The Japanese Whale Research Program under Special Permit in the western North Pacific Phase-II (JARPNII): results and conclusions in the context of the three main objectives, and scientific considerations for future research

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ABSTRACT

The International Whaling Commission Scientific Committee (IWC SC) will carry out a workshop to review final data and results of the Japanese Whale Research Program in the western North Pacific (JARPNII). The review workshop will follow the guidelines specified in Annex P. A number of scientific documents are now available, which present results from JARPNII in the period 2000-2014. Several analyses were based on combined samples and data from both JARPNII and the previous research program JARPN (1994-1999). The present paper was prepared to facilitate the understanding of this large research program in a comprehensive manner. First a background explaining the origin, objectives, research area and analytical methodology of JARPNII, is presented. Next the results are presented by objectives and sub-objectives of the research program. Results of research not directly related to the main objectives are also summarized. Finally some considerations of future research are presented.

CONTENTS

1. GENERAL INTRODUCTION

2. OVERVIEW

   2.1 The JARPN
   2.2 From JARPN to JARPNII
   2.3 Objectives and sub objectives of JARPNII
   2.4 Brief outline of the research area and analytical methodology

3. DATA OBTAINED BY JARPNII AND DATA AVAILABILITY

4. RESULTS OF THE RESEARCH UNDER JARPNII AND FUTURE RESEARCH CONSIDERATIONS

   4.1 Executive summary
   4.2 Detailed results
   4.3 Integration of results and consideration of future research

5. SUMMARY RESPONSE TO RELEVANT TOR OF THE JARPNII REVIEW WORKSHOP SPECIFIED IN ANNEX P

6. ACKNOWLEDGEMENTS

7. LITERATURE CITED

ANNEXES

Annex 1: List of documents for the JARPNII Review Workshop.

Annex 2: Brief outline of the research area, target species and sample size of JARPNII.

Annex 3: A summary of samples/data collected by JARPNII (2000-2014).

Annex 4: Protocol for access to samples/data from the Institute of Cetacean Research (ICR), Tokyo, Japan, under Procedure B.

Annex 5: Summary of the work carried out by Japanese scientists in response to several recommendations and suggestions on JARPNII research offered by the IWC SC in 2009.

1. GENERAL INTRODUCTION

There are two pillars in the Japanese Whale research Program under Special Permit in the western North Pacific Phase II (JARPNII). The first is contribution to the conservation and management of whale resources in the western North Pacific Ocean through provision of scientific data especially to the RMP *implementation* process. The second is contribution to the fisheries management in the western North Pacific Ocean through application of the ecosystem approaches (*e.g*. building ecosystem models).

The International Convention for the Regulation of Whaling (ICRW) gives particular importance to science as the basis for the conservation and management of whale resources. While the IWC adopted the commercial whaling moratorium, paragraph 10 (e) of the Schedule provides as follows: "…This provision will be kept under review, based upon the best scientific advice, and by 1990 at the latest the Commission will undertake a comprehensive assessment of the effects of this decision on whale stocks and consider modification of this provision and the establishment of other catch limits". In other words, this paragraph sets forth the necessity of scientific data and thus scientific research for the "review" and "comprehensive assessment". The term "Comprehensive Assessment (CA)" is similar to the term "In-Depth Assessment", and it was defined by the IWC SC as `an in-depth evaluation of the status of all whale stocks in the light of management objectives and procedures` and that `this would include the examination of current stock size, recent population trends, carrying capacity and productivity`(IWC, 1989). In 1992, the IWC SC developed the Revised Management Procedures (RMP), a scientific system to calculate catch limits for baleen whales, in accordance with paragraph 10(e). In the western North Pacific, the RMP *implementation* process has been applied to common minke whale (*Balaenoptera acutorostrata*) and Bryde's whale (*B. edeni*). In recent years, scientific information about sei whale (*B. borealis*) has also been accumulated. JARPNII is designed to contribute to these processes.

The western North Pacific supports the existence of a vast amount of marine living resources including zooplankton, schooling fishes, oceanic squids, seabirds and cetaceans. The western North Pacific is also a very important fishing ground for Japan and other coastal countries. In order to achieve sustainable utilization of marine living resources of the western North Pacific, it is imperative to apply the ecosystem approaches to the fisheries, including through building ecosystem models which take account of the interaction between marine mammals and fisheries. This represents the second pillar of JARPNII.

Because conservation and management of marine living resources, including whale species, entails uncertainties in terms of biological parameters and environmental fluctuations, to name a few, and pertains ongoing activities, *e.g*. fisheries and marine ecosystem processes, it requires careful considerations in designing and implementing research and analysis projects.

In reviewing the achievements of JARPN and JARPNII, it is important to have an "adaptive" perspective. There are uncertainties in the subjects of the research activities. They will be reduced when the research make expected achievements while the character of the uncertainties may change as a results of the environmental and marine ecosystem fluctuations/changes.

Objective and contents of this document

The present document explains the origin, objectives and progress in research made in the JARPNII in a comprehensive and easy-to-understand manner. The aim of this document is to assist members of the Review Panel that may not be familiar with the origin, scientific purposes, and technical details of JARPN and JARPNII.

Before explaining JARPN II, it is necessary to understand its predecessor, the JARPN. The JARPN was conducted between the 1994 and 1999 and produced a considerable amount of data for an improved understanding of the common minke whale and its environment (IWC, 2001). Section 2.1 of this document shows the origin and objectives of JARPN. Section 2.2 summarizes the key results of JARPN and how these results were taken into consideration in developing the research objectives of JARPNII.

Objectives and sub objectives of JARPNII are presented in Section 2.3, and Section 2.4 presents a brief outline of the research area and analytical methodology. Section 3 shows the data obtained by JARPN II, and the protocol available for accessing the data. An executive summary of results by research objective is presented in Section 4.1 while detailed results and conclusions of the research under the three main objectives are presented in Section 4.2. Integration of results and consideration of future research is presented in Section 4.3. Finally Section 5 presents a summary response to the relevant Terms of Reference (TOR) of the specialist workshop for the final review of JARPNII as detailed in Annex P (see Annex P, IWC, 2009a; 2013a; 2015a).

