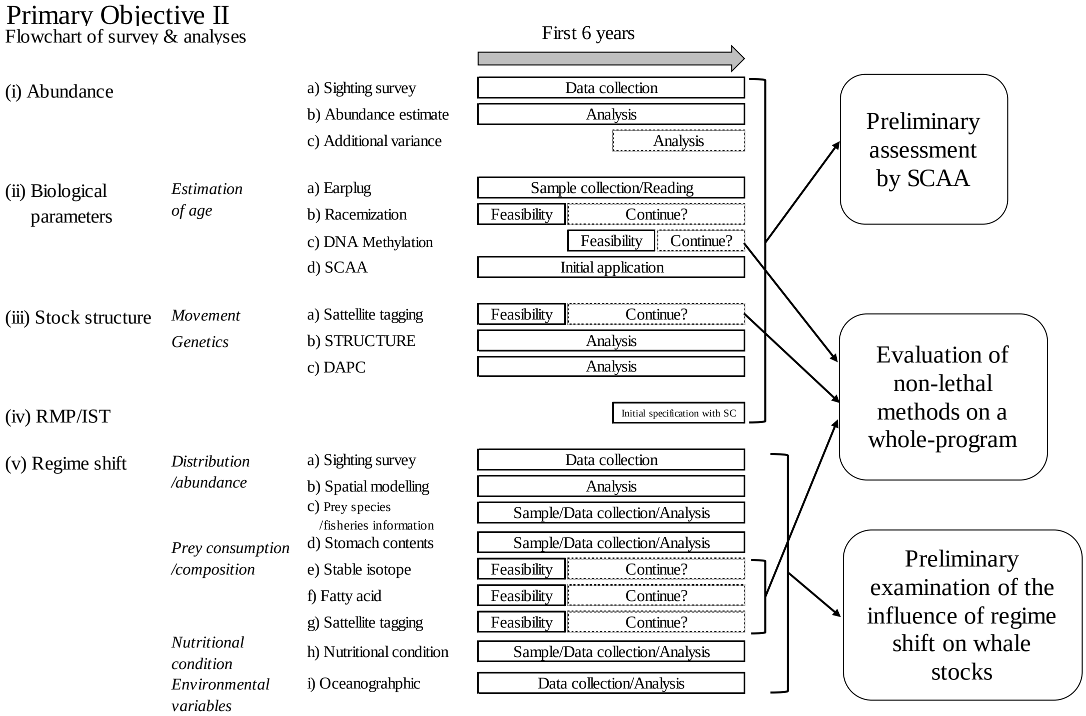

Primary Objective I
First 6 years
Review
Second 6 years
Review
(i) Mixing proportion J stock
Genetics
Morphology
a) DNA Assignment
Sample/Data collection/Analysis
Sample/Data collection/Analysis
b) Flippers pattern
Sample/Data collection/Analysis
Sample/Data collection/Analysis
c) J stock proportion trend
Statistical analysis
Statistical analysis
(ii) Abundance
a) Sighting survey
Data collection
Data collection
b) Abundance estimate
Analysis
Analysis
c) Genetic mark-recapture
Feasibility
Continue?
(iii) Verify no O stock structure
Genetics
Others
a) Kinship analysis
Sample/Data collection/Analysis
Sample/Data collection/Analysis
b) Sattellite tagging
Feasibility
Continue?
c) Biopsy sampling
Feasibility
Continue?
(iv) Age data in conditioning
Biological information
a) Earplug
Sample collection/reading
Sample collection/reading
b) Racemization
Feasibility
Continue?
c) DNA Methylation
Feasibility
Continue?
d) Reproductive status
Sample/Data collection
Sample/Data collection
e) SCAA
Initial application
Improvement
(v) Regime shift
Distribution /abundance
a) Sighting survey
Data collection
Data collection
b) Spatial modelling
Analysis
Analysis
c) Prey species /fisheries information
Sample/Data collection/Analysis
Sample/Data collection/Analysis
Prey consumption /composition
d) Stomach contents
Sample/Data collection/Analysis
Sample/Data collection/Analysis
e) Stable isotope
Feasibility
Continue?
f) Fatty acid
Feasibility
Continue?
g) Sattellite tagging
Feasibility
Continue?
Nutritional condition
h) Nutritional condition
Sample/Data collection/Analysis
Sample/Data collection/Analysis
Environmental variables
i) Oceanographic
Data collection/Analysis
Data collection/Analysis


Primary Objective I
First 6 years
(i) Mixing proportion J stock
Genetics
Morphology
a) DNA Assignment
Sample/Data collection/Analysis
b) Flippers pattern
Sample/Data collection/Analysis
c) J stock proportion trend
Statistical Analysis
(ii) Abundance
a) Sighting survey
Data collection
b) Abundance estimate
Analysis
c) Genetic mark-recapture
Feasibility
(iii) Verify no O stock structure
Genetics
Others
a) Kinship analysis
Sample/Data collection/Analysis
b) Sattellite tagging
Feasibility
Continue?
c) Biopsy sampling
Feasibility
Continue?
(iv) Age data in conditioning
Biological information
a) Earplug
Sample collection/Reading
b) Racemization
Feasibility
Continue?
c) DNA Methylation
Feasibility
Continue?
d) Reproductive status
Sample/Data collection/Analysis
e) SCAA
Initial application
(v) Regime shift
Distribution /abundance
a) Sighting survey
Data collection
b) Spatial modelling
Analysis
c) Prey species /fisheries information
Sample/Data collection/Analysis
Prey consumption /composition
d) Stomach contents
Sample/Data collection/Analysis
e) Stable isotope
Feasibility
Continue?
f) Fatty acid
Feasibility
Continue?
g) Sattellite tagging
Feasibility
Continue?
Nutritional condition
h) Nutritional condition
Sample/Data collection/Analysis
Environmental variables
i) Oceanograhphic
Data collection/Analysis
Preliminary evaluation of trends in J stock proportion and abundance
Preliminary assessment by SCAA
Evaluation of non-lethal methods on a whole-program basis
Preliminary examination of the influence of regime shift on whale stocks

Primary Objective II



Primary Objective II
Flowchart of survey & analyses



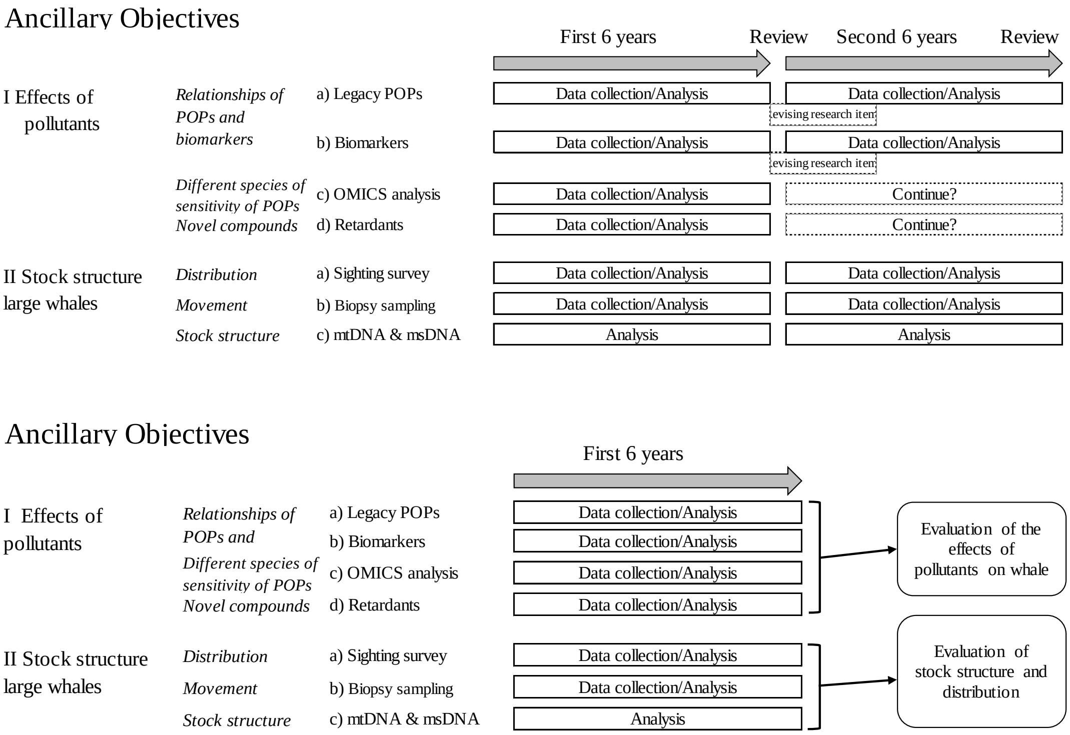


Figure 3. Research items associated to Primary and Ancillary Objectives and timeframe for six and 12-year period.

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).

Secondary Objective I (v): *Investigation of the influence of regime shift on the whale stocks*

NEWREP-NP will attempt to collect some key information that could assist in the understanding of the regime shift, its effect on whales and implication for management under the RMP. Data and methods for collecting data are similar to those described in Tamura *et al*. (2016a; b), which were welcomed and commended by the JARPNII final review workshop (IWC, 2016c).

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

3.1.7 Description of use of data from other projects or programmes (Objectives are indicated in parethesis)

- 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))
- Oceanographic data based on ocean circulation models such as FRA-ROM (National Research Institute of Fisheries Science, Japan) (I (v))

- Fisheries data (Hokkaido National Fisheries Research Institute, Japan) (I (v))
- Fisheries data (Hokkaido Research Organization, Japan) (I (v))

3.2 Primary Objective II

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 140 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 13 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 sampling procedure will be used (e.g. Pollard *et al*., 2002) when the density of whales are expected to be high.

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 13 for details of the sei whale sampling procedures.

- 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), stomach contents and data to assess nutritional conditions such as blubber thickness, girth and fat weight (Objective II (v)). 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 14-16 shows the laboratory and analytical procedures for Secondary Objectives II (i), (ii) and (iii), respectively. Procedures for Objective II (v) were shown in Annex 11. Below is a brief summary of the laboratory work for the most relevant research items. Secondary Objectives are referred to in parentheses.

- Age and sexual maturity determination (II (ii))

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

- Genetics (II (iii))

Laboratory procedures are the same as in the case of common minke whale (see Annex 16 for the application in the case of the sei whale).

- Stomach contents (II (v))

Laboratory procedures are the same as in the case of common minke whale (see Annex 11).

3.2.3 Analytical methods, including estimates of statistical power where appropriate

Annexes 14-16 shows the laboratory and analytical procedures for Secondary Objectives II (i), (ii) and (iii), respectively. Procedures for Objective II (v) were shown in Annex 11. 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

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 extent of improvement increases with increasing sample size, which provides the basis to make the sample size choice. Specifically the approach followed is based on the age- and sex-structured model applied to the single pelagic stock of sei whale for conditioning and generating future data in simulation. The target is to estimate the natural mortality rate by using SCAA methodology. Simulations for M= 0.05 and M=0.07 under MSYR=4% were conducted since unlike for many other baleen whales species, little attention has been paid to the estimation of M for sei whales even though this is one of the most fundamental parameters of population dynamics model. The estimation performance is, as expected, improved when the sample size increases. Simulations conducted suggest that the preferred sample size is 200 if M=0.05, and 140 if M=0.07. Both M=0.05 and M=0.07 were considered to be realistic assumptions as a natural mortality rate for North Pacific sei whale. The annual sample size of 140 was found to be consistent with the policy to limit the sample size to the extent necessary to achieve the research objectives. The annual sample size of 140 was also found to be a feasible sample size in terms of the capacity of research vessels. Taking account of these factors, it was concluded that the sample size of140 per annum is the optimal size for this research plan. Annex 17 provides the details on sample size estimates for sei whale.

- 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 14.

- SCAA (II (ii))

The analysis is similar to that described for common minke whale under Primary Objective I above (see Annex 15 for the application of SCAA to sei whale).

- Estimate of prey composition and consumption, and spatial modeling

The analyses are similar to those described for the case of common minke whale under Primary Objective I above (see Annex 11).

3.2.4 Time frame with intermediate targets

Figure 2 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, 2014e). It can be used for sei whales in the North Pacific as well.

Secondary Objective II (iii): *Additional analyses on stock structure in North Pacific sei whale for RMP Implementation*

The IWC SC agreed that a single stock occupies the pelagic region of the North Pacific. While standard genetic analyses based on microsatellites and mtDNA sequencing will be continued, the emphasis here will be to investigate the movement of whales with the feeding grounds as well from the feeding grounds and breeding grounds. The method proposed is satellite tracking, which is widely used by IWC SC members, which was also useful to track the movement of Bryde’s whales in the North Pacific (Murase *et al*., 2016b).

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.

Secondary Objective II (v): *Investigation of the influence of regime shift on whale stocks*

NEWREP-NP will attempt to collect some key information that could assist in the understanding of the regime shift, its effect on whales and implication for management under the RMP. Data and methods for collecting data are similar to those described in Tamura *et al*. (2016a; b; c), which was welcomed and commended by the JARPNII final review workshop (IWC, 2016c).

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 (Objectives are indicated 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))
- Oceanographic data based on ocean circulation models such as FRA-ROM (National Research Institute of Fisheries Science, Japan) (II (v))
- Fisheries data (Hokkaido National Fisheries Research Institute, Japan) (II (v))
- Fisheries data (Hokkaido Research Organization, Japan) (II (v))

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 I (v). 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 for addressing Secondary Objectives I (iii) and I (iv). This area is the area where the putative Ow and Oe stocks have been proposed under stock structure Hypothesis C. The area is also an area for future coastal commercial operations and therefore the optimization of the RMP through the use of age data and plausible stock structure information become very important. The number of samples (127) is considered moderate and is well supported by the statistical 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 (140) 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 Ancillary Objective I

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).

3.5 Ancillary Objective II

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 an objective and balanced 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 till 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 on stock structure hypothesis A, which proposes two stocks around Japan, J and O, which mix to each other temporally and spatially.

- 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) will be used for the aim of 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 into account uncertainty and projects

Pacific side of Japan (sub-areas 7-9)

Figure 4 shows projections of the cases considered for the O stock common minke whales (drawn from the NP common minke *Implementation Simulation Trials* – see Annex 12 and also Kitakado and Maeda, 2016). Only the single O stock case has been considered as the plausibility of the existence of a coastal Ow stock is now considered to be so low (see Annex 4) that there is no real need for it to be considered here (see also 'information on stock structure' above).

It is evident that for the baseline situation – the standard stock recruitment relationship of Annex 12 applies throughout the 100 year projection period, without any marked changes to recruitment per adult female of the nature introduced in that Annex – the impact of an annual catch of 107 whales is very small. This is particularly clear when the ratio of projections with and without catches is considered.

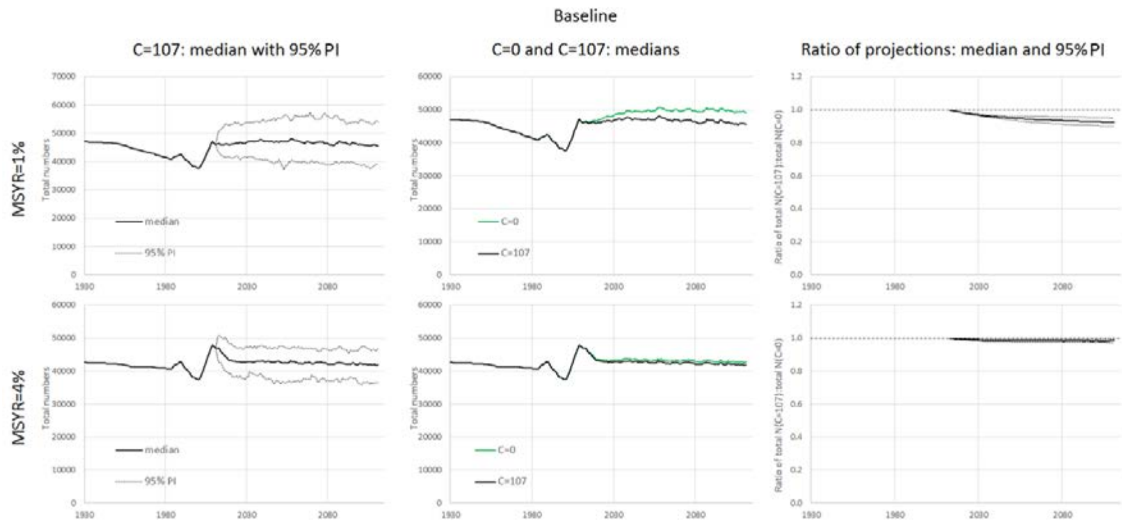


Figure 4. Population trajectories (with 95% prediction interval, PI) of the O stock common minke whale under the scenario of annual catch of 107 animals for a period of 100 years, for MSYR 1% (above) and 4 % (below). Figure in the middle shows the trajectory compared with the scenario of no catches. Figure on the right show the ratios of the projections (ratio of total N (C=107) to total N (c=0).

When consideration is extended to the primary recruitment-change case considered in Annex 12, the results are as shown in Figure 5. Here projections under an annual catch of 107 show a marked drop, and to a greater extent for the lower (and less plausible) value of 1% for MSYR. However, as is standard practice for RMP trials in the IWC SC, when environmental changes occur, the impact of catches on the population needs to be considered relative to the trajectory in the absence of any catches. The ratio plots on the right hand side provide such results, and indicate a relatively small impact of catches for MSYR=4%. For MSYR=1% the impact of the catches is bigger, but this needs to be considered in the context that this MSYR refers to MSYR(mature) as used for the IWC trials on which these analyses are based (IWC, 2014a), and that the IWC SC has subsequently increased this lower bound to the larger MSYR(1+). Furthermore, in a real situation such an occurrence would be detected well before the end of the 100 year projection period shown (see Annex 12), and catches adjusted accordingly – the examples here, which assume fixed catches for 100 years, have been constructed for the purpose of illustrating trajectory change detectability in a simple manner, rather than pretending to be realistic in every respect.

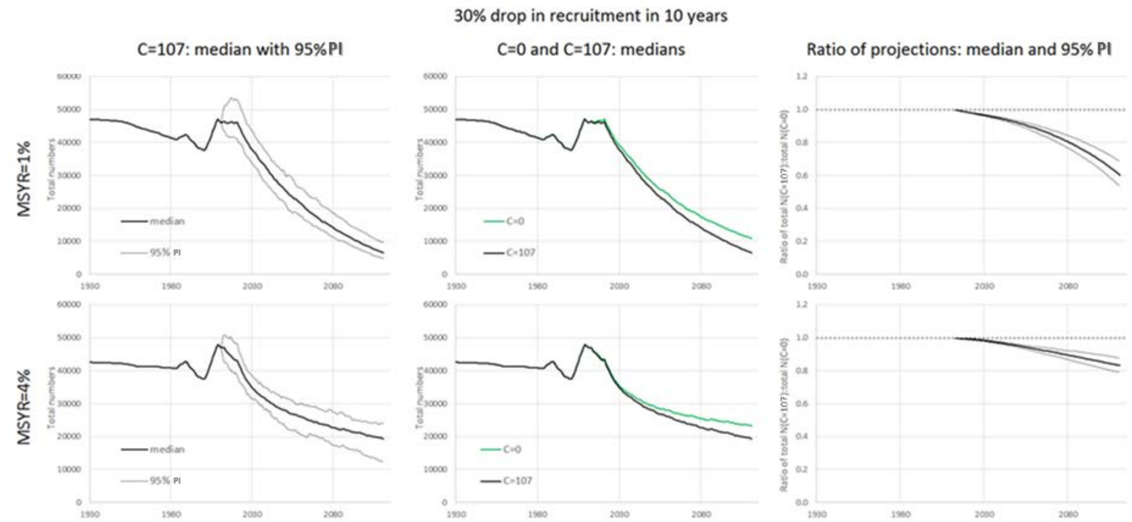


Figure 5. Same as in Figure 4 but for the case of 30% drop in recruitment in 10 years.

<u>North of Hokkaido (sub-area 11)</u>

The effect on the J stock of the proposed catch in sub-area 11(14) and those in sub-areas 7CS and 7CN (20) is examined for 50 years. For this examination, Hitter runs with fixed MSYR(1+) for MSYR(1+)=1% and 4%, were conducted.

Mixing rate of the J stock in proposed future catches is assumed to be 30% in sub-area 11 (c=14) and 20% in sub-areas 7CS and 7CN (n=20) (see Annex 7 for information on mixing rates between J and O stocks). The following biological parameters were used: MSY level of 0.6, age-at-sexual maturity (ASM) are 7 (50%) and 10.53 (95%). It is assumed that the natural mortality is $0.077yr^{-1}$ for ages <=4, and is increasing by $0.001875yr^{-1}$ per one age for 4-20, and is $0.115yr^{-1}$ for ages >=40 (IWC, 2014a). Abundance of 16,162 (CV=0.277) in 2005 is assumed to be hit to the population trajectory of the J stock.

For MSYR(1+)=1%, the left upper panel of Figure 6 shows a comparison of population trajectory with and without proposed catches. The figure suggests that the population decrease from 1930 and that this decrease is observed even if the proposed catches are 0. It can be considered that the decrease is due mainly to bycatches. The right upper panel of Figure 6 shows the ratio of the projections with and without the proposed catches. The ratio become 0.8 after 50 years, which suggest that the effect on the stock of the proposed catches is not substantial. For MSYR(1+)=4%, population increase (left lower panel of Figure 6). Left and right lower panels of Figure 6 show that the population trajectory with and without proposed catches are very similar to each other and this suggests there is no negative effect on the J stocks for MSYR(1+)=4%.

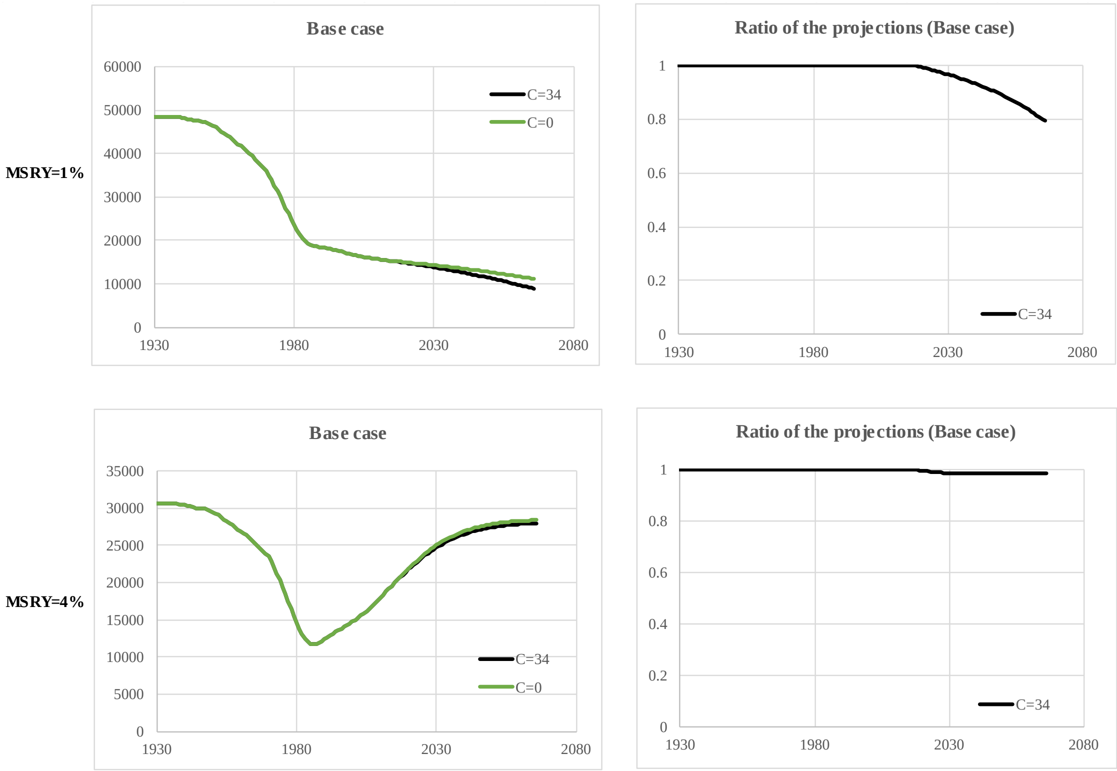


Figure 6. Population trajectory of J stock for 50 years with and without the proposed catches (left panel). The ratio of the projections with and without the proposed catches is shown in the right panel. Trajectories are for both MSYR (1+)=1% (upper panel) and 4% (lower panel).

The mixing proportion of the J stock in the commercial catches was estimated in 1.8% (Annex 7). As a sensitivity test, trajectories were investigated assuming a mixing proportion of J stock of 10 % for commercial catches in sub-areas 7CS and 7CN. Results are similar to the base case scenario (Figure 7).

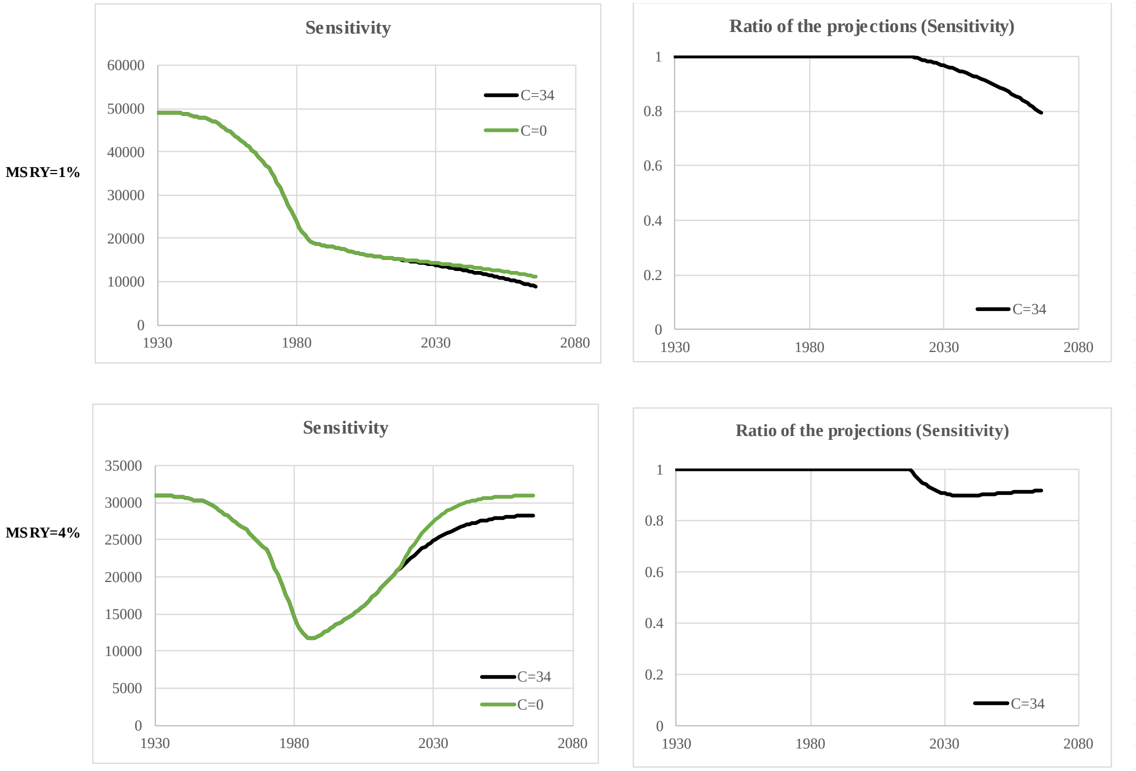


Figure 7. Same as in Figure 6 but in this case the mixing rate of J stock in commercial catches is assumed to be 10% (in contrast to the base case where the proportion was 1.8%).

The catch in Sub-area 11 includes a number of O stock minke whales (33). While the analyses on the effect on the O stock was conducted for the 107 whales to be taken in sub-areas 7-9 (see Figures 4 and 5), an additional analysis considered the take of n=160, which could account for the number of O stock animals to be taken in sub-area 11. Even with the take of this larger number of animals, no negative effect on the stock was detected (data not shown).

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 (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 underestimate of variances of abundance estimates.

Abundance estimates considering additional variance will be used for the aim of an assessment 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 into account uncertainty

Figure 8 shows projections of the cases considered for the NP sei whales. The calculation was conducted based on conditioned age-/sex-structured models. Regardless of parameters assumed, there is no serious difference in the median trajectory between the two catch scenarios (0 and 140 per year) in the 12 years research period, and therefore it is evident that the impact of an annual catch of 140 whales is very small.

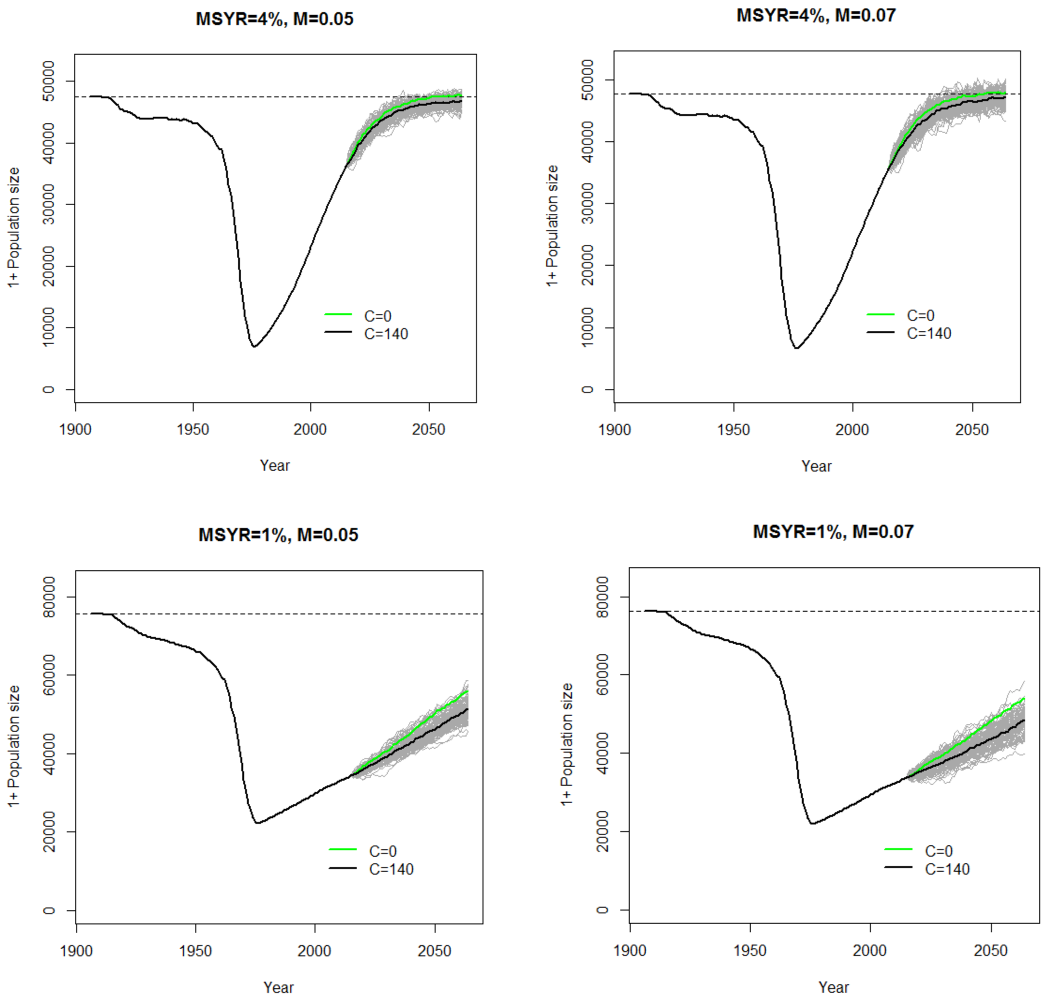


Figure 8. Population trajectory for the sei whales for 50 years. The black line shows the median trajectory with the proposed catch of 100 replicates (gray lines). The green line is the median for no catch. The dashed line shows the carrying capacity for the 1+ population.