Details of the analyses and results summarized in Section 4 can be found in the individual papers (Annex 1). This annex also includes a list of relevant 'For Information' documents. Annex 2 presents a brief outline of the research area, target species, sample size and general methodology of JARPNII. The analyses are based on samples and data collected by JARPN II in 2000-2014 (Annex 3), although some of the analyses were conducted using both JARPN and JARPNII samples. The data were available to IWC SC members through its data access protocol (Procedure B). Annex 4 shows the protocol for sample/data access from the Institute of Cetacean Research under this Procedure. The different analyses conducted took into consideration previous suggestions and recommendations from the IWC SC. The list of previous recommendations and the responses from Japanese scientists are summarized in Annex 5.

2. OVERVIEW

2.1 The JARPN

The JARPN started in 1994. Surveys were conducted in each year between 1994 and 1999, and a total of 498 common minke whales were sampled as part of the lethal component of the program (Fujise, 2000). The main objective was to elucidate the stock structure of common minke whales in the Pacific side of Japan. In a management context, stock structure is a key piece of information for the application of the RMP, a procedure adopted by the IWC in 1994 to calculate a catch limit of baleen whales for future commercial whaling.

One of the major components of the RMP is the '*Implementation Simulation Trials*' (*ISTs*), which are conducted to guarantee the performance of RMP prior to the actual application of RMP to calculate a commercial catch limit of whales. The main purpose of the *ISTs*, which are specific to species/areas, is to assure a sustainable exploitation of whale resources by avoiding depletion of individual stocks. Therefore the hypotheses on stock structure and their plausibility are important, and are the basis for the establishment of Small Areas, for which catch limits are calculated.

Regarding stock structure of western North Pacific common minke whales the IWC SC recognized in 1993 two stocks of common minke whales, the Okhotsk Sea/Western Pacific ('O' stock) and the Yellow Sea/East China Sea/Sea of Japan ('J' stock). It also proposed a complicated sub-stock scenario with several sub-stocks composing the 'J' and 'O' stocks and hypothesized a western stock ('W' stock) in offshore areas in the Pacific side of Japan (IWC, 1994) (see Figure 1 for the definition of sub-areas for management by the IWC SC in 1994).

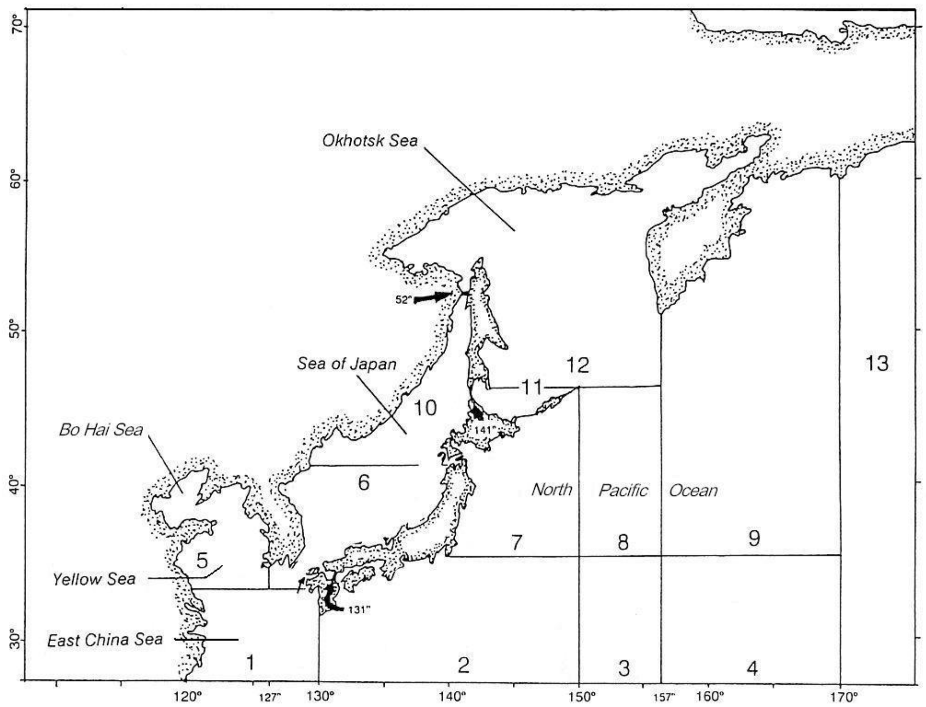

Figure 1. Sub-areas defined by the IWC SC in 1994 for management purpose of the common minke whale.

The issue of stock structure was discussed again by the IWC SC in 1996. During that meeting the IWC SC discussed the new scientific information derived from JARPN and concluded that the sub-stock scenario proposed in 1993 was not plausible (IWC, 1997).

The IWC SC reviewed the final results of JARPN during a Workshop conducted in 2000. Based on the information presented, the Workshop did not discard the hypothesis of occurrence of 'W' stock in offshore areas in the Pacific side of Japan, at least in some years of the period of JARPN. The Workshop recommended that further research was necessary to examine the hypothesis of the 'W' stock (IWC, 2001).

A second objective of JARPN, 'the feasibility study on the feeding ecology of minke whales in the research ground', was added in 1996. Previous studies based on commercial samples were basically qualitative descriptions of the prey species eaten by whales (*e.g*. Nemoto, 1959; Kasamatsu and Tanaka, 1992). For ecosystem modeling purposes, however, both qualitative and quantitative data on prey consumption are required. Research under the feeding ecology objective of JARPN allowed scientists to collect information on both qualitative and quantitative aspects of stomach contents of common minke whales. JARPN research also showed that the distribution of minke whales overlapped with the area of operation of some important commercial fisheries in Japan.