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 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.

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 (particularly regarding regime shift investigations) with scientists from other domestic and/or foreign organizations (see Annex 20).

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 (I (v), II (v)): Feeding Ecology Laboratory of ICR, Tokyo. Three experienced scientists.

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

Pollutant monitoring and whale health (Ancillary Objective I): 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 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 bad weather, (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 be reduced sample size, unsurveyed research areas, sampling bias and missed research periods. They could mean reduced accuracies, reduced randomness, and other increased biases.

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

In case of a disruption, the head of the research (e.g. the cruise leader) will decide whether the research activities will 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 could 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, 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 proposed 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. This proposed plan for NEWREP-NP is drafted to address these items for review provided in Annex P.

At the same time, Japan developed this proposed 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)"[1] 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

Element 1: "decisions regarding the use of lethal methods"

- 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

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

research plan, the 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), nor for obtaining stomach content data required for achieving Objective I (v) (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, Mogoe *et al*. (in prep) 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" is also likely to be "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), nor for obtaining stomach content data required for achieving Objective II (v) (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 12 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-area 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 127 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. Simulations for M= 0.05 and M=0.07 under MSYR=4% were conducted. The estimation performance is, as expected, improved when the sample size increases. Simulations conducted suggest that the preferred sample size is 200 if M=0.05, and 140 if M=0.07. Both M=0.05 and M=0.07 were considered to be realistic assumptions as a natural mortality rate for North Pacific sei whale. The annual sample size of 140 was found to be consistent with the policy to limit the sample size to the extent necessary to achieve the research objectives. The annual sample size of 140 was also found to be a feasible sample size in terms of the capacity of research vessels. Taking account of these factors, it was concluded that the sample size of 140 per annum is the optimal size for this research plan.

Element 4: “a comparison of the target sample sizes and the actual take”

- 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).

Element 5: “the time frame associated with a programme”

- 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. An assessment of the plan, including that in relation to the feasibility of non-lethal methods will be made on a yearly basis. 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).

Element 6: “the programme’s scientific output”

- 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.

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

- 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). After the process of “review and comment” by the Scientific Committee on this proposed plan, those comments will be given due regard and the plan will be revised, if necessary.

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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.

More open opportunities for discussing the plan are secured at a later stage of the official review process at the IWC Scientific Committeee after the proposed research plan is submitted in accordance with the "Annex P." Japan plans to have 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 and then finalize the substance of the proposed plan.

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.

Year	Catch	No. catchers: Motor boat	No. catchers: Total	Total tonnage	CM	CPUE1	CPUE2: A	CPUE2: B	CPUE2: C	CPUE2: 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	CPUE2 series: 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%		

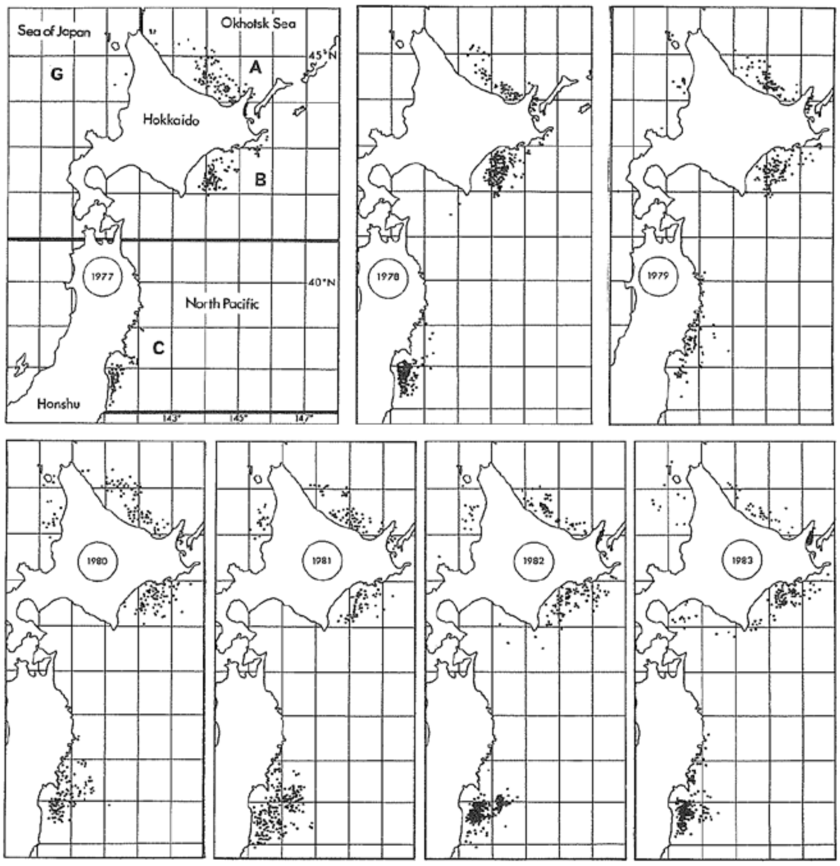

Fig. 1. Whaling regions and catch positions of minke whales, 1977–83.

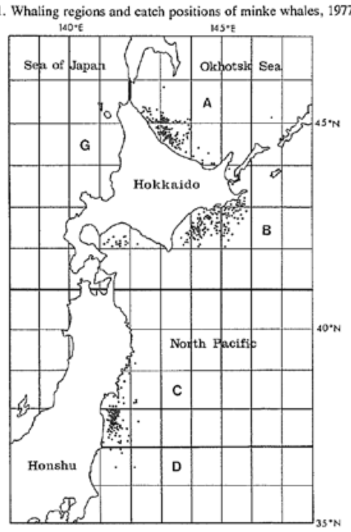

Figure 1. Whaling regions and catch positions of common minke whales, 1977-1984 (Wada, 1985; 1986). Region A: Okhotsk Sea coast of Hokkaido, Region B: Pacific coast of Hokkaido, Region C: Pacific coast of Sanriku, between 37^{o}N and 41^{o}N. Region G: Sea of Japan coast of Hokkaido. Bottom figure shows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

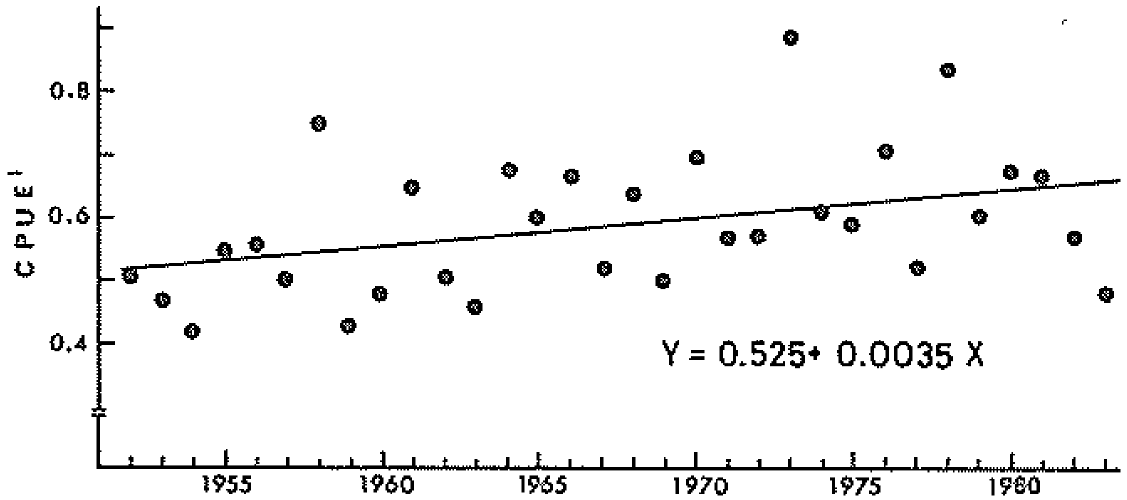

Figure 2. Yearly change in $CPUE_1$ series during 1952-1983 for Japanese coastal common minke whales (Wada, 1985).

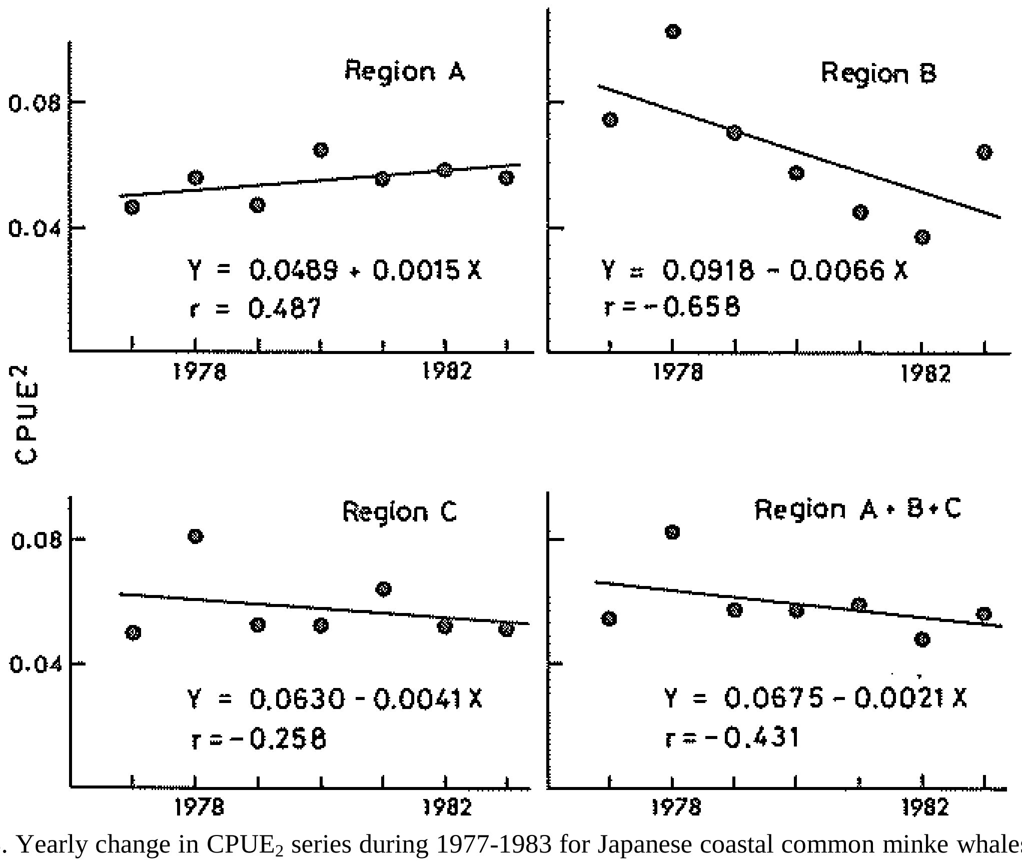

Figure 3. Yearly change in $CPUE_2$ series during 1977-1983 for Japanese coastal common minke whales (Wada, 1985). Region A: Okhotsk Sea coast of Hokkaido, Region B: Pacific coast of Hokkaido, Region C: Pacific coast of Sanriku, between 37°N and 41°N.

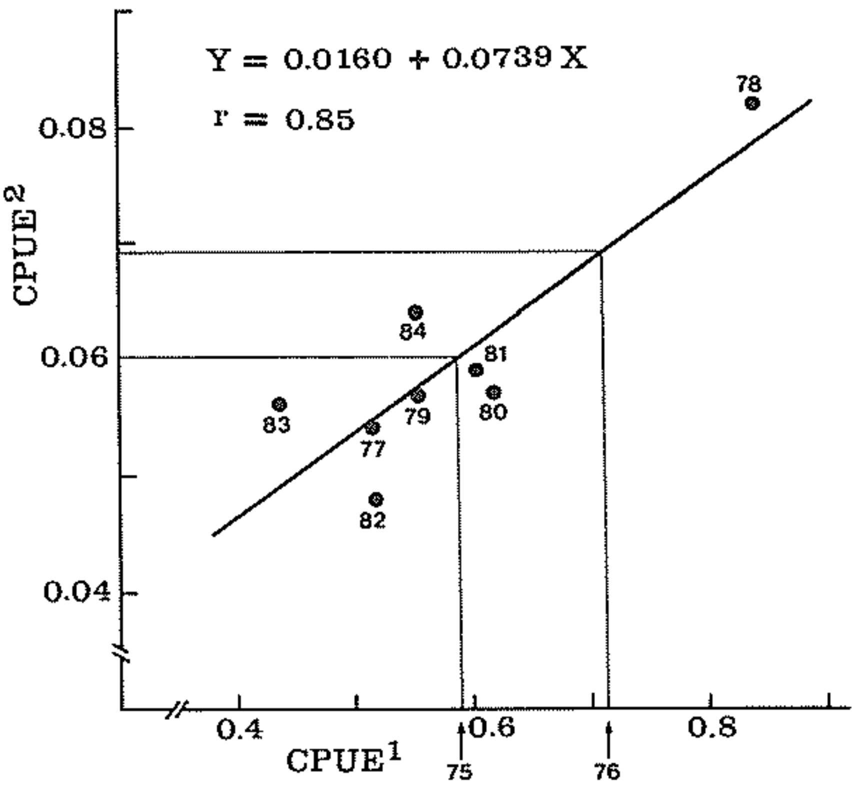

Figure 4. Regression between $CPUE_1$ and $CPUE_2$, for 1977-1984 and predicted $CPUE_2$ for 1975 and 1976 (Wada, 1986).

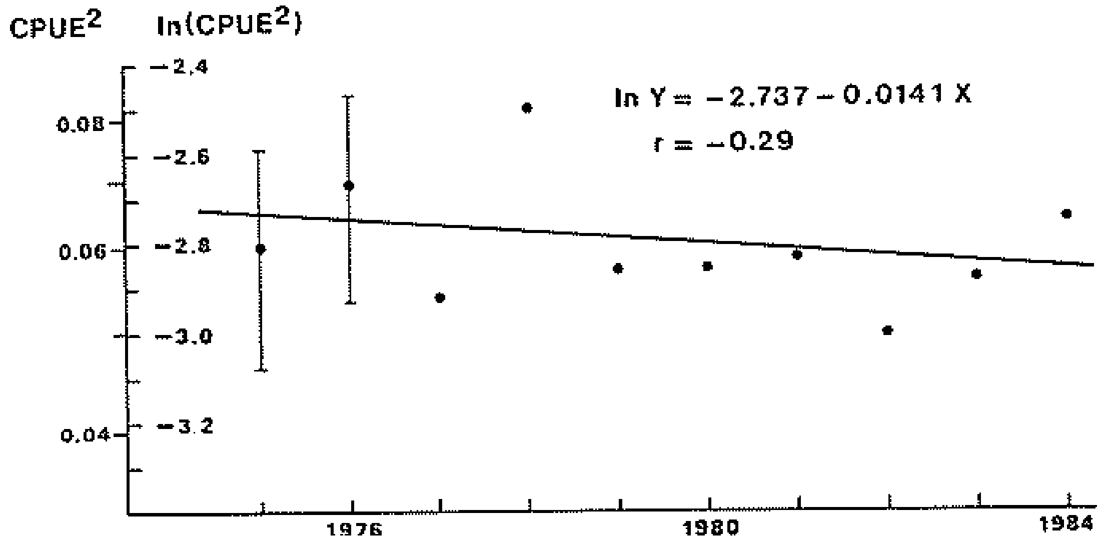

Figure 5. Annual trend of $CPUE_2$ for seasons 1975 to 1984 in Wada (1986). Vertical bars show the 95% confidence intervals of the estimates for 1975 and 1976.

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

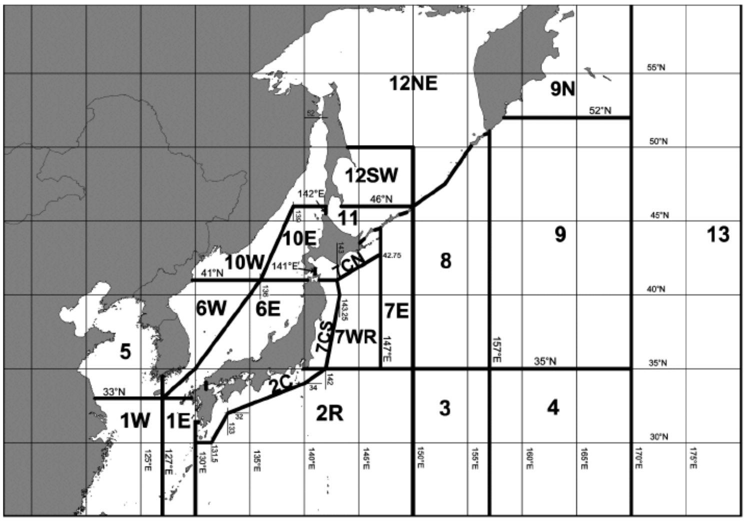

Figure 1. Sub-areas used during the 2013 RMP *Implementation*

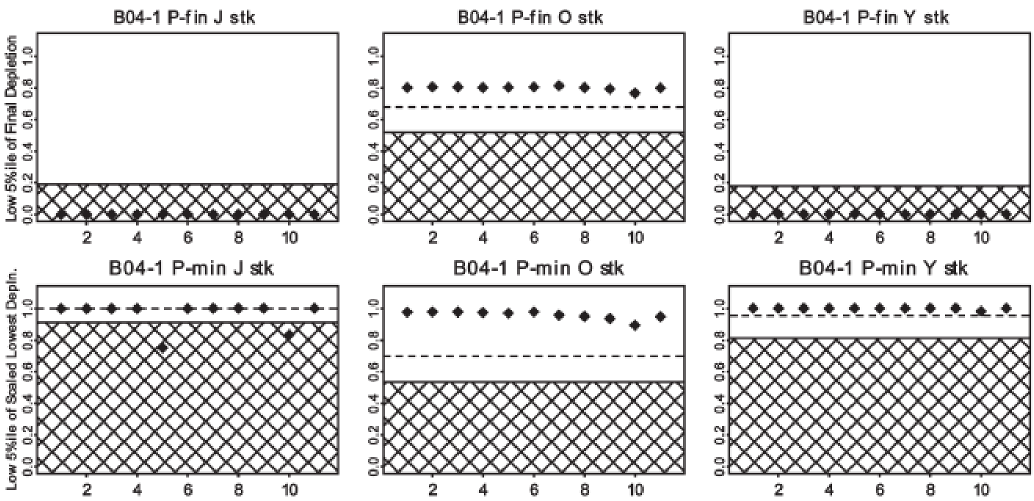

Figure 2. Performance plot for trial B04

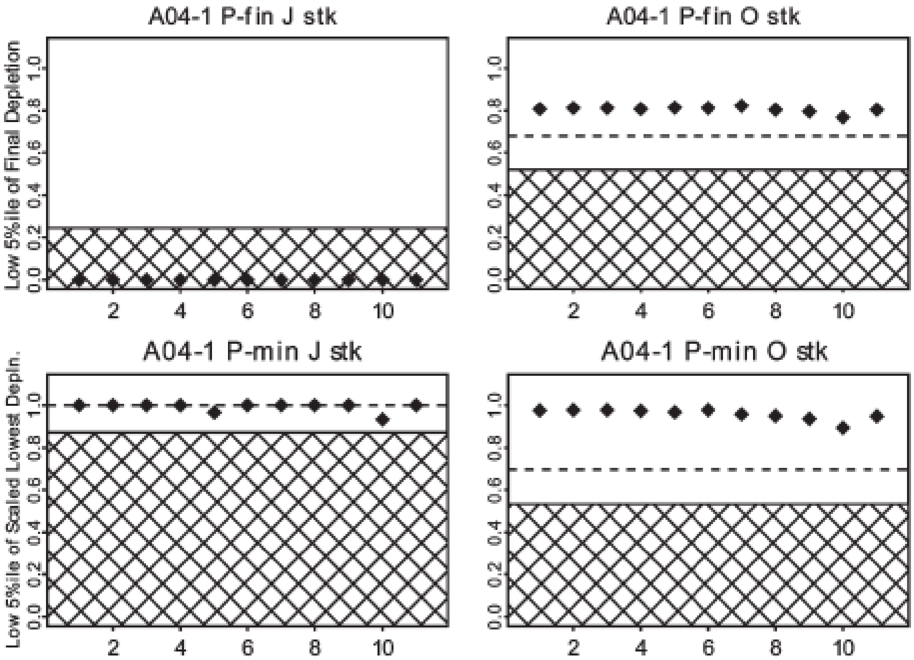

Figure 3. Performance plot for trial A04

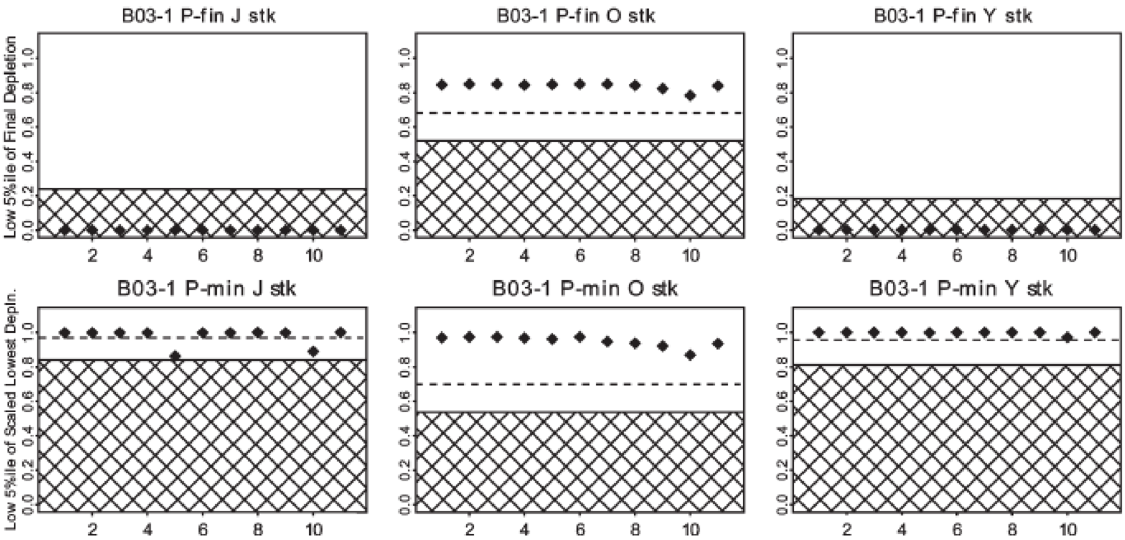

Figure 4. Performance plot for trial B03

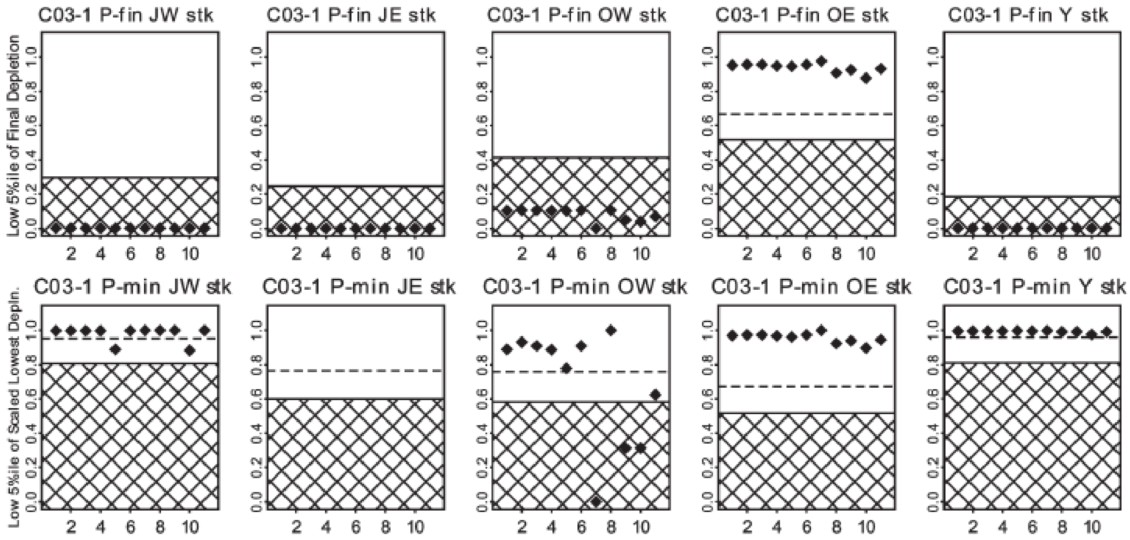

Figure 5. Performance plot for trial C03

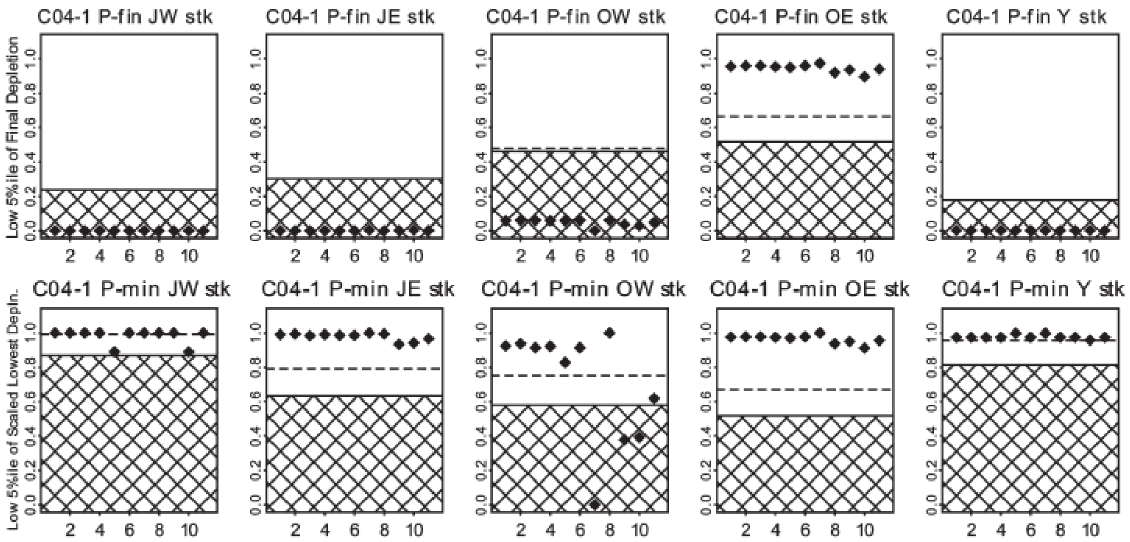

Figure 6. Performance plot for trial C04

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 (DAPCA, 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 is very important to further test the hypothesis of the existence of a coastal O stock (the Ow) stock. Both lines of research (kinship and SCAA) will be implemented in NEWREP-NP.

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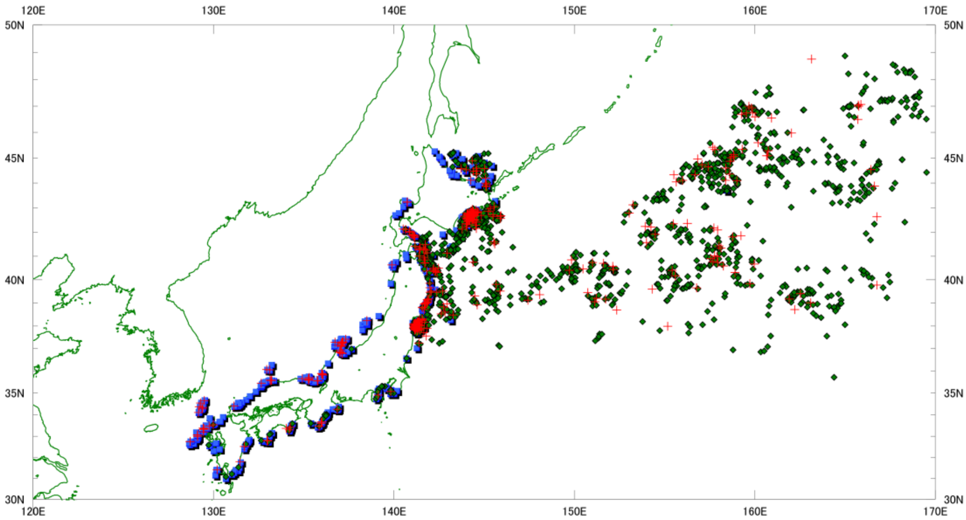
A)



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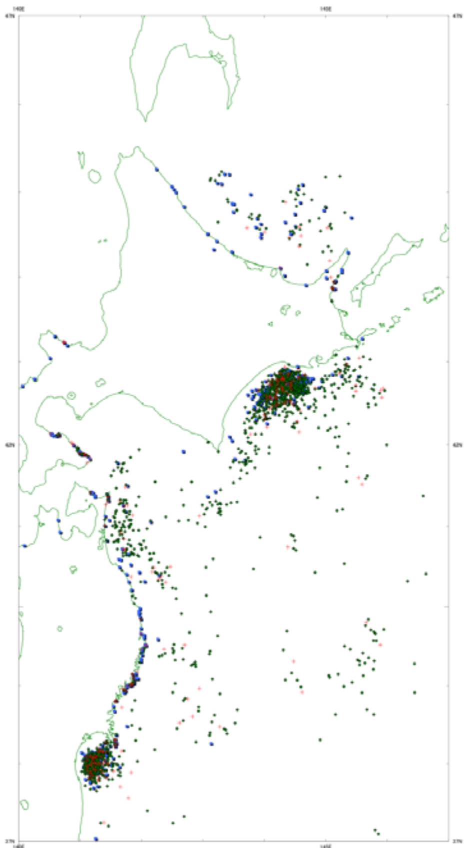

Figure 1. Location of the common minke whales that were assigned to O stock (green), J stock (blue), and unassigned (red), based on STRUCTURE. A) total areas; B) zoom of A) for coastal areas.

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%.

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Annex 6

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

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 127 animals while that in sub-area 11 for the first 6 years will be 47 animals. In the Pacific side of Japan, 100 will be sampled in coastal subareas (7CS and 7CN) and 27 will be sampled in offshore waters (sub-areas 7WR, 7E, 8 and 9) (see details on sample size estimates in Annex 12).

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.

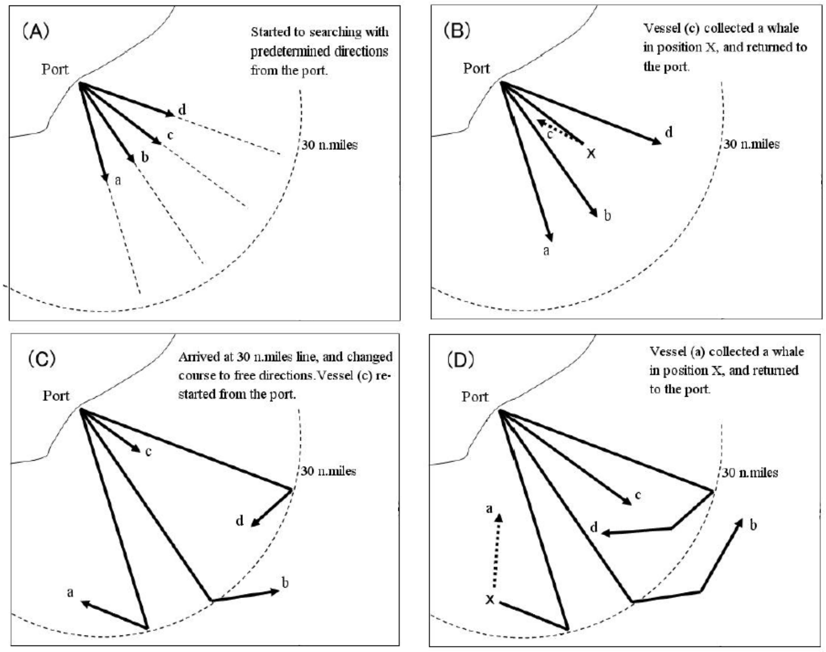

Figure 1. Schematic diagram showing the searching mode for sampling in the coastal component of the NEWREP-NP. Arrows with letters ‘a’ to ‘d’ indicate examples of the movements of respective small-type whaling catcher boat.