Furthermore the analysis of stomach contents demonstrated that this whale species feeds on several prey species, all of which are also the target of commercial fisheries in Japan. Therefore the first priority of JARPN II (second phase of JARPN) was placed on feeding ecology and ecosystem studies in this 'hot spot' area for cetacean/fisheries interaction.

The JARPN Review Meeting in 2000 pointed out the necessity to obtain an improved understanding of the distribution and abundance of relevant prey species to better understand the dynamics of common minke whale food choice and consumption. It recommended that acoustic and trawl surveys, designed to address some questions, should be conducted concurrently with future whale surveys, if possible (IWC, 2001).

2.2 From JARPN to JARPNII

The JARPN workshop in 2000 agreed that there were unresolved scientific issues related to common minke whale stock structure and also made a series of recommendations to strengthen the feeding ecology part of the program (IWC, 2001).

At the time the JARPN was completed it was noted that while the fisheries have provided 40% of annual protein with variety of fish products in Japan, the level of fisheries resources and catches had decreased. The catch by Japanese fisheries were drastically shrank from 12.8 million tons 1988 to 6.7 million tons in 1998. In 1999, the fisheries Agency announced the principle for the fundamental policy on fisheries. In principle, the first priority was given to science-based management and sustainable utilization of fisheries resources within Japan's EEZ. To aid the recovery of the resources, investigations should be carried out taking into account the management and sustainable utilization of whole ecosystem including marine mammals. The principle of multi-species management had been discussed by many international organizations including the FAO. The Indian Ocean Tuna Commission (IOTC) recognizing the importance of the ecosystem approach to fisheries management. The North Pacific Marine Science Organization (PICES) also set up a working group on food consumption by marine mammals and seabirds in 1995.

It was then proposed that JARPN should be continued as a second phase program (JARPNII) to follow up the issues indicated above, including the recommendations from the JARPN review meeting. The highest priority of JARPN II would be on feeding ecology and ecosystem studies in the western North Pacific. In this regard, qualitative and quantitative data for feeding ecology would be the most important information to collect. The second priority was to monitor environmental pollutants, and the third priority was on stock structure of large whale species. To cover the temporal and spatial gaps, which cannot be sampled by the research base ship *Nisshin Maru*, a coastal component of JARPN II was designed, focused on common minke whale. Annex 2 presents details of the species selected for the lethal component of JARPN II and the rational used for the calculation of sample sizes.

In 2009 the IWC SC carried out a review workshop of JARPNII for the first six years of the full program (2002-2007). Results obtained by JARPNII for that period were summarized by Pastene *et al.* (2009a), and the report of the review workshop is available in IWC (2010). In the view of the Japanese scientists, the workshop report represented a fair and balanced evaluation of the work conducted by the JARPNII in its first six years, and valuable recommendations were made to improve the research (Pastene *et al*., 2009b).

The JARPNII work conducted after the 2009 review workshop took into consideration most of the recommendations offered by the review workshop in 2009. One of the important recommendations from the 2009 review workshop was the development of refined, more quantified sub-objectives for each component of the program (IWC, 2010). In response, Japanese scientists developed sub-objectives within each objective of JARPNII (see next section).

As noted above, most of the technical recommendations from the 2009 review workshop were taken into account by the analysts (see Annex 5 for a summary of recommendations and responses).

2.3 Objectives and sub objectives of JARPNII
The rational for the objectives of JARPNII was explained previously (Government of Japan; 2002; Pastene *et al.*, 2009a). This section provides information on sub-objectives within each objective.

The objectives of JARPNII are the following:
Objective 1: Feeding ecology and ecosystem studies
Objective 2: Monitoring environmental pollutants in cetaceans and the marine ecosystem
Objective 3: Stock structure of large whales

A general explanation for each objective and the identification of sub-objectives under each objective is explained in this section.

Objective 1: Feeding ecology and ecosystem studies
This is the top priority research objective in the program, which include i) prey consumption by cetacean, ii) prey preference of cetaceans, and iii) ecosystem modeling.

The original research plan of JARPNII stated several questions relevant to this main objective. For example, do cetaceans consume a large quantity of fisheries resources compared to the catches of commercial fisheries? Does the consumption by cetacean have a significant impact on natural mortality and recruitment of the prey? Inversely, does the abundance and distribution of the prey species affect the migration pattern, recruitment and geographical segregation by sex of cetaceans? Is there direct and/or indirect competition among cetaceans and between cetacean and other top predators such as fur seals, tunas and sharks? Do sperm whales have an impact on the surface ecosystem? (Government of Japan, 2002).

JARPNII attempted to respond these questions through a comprehensive research on the western North Pacific ecosystem including cetacean, prey species and the environment (Figure 2).