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 13.

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).

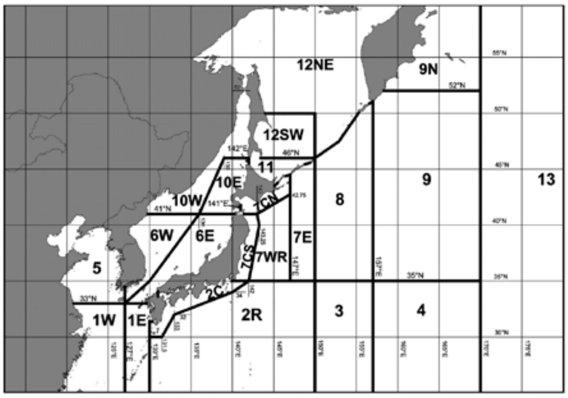

Figure 1. Sub-areas used for the management of common minke whale under the RMP.

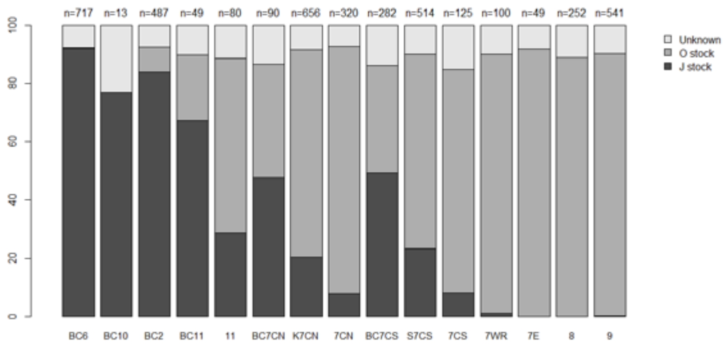

Figure 2. Spatial occurrence of O and J stocks in waters around Japan. BC2, BC6, BC7CS, BC7CN, BC10, BC11= bycatches from sub-areas 2, 6, 7CS, 7CN, 10 and 11. K7CN= coastal survey at Kushiro. S7CS= coastal survey at Sanriku. 7CS, 7CN, 7WR, 7E, 8, 9 and 11= offshore survey of JARPN and JARPNII. Sample 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).

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).

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

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.

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

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

Genetic samples

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.

Morphology (flipper coloration pattern)

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

Genetics

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.

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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

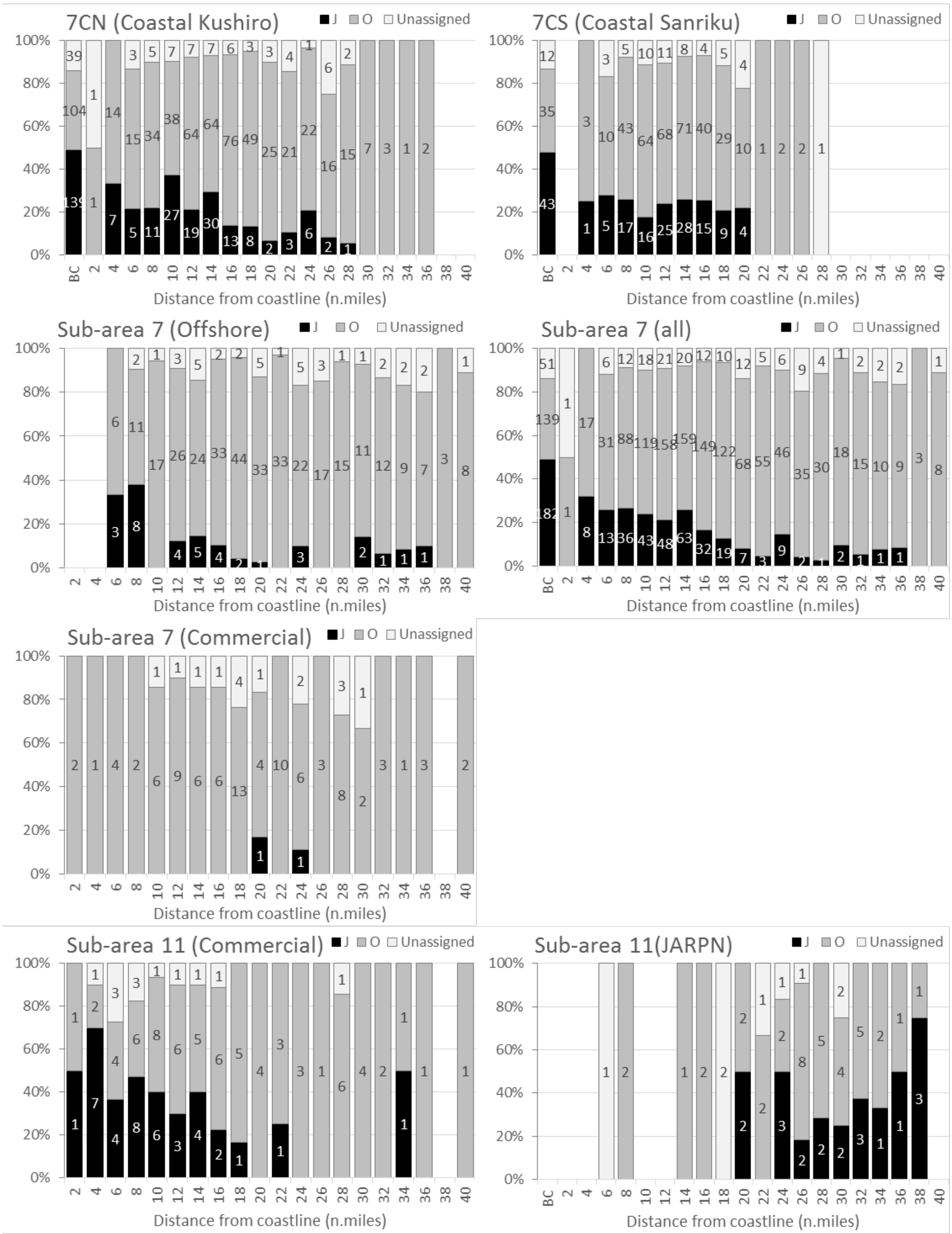

Figure 1. Differences in composition of J and O stock common minke whales in relation to the distance from the coastline. Data of sub-area 7 were summarized for JARPNII coastal component off Sanriku and Kushiro, offshore component and commercial whaling. Data of sub-area 11 were summarized for commercial 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.

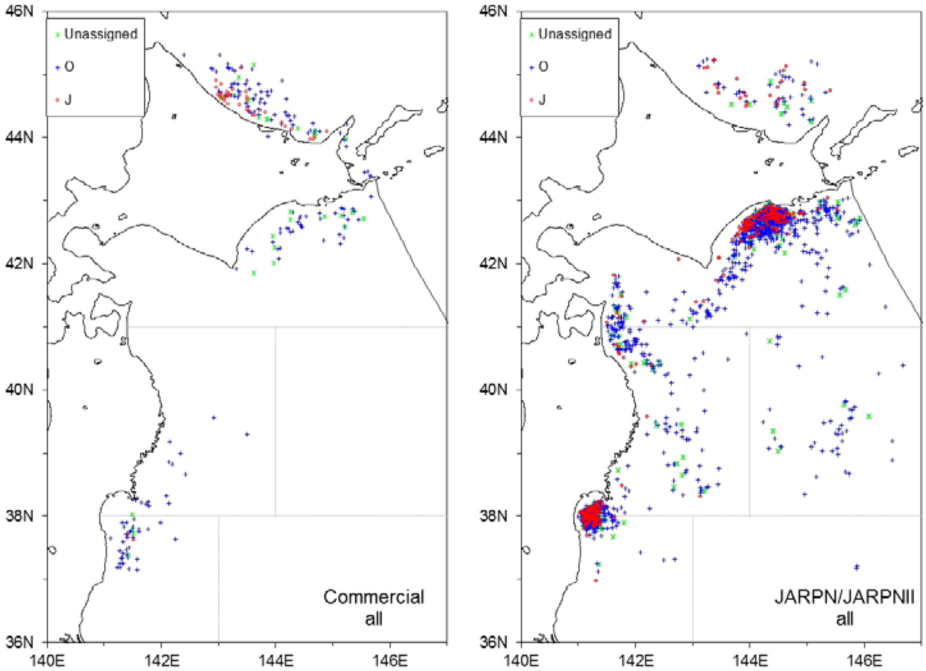

Figure 2. Sighting/catch position of common minke whales collected during 1983-1987 commercial whaling (left) and 1994-2014 JARPN/JARPNII surveys (right) in sub-areas 7 and 11 assigned as O stock (blue), J stock (red) and unassigned (green), based on microsatellite DNA and STRUCTURE analysis.

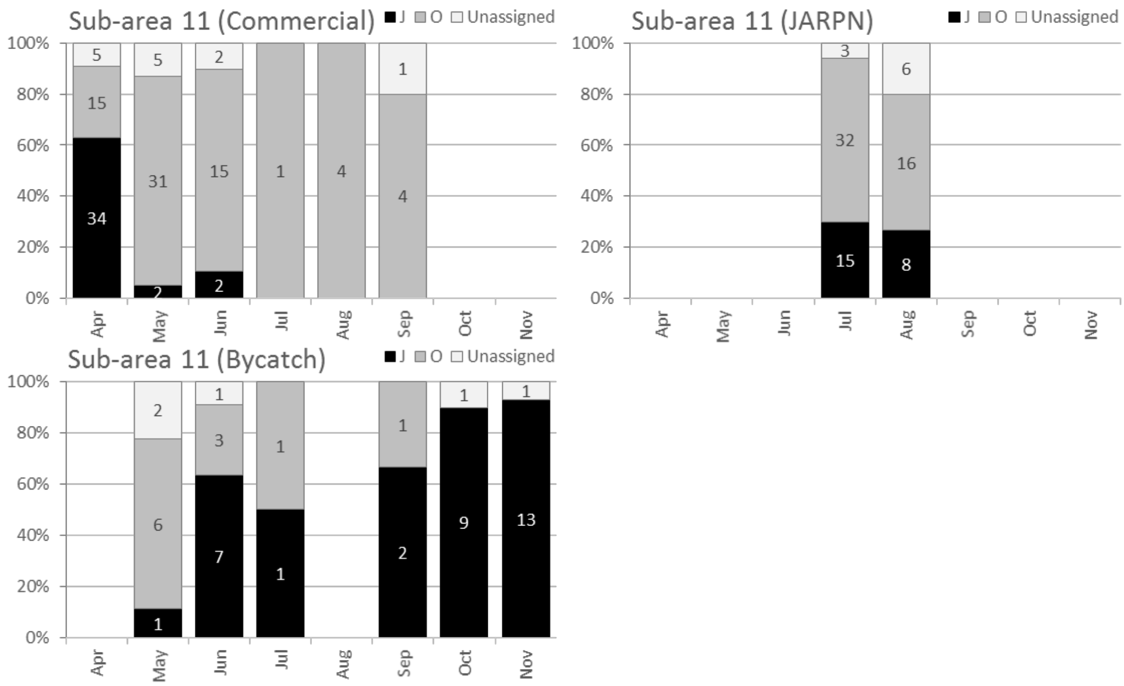

Figure 3. Monthly composition of J and O stock common minke whales collected in sub-area 11 by commercial whaling, JARPN and bycatches.

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 14).

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).

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
Further studies on movement of whales within the feeding grounds and between high and low latitudes areas can be investigated through satellite tracking. If the Ow-Oe stock scenario is true, movement of whales between Ow and Oe areas will be very limited. At the same time, animals distributed in both areas will migrate to independent breeding grounds.

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).

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 assessing the plausibility of Hypothesis C. If the Ow-Oe stock scenario is true, we expect no 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

Secondary Objectives I (v) and II (v)

Investigation of the influence of regime shift 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 regime shifts 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 regime shift 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 regime shift 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 regime shift. 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.

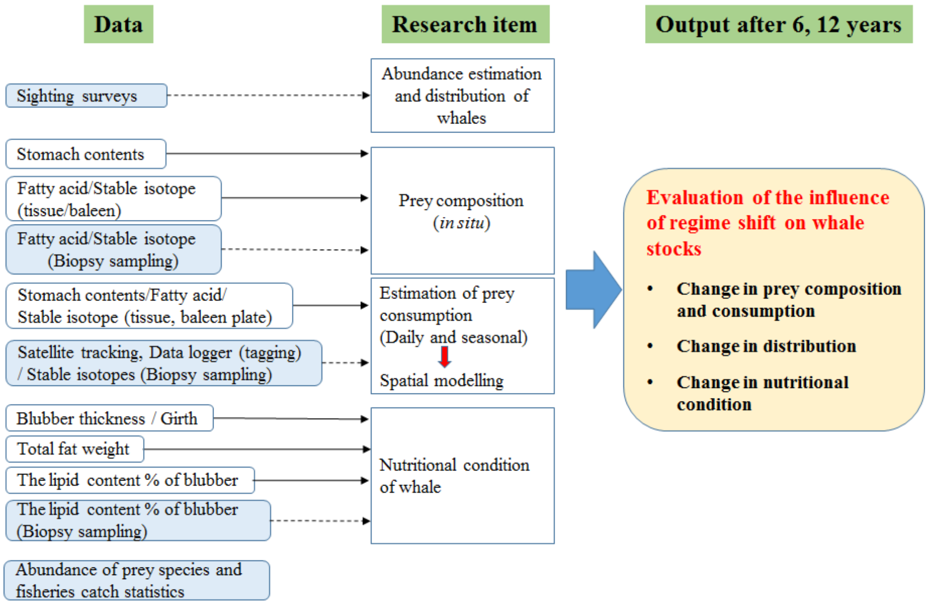

Figure 1. Flow chart with data, analyses and outputs of the research related to Secondary Objectives I (v) and II (v).

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 regime shift 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 13.

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 *et al.* (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 sampling method of stomach contents will be applied as described by Tamura *et al*. (2016b, c). A sub-sample (1-5kg) of the first compartment (forestomach) and second compartment (fundus) contents will be removed and frozen and/or fixed with 10% formalin water for later analyses. The stomach contents 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 regime shift 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.

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Annex 12

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

1. Pacific side of Japan (sub-areas 7-9)

Introduction

This Annex provides the details of the evaluation 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 determine 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).

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 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 overdispersion. Appendix D explains this and how it is taken into account.

Results

Results are presented to show the dependence on (aged) sample size of the detectability of a 30% change 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 first scenario examined, this change is assumed to take place 10 years into the projection period (corresponding to 2022).

Results are shown for estimation of trajectories of both O-stock abundance in terms of total numbers, and of 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 overdispersion). Figure 1 reports results for the first scenario which considers a 30% drop in recruits per adult female after the 10^{th} 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 100 years, and include both medians and standard deviations, where the latter are after adjustment for the estimation bias that is evident in these plots. Figure 2 shows further results for this case, where the estimates obtained are shown after periods of 10, 20, 30, 40, 50 and 100 years to clarify how soon after the recruitment change the estimator is able to detect that this has occurred.

The remaining Figures reflect sensitivity tests of performance to different scenarios for the recruitment change. In the interests of space, given that an effective sample size n=80 is being proposed (corresponding to an actual sample size of 107), these results contrast only the n=0 and n=80 situations. Figure 3 repeats results for the first scenario (of Figures 1 and 2), but for the recruitment drop after 20 rather than 10 years. Figures 4 and 5 duplicate those two scenarios, but with a recruitment increase rather than decrease. Finally Figures 6 and 7 again repeat that first pair of scenarios, but with MSYR (mature) equal to 4% rather than 1%.