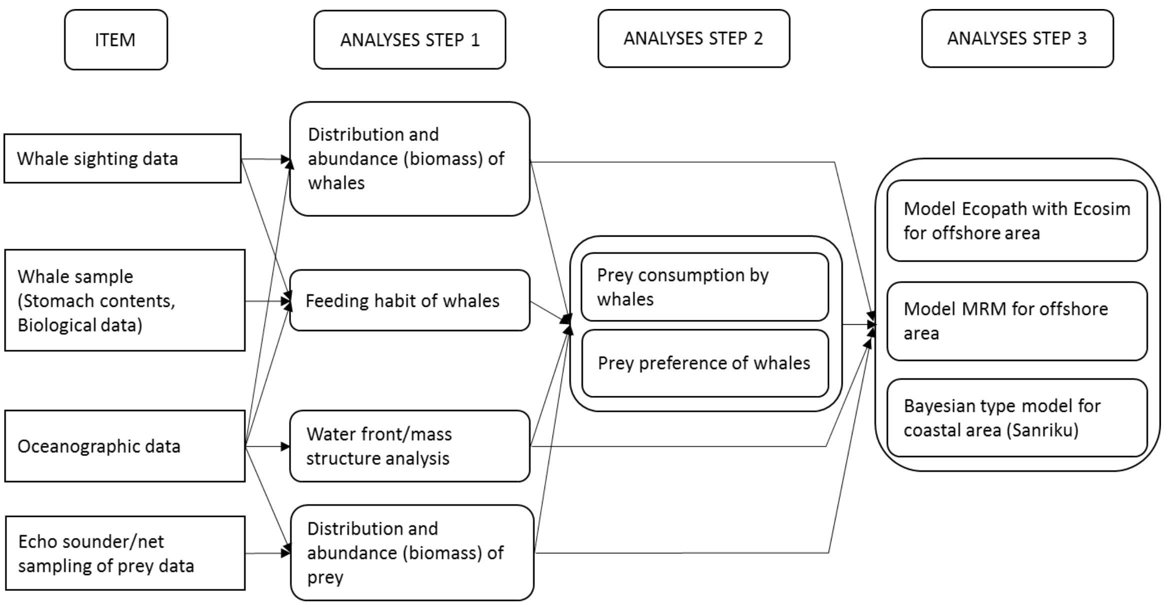

Figure 2. Schematic representation of the research components under Objective 1 of JARPNII.

It should be noted here that responses to the questions listed above can derive from both research conducted under individual components in the figure above as well from the outputs from the ecosystem models, which integrate information from several components.

To facilitate the review of the results under Objective 1, several sub-objectives were identified for the different components as follow:

Oceanographic conditions

Oceanographic conditions in the Pacific side of Japan are very complex with several oceanographic systems interacting in this ocean basin. Furthermore yearly changes in oceanographic conditions have been reported. Changes in oceanographic conditions have important implications for primary production and thus distribution of prey species of cetacean in the research area. JARPN and JARPNII have collected oceanographic data in a systematic manner for several years with the following aim:

Objective 1, Sub-objective 1:

Investigate the oceanographic conditions that are relevant for the understanding of prey species's distribution and abundance in the research area.

Relevant documents: SC/F16/JR5-6.

Distribution and abundance of whales

On one hand there is the need to investigate the pattern of distribution of whales and the possible factors affecting distribution, which is important to interpret abundance estimates. On the other hand there is the need to know the abundance of animals in the research area. The latter information is particularly important for the aims of prey consumption estimation and ecosystem modeling. Here, the abundance estimation refers to the number of whales present in a particular area and at a particular season for the aim of Objective 1, and it does not mean the total abundance of the whale stock. The target C.V. of abundance estimation is < 0.3. On this topic the following sub-objectives were identified:

Objective 1, Sub-objective 2:

To investigate the distribution pattern of baleen whales in the research area and the possible factors affecting such pattern.

Relevant documents: SC/F16/JR7-10

Objective 1, Sub-objective 3:
To estimate abundance of baleen and sperm whales using JARPNII sighting data and standard IWC SC methodology.

Relevant documents: SC/F16/JR11-14

Prey consumption by whales

At the 2009 JARPNII review, one of the major concerns was the lack of full treatment of uncertainty in the estimate of prey consumption. Therefore a new sub-objective was identified as follow:

Objective 1, Sub-objective 4:
To estimate the prey consumption by baleen whales using JARPNII data and samples, and taking into account the uncertainties identified at the 2009 JARPNII review.

Relevant documents: SC/F16/JR15-17.

Impact of prey consumption by whales on fishery resources

One of the important questions to be addressed by the research is on the impact of whale consumption on fisheries resources. In order to address this question, the following sub-objective was identified:

Objective 1, Sub-objective 5:
To evaluate the feeding impact by whales on fisheries resources using JARPNII data and samples, and information from commercial fisheries and other research sources in coastal areas.

Relevant documents: SC/F16/JR17.

Biomass estimation of whale's prey species

For the aims of prey consumption estimation and ecosystem modeling development, the information of prey species abundance is important. On this regard the following sub-objective was identified:

Objective 1, Sub-objective 6:
To estimate prey abundance using JARPNII data, complemented with information available from other sources.

Relevant documents: SC/F16/JR18, JR19.

Prey preference of whales

In the original JARPNII research plan, prey preference of cetaceans is not for individual animals within a species but for the different species within the particular ecosystem. Prey preference data is inputted to some of the ecosystem models as one of the key parameters. On this topic, the following sub-objective was identified:

Objective 1, Sub-objective 7:
To investigate the prey preference of whales in offshore areas, using JARPNII data and samples.

Relevant documents: SC/F16/JR20-22.

Feeding habit of whales

Feeding habit is different among species of whales and it depends on environmental conditions. It is important to study these habits, its spatial and temporal changes and the reasons for such changes. On this topic, the following sub-objective was identified:

Objective 1, Sub-objective 8:
To investigate feeding habit of baleen and toothed whale species in the research area, and the environmental factors involved in determining such habits.

Relevant documents: SC/F16/JR23-26.

Body condition of whales

Temporal trend in body condition of whales can be used as a 'reality check' for the outputs of the ecosystem models. Consequently the following sub-objective was identified:

Objective 1, Sub-objective 9:
To investigate the yearly trend in body condition of baleen whales using JARPNII data and samples.

Relevant documents: SC/F16/JR27.

Ecosystem modelling

One of the final goals of JARPNII is to contribute to the conservation and sustainable use of all marine living resources including cetaceans in the western North Pacific, especially within Japan's EEZ. The output of the ecosystem models are expected to provide insights to the relations between different species in the marine ecosystem and the dynamics of the ecosystem. In line with the conclusion from FAO (2008) and IWC (2008a) that there is no one single correct model, and that the greatest benefit are to be obtained by considering a number of models that may be of quite different forms, JARPNII aimed to develop different kinds of models. On this regard, the following sub-objective was identified:

Objective 1, Sub-objective 10:
To develop several ecosystem models, in both coastal and offshore areas, using JARPNII data and samples as input. Output of the models are likely to provide information on i) the ecosystem structure, ii) effects of prey availability and consumption on the population dynamics of common minke and sei whales with consideration of levels of energy intakes, iii) predation impacts of common minke whales consumption on sandlance stock off Sanriku.

Relevant documents: SC/F16/JR28, JR29.

Objective 2: Monitoring environmental pollutants in cetaceans and the marine ecosystem

In 1992 the Commission endorsed the plan of the IWC SC to pursue studies on environmental changes and their impacts on cetaceans. In particular, there was concern that pollutants may have a negative effect on the health of cetaceans resulting ultimately in a decrease in the abundance of the stocks. The second objective of JARPNII is "monitoring environmental pollutants in cetaceans and the marine ecosystem", which is composed of: i) pattern of accumulation of pollutants in cetaceans, ii) bioaccumulation process of pollutants through the food chain, iii) relationship between chemical pollutants and cetacean health. The latter component is directly related with the IWC SC plan mentioned above.

Figure 3 shows a schematic representation of the components of Objective 2.

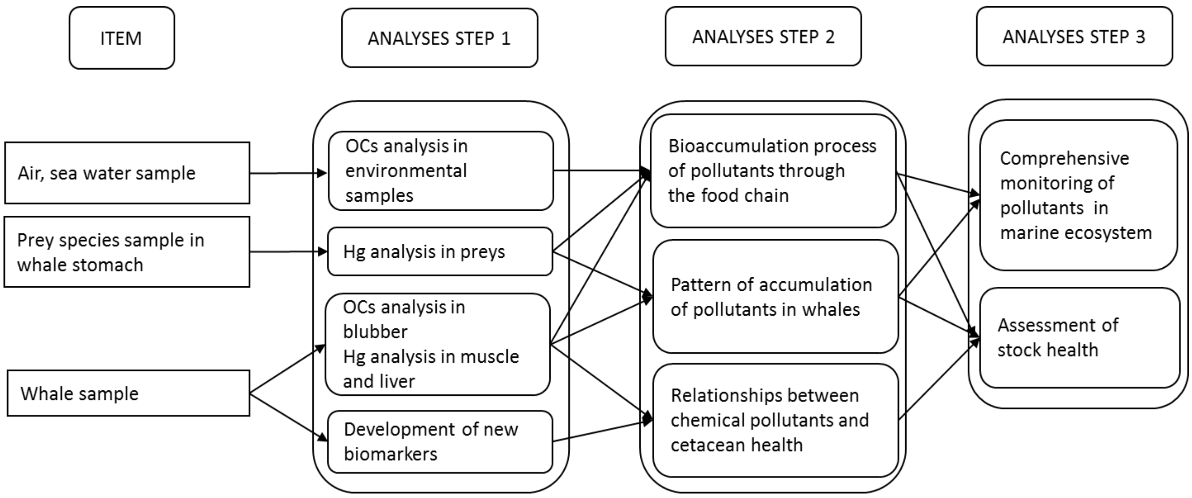

Figure 3. Schematic representation of the research components under Objective 2 of JARPNII.

The original research plan of JARPNII stated that 'a comprehensive monitoring and assessment of chemical pollutants' should be carried out and that the 'bioaccumulation process through the marine food chain' should be understood. Works on these objectives were carried out based on samples obtained in the first period of JARPNII, and results were presented to the 2009 JARPNII review workshop. Three main documents and two 'for information' papers related to objective 2 of JARPNII were presented to the 2009 JARPNII review workshop (IWC, 2010). The review workshop concluded that the results so far represented a valuable contribution to our knowledge in this area and acknowledged the considerable amount of work done, while some technical recommendations were offered to improve the work (IWC, 2010).

To facilitate a further review of JARPNII of the work done under objective 2, the following sub-objectives were identified for the different components of this objective.

<u>i) Pattern of accumulation of pollutants in cetaceans, ii) Bioaccumulation process of pollutants through the food chain.</u>

Hg, PCB and legacy pesticides such as DDTs, HCHs, HCB and CHLs are comparatively higher risk chemicals for cetaceans in marine environment. Therefore, these pollutants were monitored in large whales from the western North Pacific. The fate of the pollutants in the marine environment and differences of accumulation pattern of pollutants among species or stocks were examined using JARPN and JARPNII samples under the following research sub-objective:

Objective 2, Sub-objective 1:
To investigate pattern of accumulation of pollutants in cetaceans and their food items.

Relevant documents: SC/F16/JR30-34.

Persistent pollutants such as Hg and PCBs in cetaceans are affected by food chain length. These effects were examined by multi regression analyses with covariates such as observation in stomach content, age and nutritional index using with the JARPN and JARPNII samples under the following research sub-objective:

Objective 2, Sub-objective 2:
To investigate the bioaccumulation process of pollutants through the food chain.

Relevant documents: SC/F16/JR30-31.

iii) Relationship between chemical pollutants and cetacean health

On 11 March 2011, radio isotopes (RIs), such as I131, Cs134 and Cs137, were released to the marine environment from the Nuclear Power Plant in Fukushima following an earthquake and tsunami. This accident could represent a new health risk for cetaceans in surrounding waters. Consequently the RIs levels have been monitored in cetaceans from the western North Pacific since the 2011 JARPNII survey.

The accumulation features of total and methyl Hg and selenium in baleen and sperm whales from the western North Pacific were compared to examine sensitivity of mercury toxicity among whale species (SC/J09/JR24). Furthermore Niimi *et al*. (2005; 2007) reported the molecular characterization of various cytochrome P450 detoxification liver enzymes in minke whales, and how their mRNA expression levels relate to levels of contaminants in the liver. All these studies were reported to the 2009 JARPNII review workshop. The review workshop welcomed the results, whilst noting that these biomarkers were not necessarily indicative of health status, and it encourages the continuation of the study.

The following research sub-objective on whale health was identified:

Objective 2, Sub-objective 3:
To investigate the relationship between chemical pollutants and cetacean health.

Relevant documents: SC/F16/JR35-37.

Objective 3: Stock structure of large whales

Stock structure information is important for the development of RMP *ISTs* in the case of the common minke and Bryde’s whales, and for the in-depth assessments (IA) of other large whale species such as the sei, sperm and right whales. Figure 4 shows a schematic representation of the components of Objective 3. Several sub-objectives were identified for the different components of this objective.