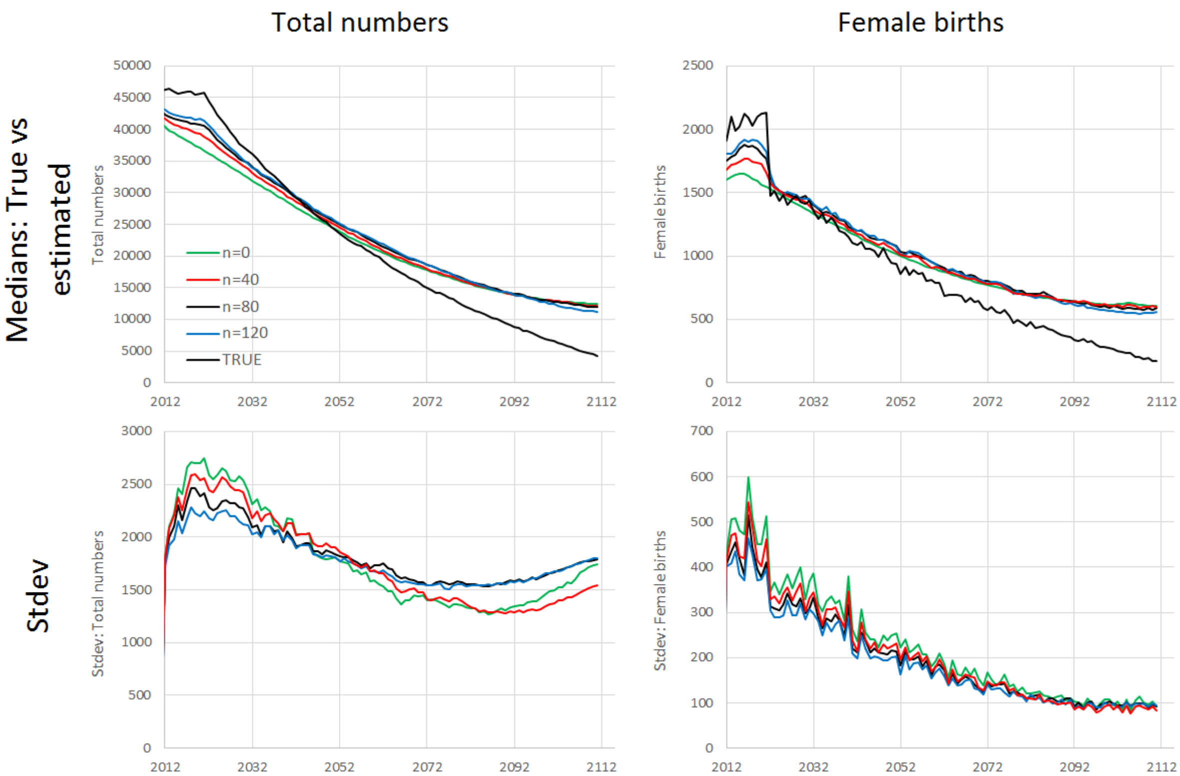

Figure 1: Medians "true" and estimated (first row), and standard deviation (bottom row) for total numbers and female births for a series of sample sizes, for **A01_1**. "**Multinomial"**, for a 30% drop in recruitment in **10 years**.

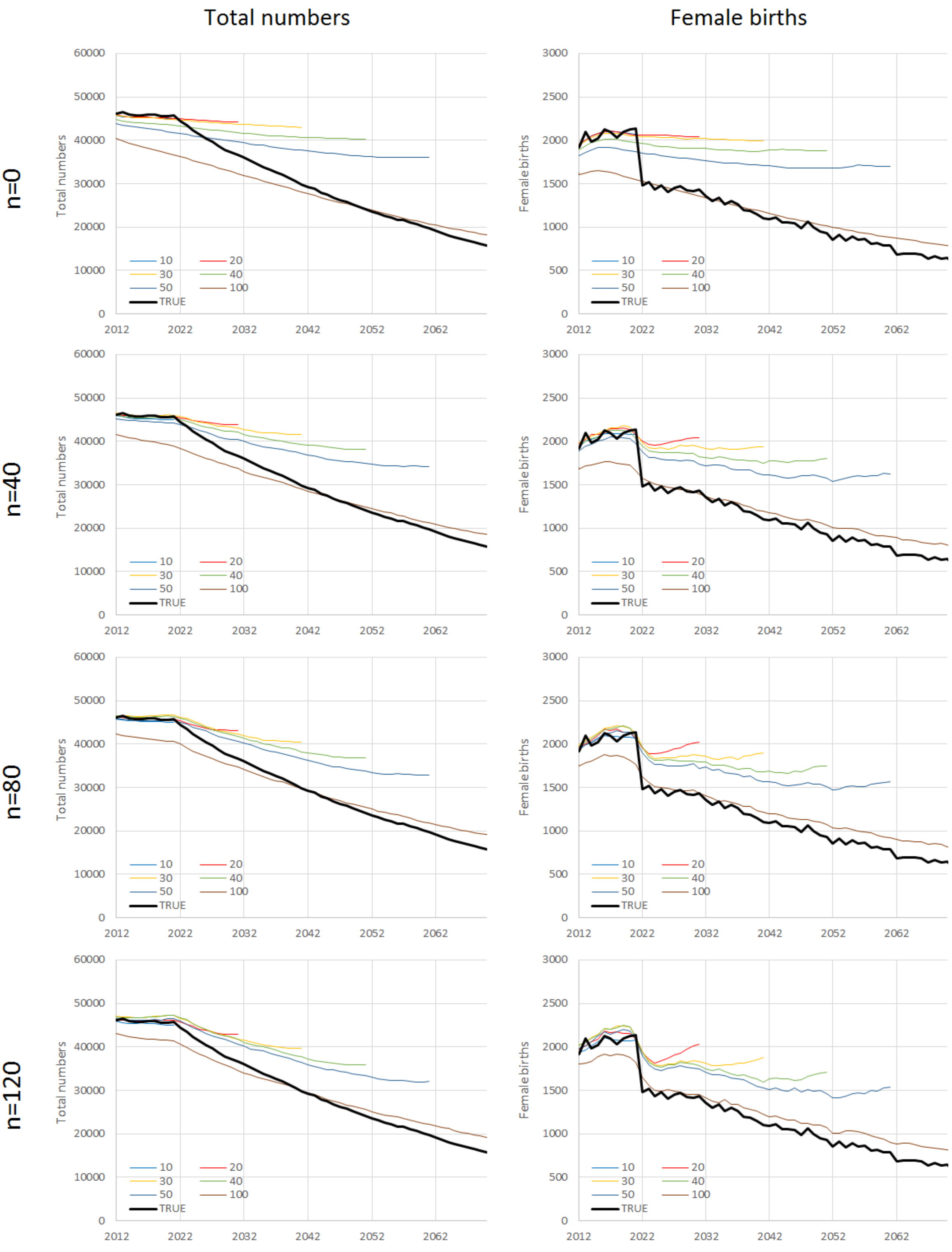

Figure 2: Medians "true" and estimated (first row), bias (second row), standard deviation (third row) and CV (bottom row) for total numbers and female births for a sample size of **0, 40, 80 and 120**, estimated after 10, 20, 30; 40, 50 and 100 years, for **A01_1**. **"Multinomial"** for a 30% drop in recruitment in **10 years.**

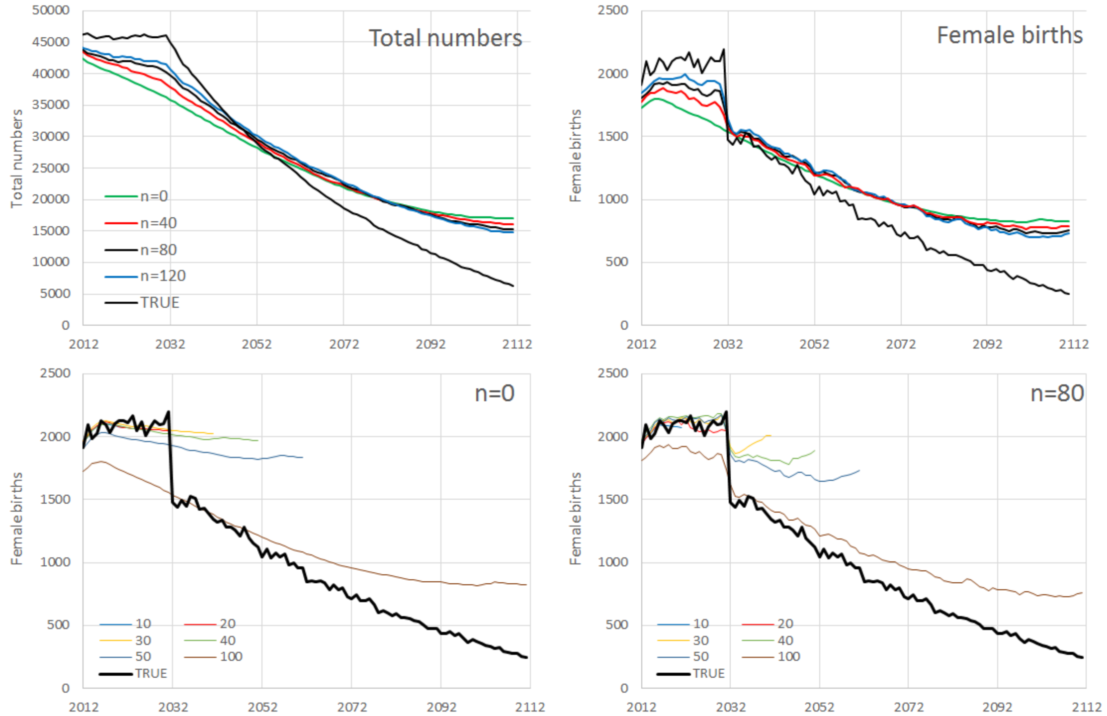

Figure 3: First row: Medians "true" and estimated total numbers and female births for a series of sample sizes. Second row: Medians "true" and estimated female births for a sample size of 0 (LHS) and 80 (RHS), estimated after 10, 20, 30; 40, 50 and 100 years, for **A01_1, with 30% drop in recruitment in 20 years**.

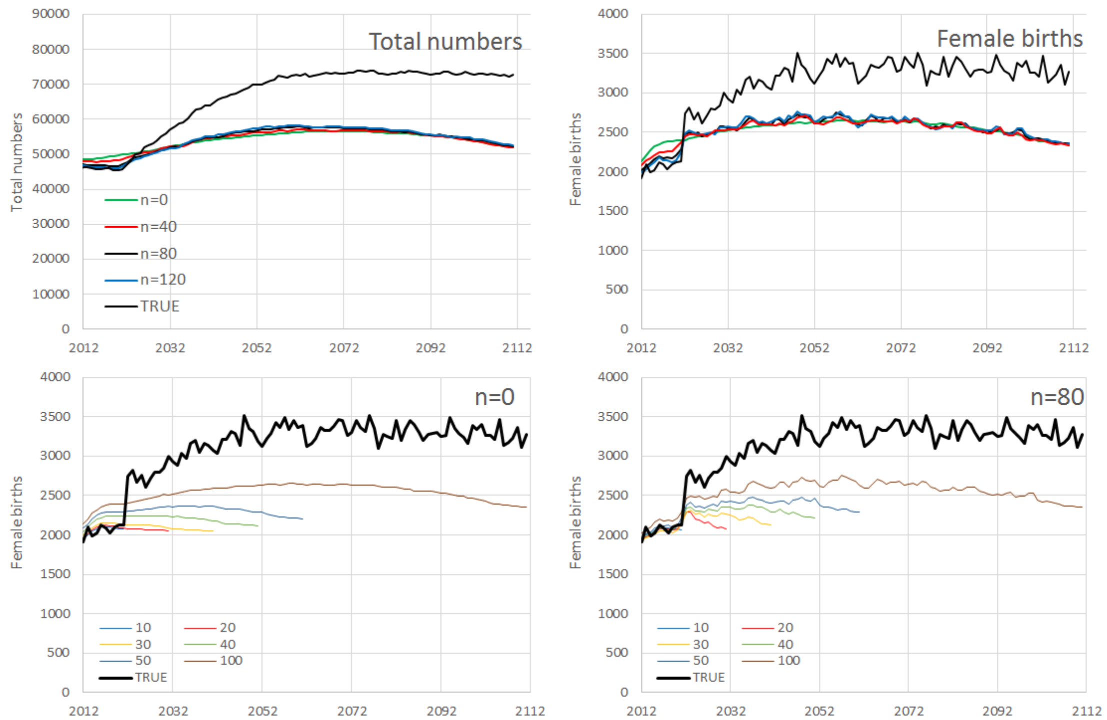

Figure 4: First row: Medians "true" and estimated total numbers and female births for a series of sample sizes. Second row: Medians "true" and estimated female births for a sample size of 0 (LHS) and 80 (RHS), estimated after 10, 20, 30; 40, 50 and 100 years, for **A01_1, with 30% increase in recruitment in 10 years**.

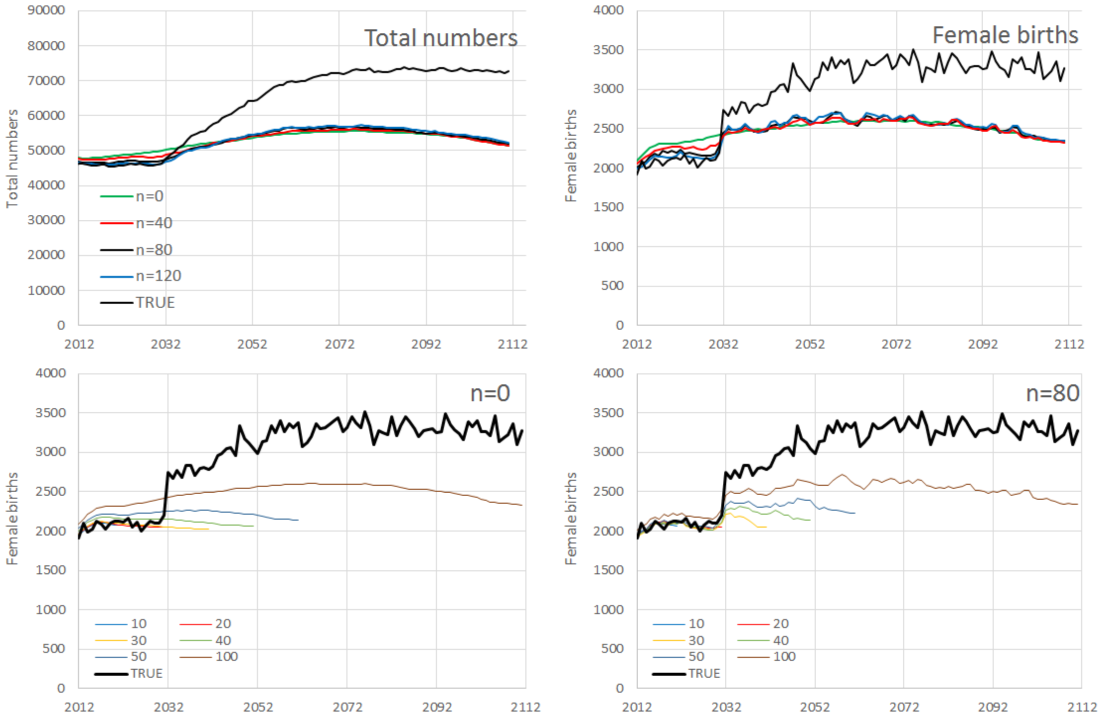

Figure 5: First row: Medians "true" and estimated total numbers and female births for a series of sample sizes. Second row: Medians "true" and estimated female births for a sample size of 0 (LHS) and 80 (RHS), estimated after 10, 20, 30; 40, 50 and 100 years, for **A01_1, with 30% increase in recruitment in 20 years**.