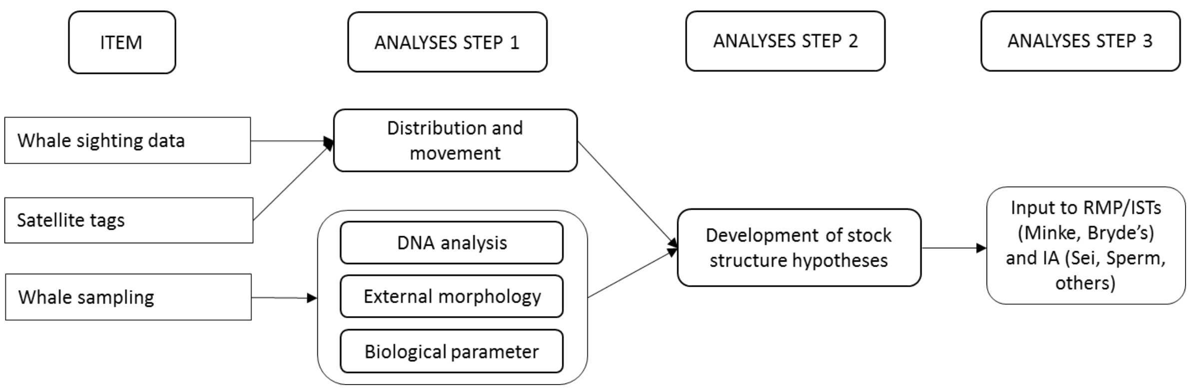

Figure 4. Schematic representation of research components under Objective 3 of JARPNII.

Common minke whale

The IWC SC completed the *Implementation Review* (*IR*) of the western North Pacific common minke whale at its 2012 and 2013 Annual meetings (IWC, 2013b; 2014). Most of the information on stock structure presented and discussed during the IR was based on data and information from JARPN and JARPNII.

A total of 22 sub-areas were set for the aim of the *IR* (Figure 5), and three stock structure hypotheses were used (Figure 6).

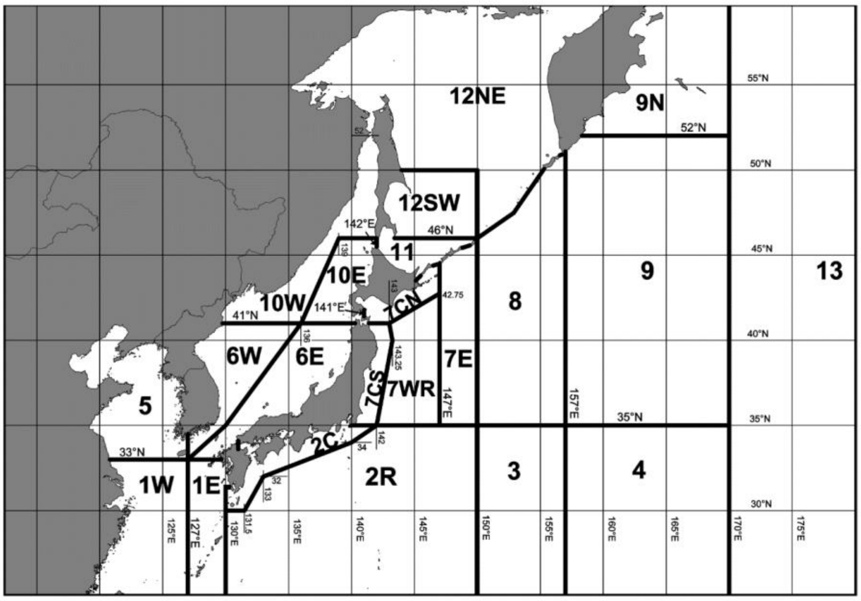

Figure 5. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific common minke whale (IWC, 2014 pp11).

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 (JE, JW, OE, OW and Y) involved in the different hypotheses (IWC, 2013b pp135). It should be noted that their evaluation was made based on the available genetic information only despite plenty of non-genetic information was available for the *IR*. The result of their evaluation is reproduced in Table 1.

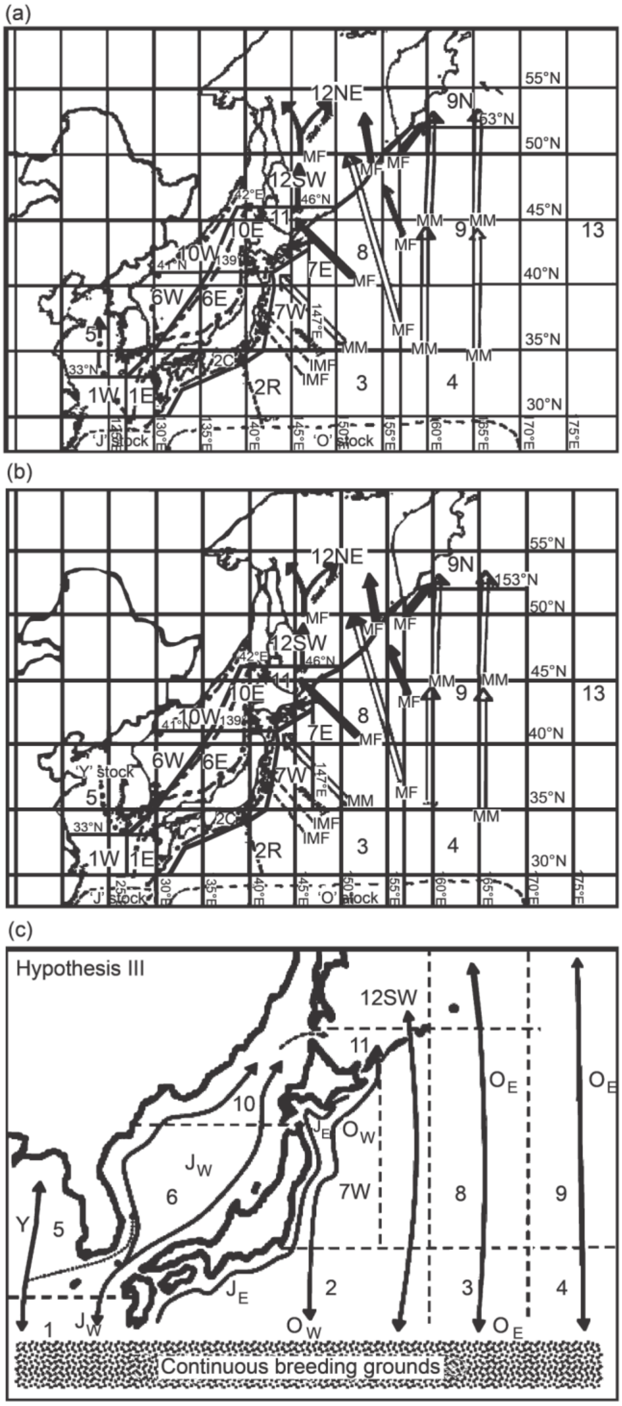

Figure 6. Representation of stock structure hypotheses I, II and III used during the *IR* of North Pacific common minke whale (IWC, 2013b pp103).

Table 1. Evaluation of the main components of stock structure hypotheses of common minke whale in the western North Pacific based on genetic data (IWC, 2013b pp135).

Stock	Evidence for:	Evidence against:
Y	**Moderate**: Significant microsatellite DNA F_{st} values between SA5 and Sea of Japan samples, and seasonal evidence for mixing based on HW deviation.	**Low**: No significant F_{st} based on mtDNA, but small sample sizes. Microsatellite DNA F_{st} values small.
JW (J)	**High**: Case for a core J stock is strong based on various data.	N/A
JE	**Low**: Significant mtDNA F_{st} comparing 6E and 2 based on non-purged dataset. Differential haplotype frequencies for two most common haplotypes. Weak suggestion of one or more additional stocks based on initial one and two locus Wahlund effects.	**Moderate or High**: F_{st} values were very small. Some mtDNA haplotype data suggest mixing between J and O (e.g. the number of haplotypes per individual is 0.19 in 2BC compared to 0.08 in 6BC and 0.10 in 8 and 9). Possible considerations of temporal aspects of comparisons (with bycatch not representing the same time period as the hunt). PCA found no evidence for differentiation between 2C and 6E. One and two locus Wahlund effect method requires further trials, as evidenced by preliminary simulation data presented in SC/64/NPM9. Fis results for SA2 indicate a mixture (not a new pure stock) and appear consistent with a mixture of just O and J.
OW	**Moderate**: PCA results using J-purged O stock sample provided support for an additional stock in OW compared to OE. Significant F_{st} differentiation comparing non-purged samples. Suggestion of one or more additional stocks based on initial one and two locus Wahlund effects. Haplogroup data suggests different frequencies in 7CN and 7CS regions compared to O-stock (8 and 9).	**Low or Moderate**: PCA work requires simulation analysis to evaluate effects of purging. PCA regression against length was not significant. Small but positive Fis considering all loci together suggests mixing in 7W-K and 7W-S regions. One and two locus Wahlund effect method requires further trials, as evidenced by preliminary simulation data presented in SC/64/NPM9. Haplogroup data (based on two SNPs) not clearly inconsistent with mixing.
OE (O)	**High**: Case for a core O stock is strong based on various data.	N/A

Despite this effort by geneticists, it was not possible for the IWC SC to agree on plausibility of the three stock structure hypothesis. As a consequence, all three main stock structure hypotheses were 'no agreement' and were therefore treated as if they had been assigned 'Medium' plausibility in the trials (IWC, 2013b pp126).

There are, however, some interesting points in the evaluation of different stocks by the five geneticists. From Table 1 it is clear that the plausibility of additional structure in the J stock is low, and consequently further analyses under the JARPNII were not focused to investigate subdivision within this stock. The J stock distributes mainly in the Sea of Japan but it mix with the O stock in the coast of northern Hokkaido and in the Pacific side of Japan. What it is important is the study of the dynamics of the J stock around the Japanese coast, and the interaction with the O stock, mainly in the Pacific side of Japan. This is the basis for the first sub-objective under Objective 3 of JARPN II:

Objective 3, Sub-objective 1:
Monitoring of the spatial and temporal distribution of J stock on both west and east coasts of Japan using genetics and non-genetics approaches, and all sources of samples available e.g. JARPN, JARPN II and by-catches.

Relevant documents: SC/F16/JR38, JR39.

With regard to the O stock, the genetic evidence summarized in Table 1 cannot discard definitively the possibility of additional structure within the O stock. Therefore the second sub-objective within Objective 1 is the following:

Objective 3, Sub-objective 2:
Using genetic and non-genetic data from JARPN and JARPNII, investigate whether or not the sub-division of the O stock into Ow and Oe is plausible. The genetic analysis should include those approaches mentioned in Table 1 as providing support for the existence of the Ow (e.g. PCA analyses).

Relevant documents: SC/F16/JR40-43.

<u>Bryde's whale</u>
The RMP *Implementation* for western North Pacific Bryde's whale was completed by the IWC SC in 2007 (IWC, 2008b pp 9). During the *Implementation* two sub-areas (Figure 7) (IWC, 2009b pp7), and four stock structure hypotheses (Figure 8) (IWC, 2007 pp8), were considered.