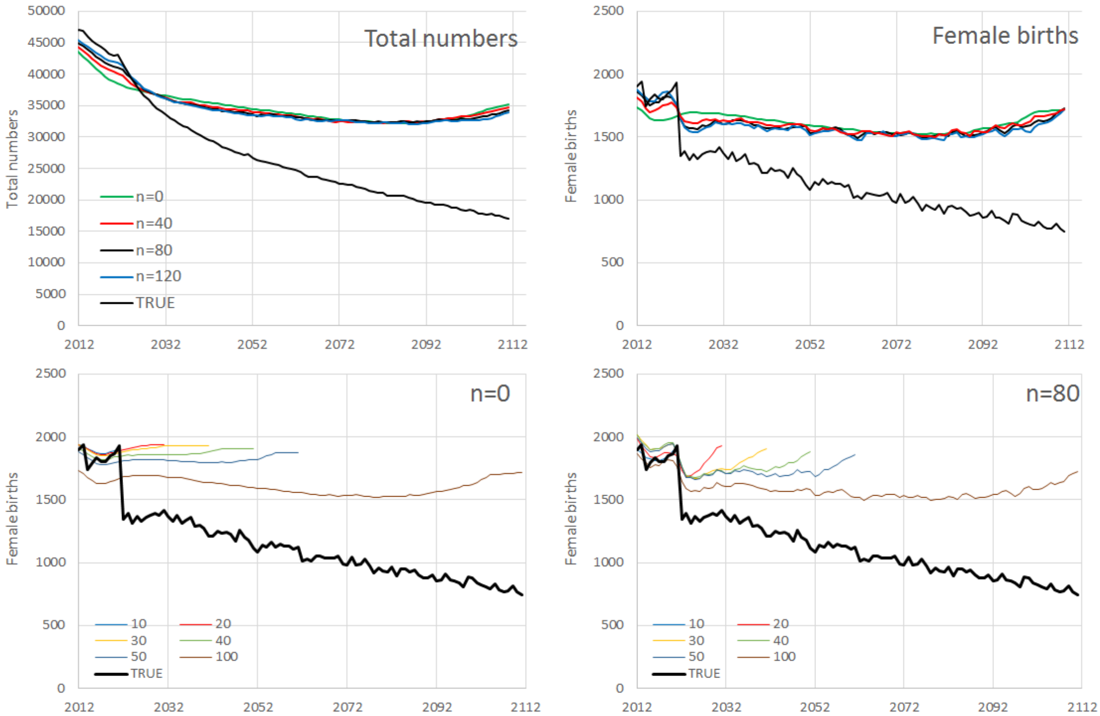

Figure 6: First row: Medians "true" and estimated total numbers and female births for a series of sample sizes. Second row: Medians "true" and estimated female births for a sample size of 0 (LHS) and 120 (RHS), estimated after 10, 20, 30; 40, 50 and 100 years, for **A01_4, with 30% drop in recruitment in 10 years**.

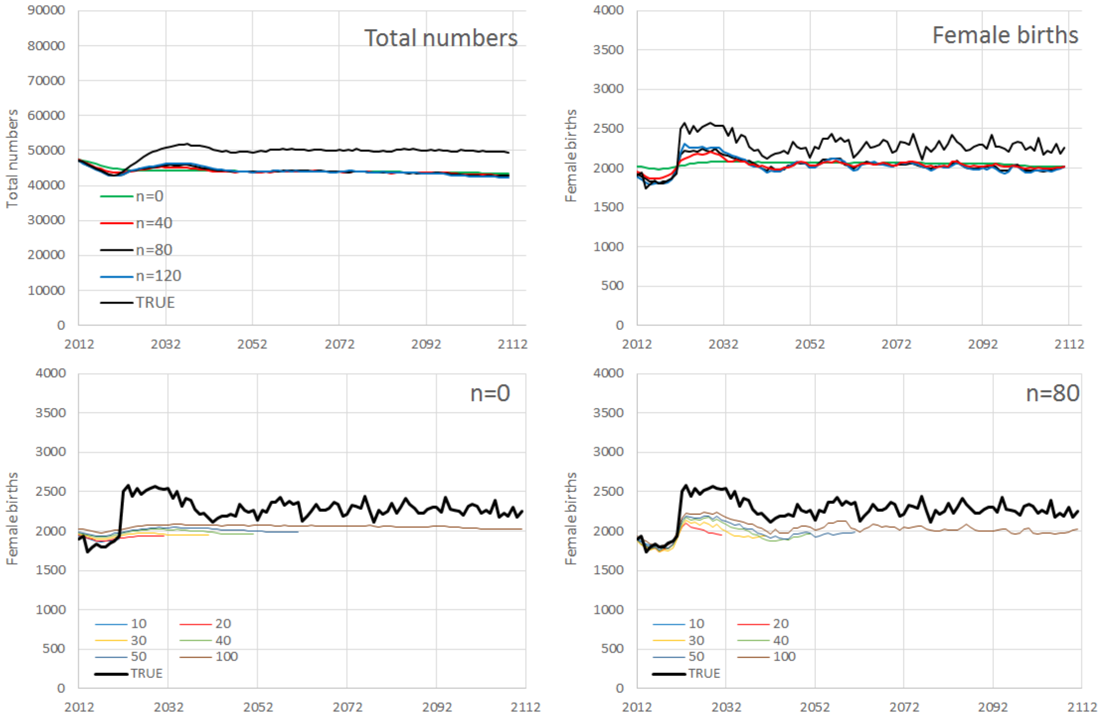

Figure 7: First row: Medians "true" and estimated total numbers and female births for a series of sample sizes. Second row: Medians "true" and estimated female births for a sample size of 0 (LHS) and 80 (RHS), estimated after 10, 20, 30; 40, 50 and 100 years, for **A01_4, with 30% increase in recruitment in 10 years**.

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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.

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Table A1: Historical male and female minke catches assumed for each scenario (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).

		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)).

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

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™ (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:

$$N^g_{y+1,a} = \begin{cases} 0.5 b_{y+1} & \text{if } a = 0 \\ \left(N^g_{y,a-1} - C^g_{y,a-1}\right) S_{a-1} & \text{if } 1 \le a < m \\ \left(N^g_{y,m-1} - C^g_{y,m-1}\right) S_{m-1} + \left(N^g_{y,m} - C^g_{m}\right) S_m & \text{if } a = m \end{cases} \qquad \text{(B1)}$$

where

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

$C^g_{y,a}$ 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.

$$b_y = B \; N^f_y \left\{ 1 + A \; \left[1 - \left(N^f_y / K^f \right)^z \; \right] \right\} e^{\varepsilon_y} \qquad \text{(B2)}$$

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),

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

a_m is the 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:

$$C_{y,a}^g = F_y^g v_{y,a}^g N_{y,a}^g \quad \text{(B3)}$$

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.

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.:

$$N_{y_0,a}^g = \begin{cases} 0.5B \quad K^f & \text{if } a = 0 \\ N_{y_0,a-1}^g S_{a-1} & \text{if } 1 \leq a < m \\ N_{y_0,m-1}^g S_{m-1}/(1 - S_m) & \text{if } a = m \end{cases} \quad \text{(B4)}$$

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 log-likelihood ($-lnL$) are as follows.

B.2.1 ESTIMATES OF MATURE FEMALE NUMBERS

$$-lnL^{abund} = \frac{(\varepsilon_y)^2}{2\sigma^2} \quad \text{(B5)}$$

with

$$\varepsilon_y = ln(I_y) - ln(\sum_a f_a^f N_{y,a}^f)$$ (B6)

where

I_y is the estimate of mature female numbers in year *y*, and

σ =0.01 (i.e. sufficiently low to force an exact fit to I_y)

B.2.2. 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:

$$-lnL^{CAA} = \sum_{y,g,a} -p_{y,a}^g ln\left(\frac{\hat{p}_{y,a}^g}{\sum_{a'} \hat{p}_{y,a'}^g}\right)$$ (B7)

where

$p_{y,a}^g$ is the observed number of whale of age *a* and gender *g* caught in year *y*,

$\hat{p}_{y,a}^g$ is the model-predicted number of whale of age *a* and gender *g* caught in year *y*,

where

$$\hat{p}_{y,a}^g = \sum_{a'} F_y^g v_{y,a'}^g r_{a'}^g N_{y,a'}^g E_{a,a'}$$ (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:

$$\varepsilon_{y,a}^g = \frac{p_{y,a}^g/\sum_{a'} p_{y,a'}^g - \hat{p}_{y,a}^g/\sum_{a'} \hat{p}_{y,a'}^g}{\sigma_{y,a}^g}$$ (B9)

with

$$\sigma_{y,a}^g = \frac{p_{y,a}^g \frac{\hat{p}_{y,a}^g}{\sum_{a'} \hat{p}_{y,a'}^g}\left(1 - \frac{\hat{p}_{y,a}^g}{\sum_{a'} \hat{p}_{y,a'}^g}\right)}{\sum_{a'} p_{y,a'}^g}$$ (B10)

A plus group of 20 has been used.

B.3. Harvesting selectivity

Fishing selectivities-at-age are estimated using a logistic form:

$$v_{y,a}^{g} = \left(1 + e^{\left(\Delta_{y,a}^{g} - a\right)/\delta_{y,a}^{g}}\right)^{-1}$$
(B11)

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:

$$v_{y,a}^{f} \rightarrow \rho \quad v_{y,a}^{f}$$
(B12)

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.: $N^g_{2012,a} \rightarrow N^g_{2012,a} e^{\varepsilon_a}$

ε_a from $N(0,(\sigma_N)^2)$

(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 to obtain $C^g_{y,a}$, and how future births are generated.

Step 3: Catch-at-age by gender and age

Catch by gender:

The male/female fishing mortality ratio is taken to stay constant at the 2007-2011 average estimated in the assessment:

$$\rho \quad = \frac{1}{5}\sum_{y=2007}^{2011} F^m_y / F^f_y$$

(C2)

So that:

$$F^f_y = \frac{C_y}{\sum_a v^f_{y,a} N^f_{y,a} + r \quad \sum_a v^m_{y,a} N^m_{y,a}}$$

(C3)

and

$$F^m_y = \rho \quad F^f_y$$

(C4)

The catch by gender is computed by:

$$C_y^g = F_y^f \sum_a v_{y,a}^g r_a^g N_{y,a}^g \qquad \text{(C5)}$$

Catch by age

$C_{y,a}^g$ is obtained by assuming that the commercial selectivity of an animal of gender g and age a for year y ($v_{y,a}^g$) stays constant in the future as estimated in the assessment.

$$C_{y,a}^g = F_y^f v_{y,a}^g r_a^g N_{y,a}^g \qquad \text{(C6)}$$

The numbers-at-age can then be computed for the beginning of the following year (y+1):

$$N_{y+1,a}^g = \begin{cases} 0.5 b_{y+1} & \text{if } a = 0 \\ \left(N_{y,a-1}^g - C_{y,a-1}^g\right) S_{a-1} & \text{if } 1 \leq a < m \\ \left(N_{y,m-1}^g - C_{y,m-1}^g\right) S_{m-1} + \left(N_{y,m}^g - C_m^g\right) S_m & \text{if } a = m \end{cases} \qquad \text{(C7)}$$

Step 4: Births

Future births are obtained assuming a density-dependence acting on the female component of the mature population.

$$b_y = B \quad N_y^f \left\{1 + A \quad \left[1 - \left(N_y^f / K^f\right)^z \quad \right]\right\} e^{\varepsilon_y} \qquad \text{(C8)}$$

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:

$$\hat{p}_{y,a}^g = \frac{\sum_{a'} v_{y,a'}^g r_{a'}^g N_{y,a'}^g E_{a,a'}}{\sum_{a*,a'} v_{y,a'}^g r_{a'}^g N_{y,a'}^g E_{a*,a'}} \qquad \text{(C9)}$$

while the sample size for the corresponding gender is a fixed proportion of the total sample size:

$$n^g = \gamma^g n \qquad \text{(C10)}$$

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:

$$I_y = \sum_a f_a^f N_{y,a}^f e^{\varepsilon_y}$$
(C11)

ε_y from $N(0,(\sigma)^2)$ with $\sigma = 0.25$.

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 $\sigma = 0.25$, 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:

$$D = \frac{\sum_{y,A}\left(\sum_{a\in A}(n_{y,a}p_{y,a}) - \sum_{a\in A}(n_{y,a}\hat{p}_{y,a})\right)^2}{\sum_{y,A}\left[\sum_{a\in A}(n_{y,a}\hat{p}_{y,a})(1-\sum_{a\in A}\hat{p}_{y,a})\right]} \quad \text{(D1)}$$

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 $n = 0.75N$.

2. North of Hokkaido (sub-area 11)

There is limited information on mixing proportion of J stock in sub-area 11 (see Annex 7). The proponents conducted a preliminary examination of the required sample size to estimate the 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; *n* is the number of the samples in the sub-area. Standard error of *p*, SE($\hat{p}$) is:

$$SE(\hat{p}) = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \quad (1)$$

Considering overdispersion ϕ (>1), equation (1) becomes:

$$SE(\hat{p}) = \sqrt{\frac{\hat{p}(1-\hat{p})\phi}{n}} \quad (1)'$$

SE($\hat{p}$) is 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 fulfill this condition:

$$\frac{0.5\sqrt{\phi}}{\sqrt{n}} > 0.1 \quad (2)$$
$$n > 25\phi$$

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:

$$n > \frac{25\phi}{(1-0.09)} \quad (3)$$

The overdispersion parameter was estimated by using the samples in sub-area 7CN, assuming a quasi-binomial error in conducting Generalized Linear Model GLM):

$$p = \frac{\exp\{-(a_1 + a_2 y)\}}{1-\exp\{-(a_1 + a_2 y)\}} \quad (4)$$

where a_1 and a_2 are coefficients to be estimated and *y* indicates year. 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 13

Whale sampling survey design under Primary Objectives II (sei whales)

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 140 animals (see details of the sample size estimates in Annex 17.

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 sampling procedure will be used (e.g. Pollard *et al*., 2002) when the density are expected to be high.

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.

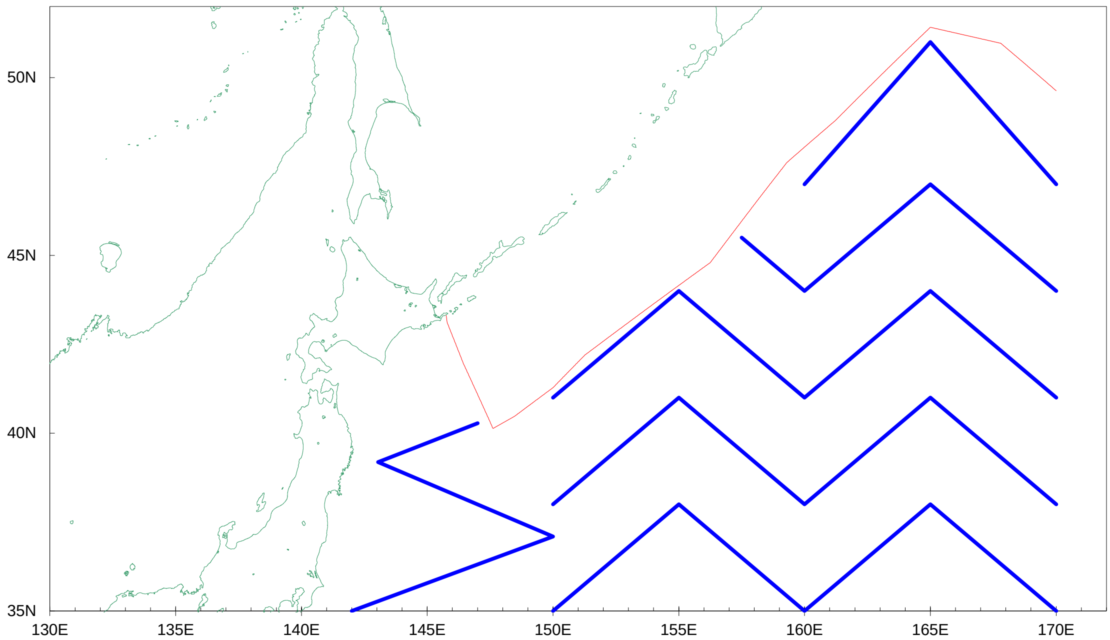

Figure 1. Schematic track line design for whale sampling in the offshore component of the NEWREP-NP.

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Annex 14

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, with tentatively assuming a single stock in the North Pacific, that the North Pacific sei whales had undergone substantial decline (approximately 20%) from 42,000 in 1963 to 8,600 in 1974 due to exploitation by the 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 170^{o}E and 135^{o}W, in the south of 20^{o}N during 2010-2016 (IWC, 2016a). Given that the sei whales are distributed in the north of 40^{o}N in summer (Horwood, 1987), most of main distribution area of the sei whales were covered except in the east of 135^{o}W 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 170°E 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 15

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 in the observation, there are several parameters which can only be derived from the results of stock assessment. 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.

Methods

Field and laboratory works

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 or Dirichlet-multinomial (DM) 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. The likelihood weights are automatically addressed when estimating overdispersion parameter (if DM distribution is assumed) and the extent of recruitment deviation. 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*.

Table 1. Key assumption in the model specification

Parameter/Structure in the model	**Assumption**
Stock structure	Single stock
$MSYR_{1+}$	0.1, 0.25 and 0.4 (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
Age-reading errors	To be estimated and incorporated into the models

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Annex 16

Secondary Objective II (iii)

Additional analyses on stock structure in North Pacific sei whale for RMP Implementation

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

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.

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 17

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, 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)

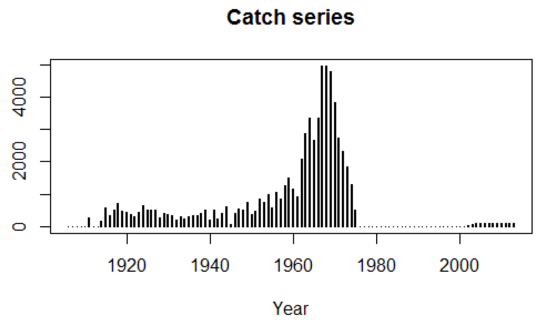


Figure 1. Catch series for the North Pacific sei whales.

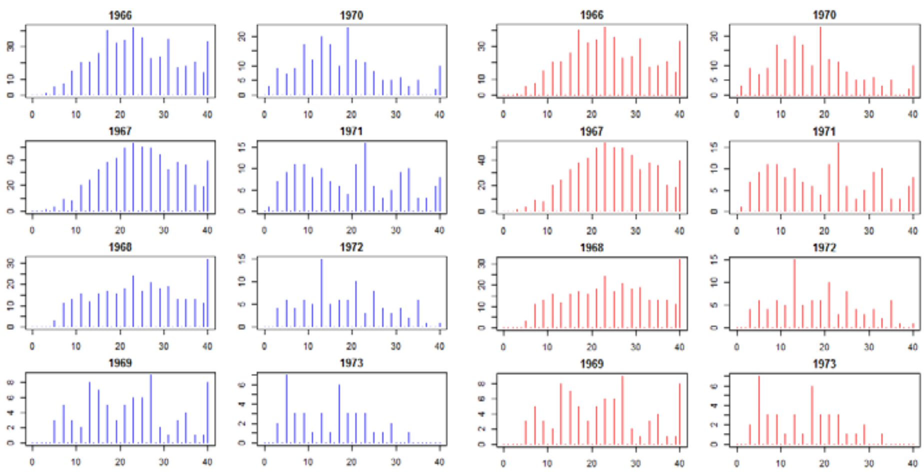


Figure 2. Catch-at-age data for male (left) and female (right) in commercial period (1966-1973)

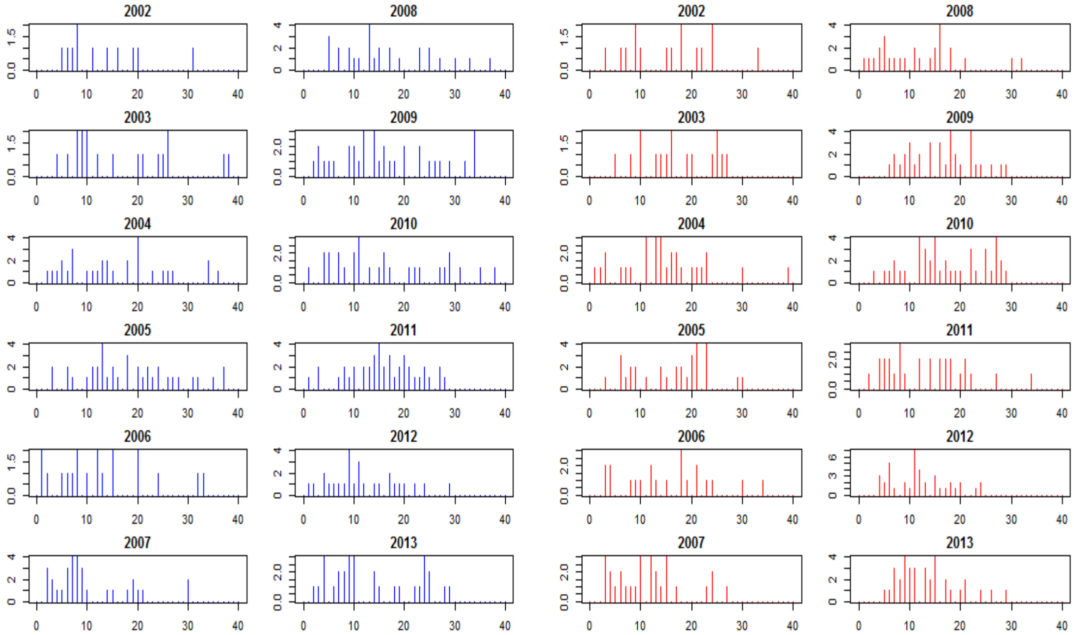


Figure 3. Catch-at-age data for male (left) and female (right) in JARPN-II period (2002-2013).

Model assumed for conditioning

The population dynamics assumed in the conditioning is same with the model shown in Annex 15 except for the recruitment as

$$R_t = f\ \tilde{P}_t^F \exp\left[A\left\{1-\left(\frac{P_{t,1+}}{K}\right)^z\right\}\right]$$

because of availability of single abundance estimate. 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=0.05 and 0.07 (/year), and the MSYR(1+) is set at 4%. 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, due to a nature of the single abundance estimate available, a procedure like 'hitter' was applied, which means the standard deviation of abundance estimate is intentionally set at a tiny value (here at 0.01) while naive multinomial distributions are assumed for the catch-at-age data. Unknown parameters 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.

Model assumed for simulation

Based on the conditioned models, projection was conducted to generate future abundance estimates and catch-at-age data. In 12 years research period, it is assumed that abundance estimate is available twice but not for the whole area of the North Pacific but only the survey area in the NEWREP-NP. These abundance estimates are subject to the process error due to inter-annual variation in spatial distribution, and therefore it was assumed that the abundance estimates inflated to the whole area have larger CV (30%) than CV=21.4% for the actual survey to take into consideration of additional variance.

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 supposed at 70% across all the ages.

Performance measures

The parameter of interest is the natural mortality (*M*), and therefore the following two measures are used for evaluation of estimation performance by sample size.

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\hat{M}_i - M\right)^2}$$

$$\text{Relative Bias} = 100\left[\frac{1}{n}\sum_{i=1}^{n}\hat{M}_i - M\right]/M$$

Here assumed annual sample sizes for the evaluation are 0, 60, 80, 100, 120, 140 and 200. In each sample size, data generation and estimation were iterated 200 times (n=200 in the measures defined above).

Results and conclusion

Figure 4 shows, as an example, results of the simulation for *M*=0.05. Figure 5 is a summary of estimation performance for the two true values of *M* (=0.05 and 0.07) under MSYR=4%. Although there are Monte Carlo errors and non-convergence cases in the iterations (if 0.001 is a threshold as a convergence criterion for the gradient), the estimation performance is, as expected, improved when the sample size increases. Simulations conducted suggest that the preferred sample size is 200 if M=0.05, and 140 if M=0.07 since variability of estimate reached asymptote at sample size of 140. Both M=0.05 and M=0.07 were considered to be realistic assumptions as a natural mortality rate for North Pacific sei whale. The annual sample size of 140 was found to be consistent with the policy to limit the sample size to the extent necessary to achieve the research objectives. The annual sample size of 140 was also found to be a feasible sample size in terms of the capacity of research vessels. Taking account of these factors, it was concluded that the sample size of140 per annum is the optimal size for this research plan. The level of CV for abundance and unaccounted overdispersion and age-reading error may drive the level of performance measures, but relative difference over candidate sample sizes might be similar with the results shown here.

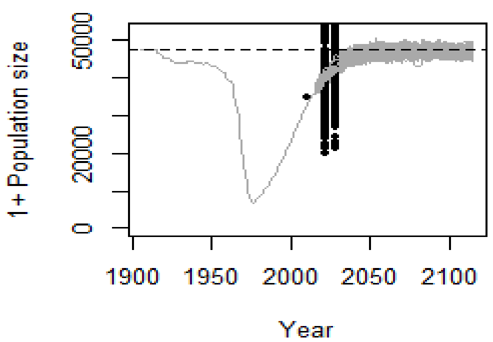
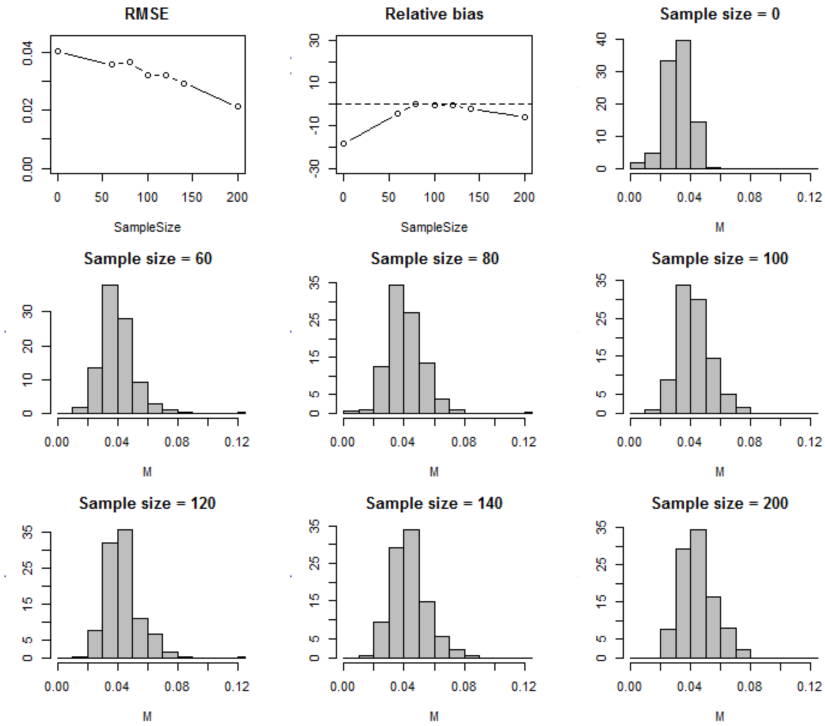


Figure 4. Trajectories of 1+ population size under the assumption M=0.05, MSYR=4% and annual sample size 140.

(A) M=0.05 (/year)



(B) M=0.07 (/year)

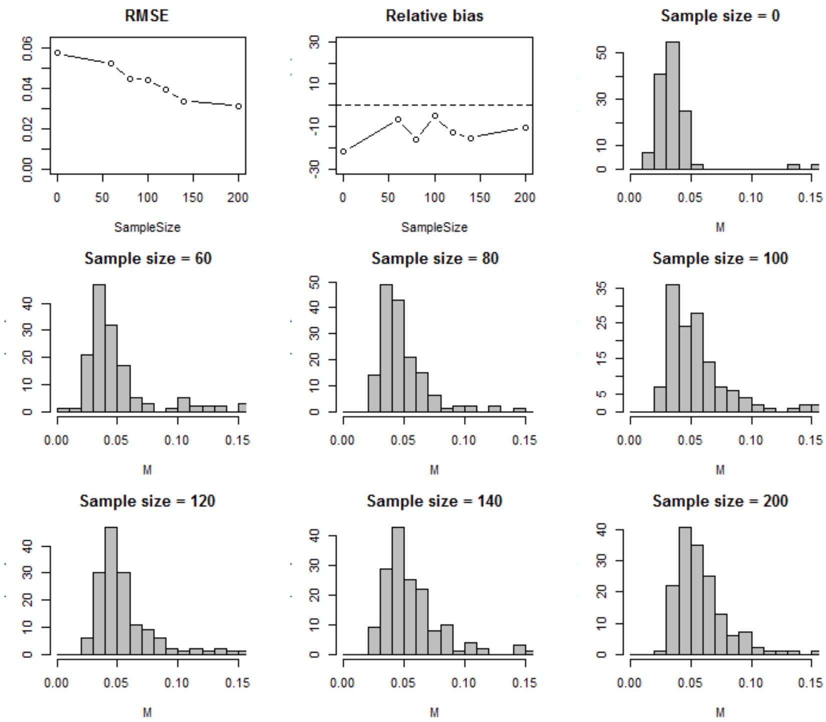


Figure 5. Summary of estimation performance for the true values of M at 0.05 and 0.07 under MSYR=4%.

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Annex 18

Ancillary Objective I
Examination of the effects of pollutants on whale stocks

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 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 relating to immune functions in the same samples will be measured by ELISA-based method (Wayland *et al.*, 2002).

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 of flame retardants such as PBDE will be measured in 10 blubber samples, 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.

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Annex 19

Ancillary Objective II
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.

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Annex 20

List of collaborating research institutions

Research activities under the NEWREP-NP will be carried out by the Institute of Cetacean Research (ICR) in collaboration with several research institutions. The ICR will coordinate the research activities with other institutions. This annex provides a list of collaborating research institutions, by NEWREP-NP objectives.

<u>Primary Objective I</u>

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)

  - 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)

  - 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)

  - 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)

  - 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).

- Secondary Objective I (v): *Investigation of the influence of regime shift on whale stocks* (Annex 11)

  - National Research Institute of Far Seas Fisheries (spatial estimation of prey consumption; consultation on satellite tracking technique).
  - Lkarts Norway (consultation on satellite tracking technique).

- National Research Institute of Fisheries Science (oceanographic data and oceanographic data analyses based on FRA-ROM) (consultation partners).
- Miyagi Prefecture Fisheries Technology Institute (prey survey).
- Hokkaido National Fisheries Research Institute (information on fisheries) (consultation partners).
- Hokkaido Research Organization (information on fisheries) (consultation partners).
- Hokkaido University (stable isotope analyses).
- Japan Chemical Analysis Center (stable isotope analyses).
- Japan Food Research Laboratories (fatty acid analyses).

<u>Primary Objective II</u>

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 14)

  - 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).
  - IWC-POWER (sighting survey).

- Secondary Objective II (ii): *Estimation of biological and ecological parameters in North Pacific sei whale for RMP Implementation* (Annex 15)

  - 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): *Additional analyses on stock structure in North Pacific sei whale for RMP Implementation* (Annex 16)

  - 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).
  - IWC-POWER (biopsy sampling).

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

  - Tokyo University of Marine Science and Technology (RMP *ISTs* specifications).

- Secondary Objective II (v): *Investigation of the influence of regime shift on whale stocks* (Annex 11)

  - National Research Institute of Far Seas Fisheries (spatial estimation of prey consumption; consultation on satellite tracking technique).
  - Lkarts Norway (consultation on satellite tracking technique).
  - National Research Institute of Fisheries Science (oceanographic data and oceanographic data analyses based on FRA-ROM; information on fisheries) (consultation partners).
  - Tohoku National Fisheries Research Institute (information on fisheries) (consultation partners).
  - Hokkaido University (stable isotope analyses).
  - Japan Chemical Analysis Center (stable isotope analyses).
  - Japan Food Research Laboratories (fatty acid analyses).

Annex 21

Research vessels

Research Base vessel

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

Sighting/sampling vessels

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

Prey survey vessel (Coastal component)

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 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	

References

International Whaling Commission. 2004. Report of the Data Availability Working Group. Annex T. *J. Cetacean Res. Manage*. 6 (*Suppl.*): 406-408.