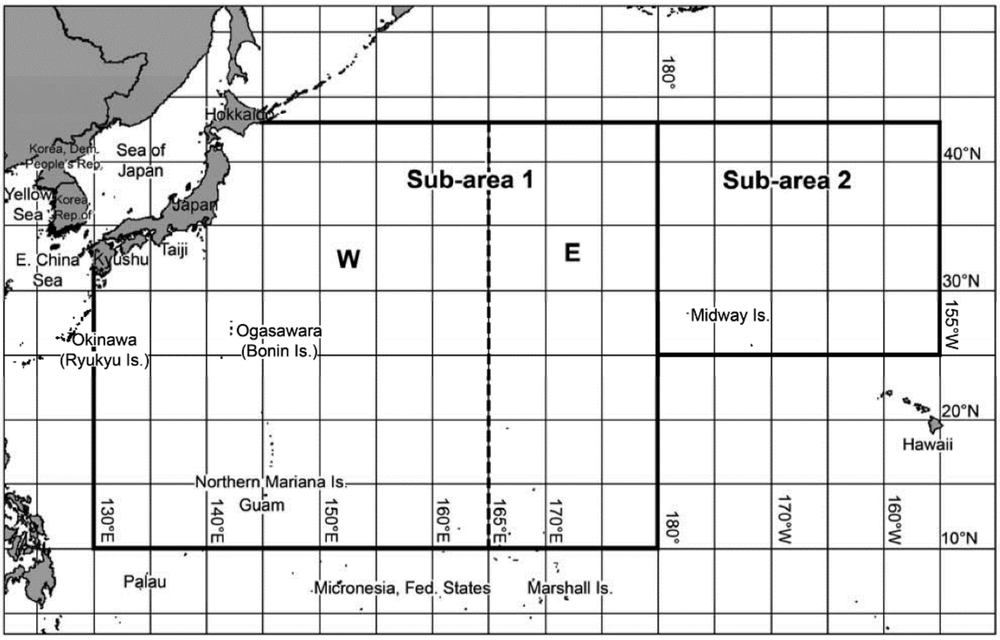

Figure 7. Sub-areas used for the RMP *Implementation* of western North Pacific Bryde's whale (IWC, 2009b pp7).

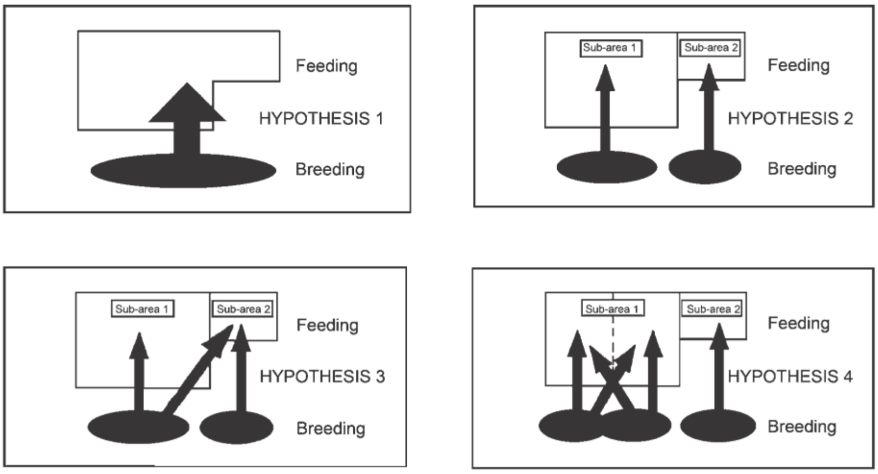

Figure 8. Stock structure hypotheses selected for the RMP *Implementation* of western North Pacific Bryde's whale (IWC 2007 pp8).

The IWC SC examined the plausibility of the four hypotheses based on the genetics and non-genetics information available in 2006. That information is summarized in Table 2 (IWC, 2007 pp95). Based on the information in Table 2, the IWC SC assigned the following plausibility to the four hypotheses: Hypothesis 1= High; Hypothesis 2= High; Hypothesis 3= High; Hypothesis 4= Medium.

Table 2. (From IWC, 2007 pp95)

General summary of the information useful to assess plausibility of alternative stock-structure hypotheses. A '+' indicates evidence in favour of a hypothesis, '-' indicates evidence against a hypothesis, '(+)' indicates weak evidence in favour of a hypothesis, '(-)' indicate weak evidence against a hypothesis, a (()) indicates very weak evidence, and 'NIW' indicates that the evidence is not inconsistent with the hypothesis. Note that the designation NIW often reflects the asymmetrical nature of information on stock structure (i.e., existence of differences can be viewed as positive evidence for multiple stocks, but absence of differences provides no information, and cannot be viewed as positive evidence for a single stock). Notations at the bottom of this table were extracted in part from the report of the 'First Intersessional Workshop' (SC/58/Rep1 published in this volume).

Evidence	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4
Allozymes	(+) [a]	(-)[a]	(-)[a]	(-)[a]
mtDNA	((+))[b]	NIW[c]	NIW[c]	-[d]
Microsatellites	NIW[b]	NIW[c]	NIW[c]	-[d]
Sighting distribution	NIW[e]	NIW[e]	NIW[e]	NIW[e]
Catch distribution	NIW[e]	NIW[e]	NIW[e]	NIW[e]
External body proportion	NIW[f]	NIW[f]	NIW[f]	NIW[f]
Biological parameters	NIW[f]	NIW[f]	NIW[f]	NIW[f]
Mark-recapture	NIW[g]	NIW[h]	NIW[h]	NIW[g]
Age distribution	NIW[i]	NIW[i]	NIW[i]	(+)/NIW[i,j]

[a]The sub-committee agreed that while the power to detect genetic structure might be considered to be low as only a single locus was analysed, the fact that this had been sufficient to detect structure in the Pacific Ocean suggest that if there are multiple stocks differentiated at a level similar to that between the western North stock and other stocks, examination of this single locus should be sufficient to detect this.

[b, c]Clustering and hypothesis testing analyses of mtDNA and microsatellites were conducted, and as noted by the sub-committee, none of these analyses revealed any significant heterogeneity within sub-area 1. Only 6 mtDNA samples are available from sub-area 2 – these provide very real evidence for hypothesis 1, but this is not sufficiently strong to be considered inconsistent with hypotheses 2 and 3.

[d]*Mixing of two sub-stocks*: There are no genetic data for the breeding grounds so the possibility of multiple sub-stocks cannot be excluded. Furthermore if two breeding stocks mix almost completely, it will be difficult to detect differences using, for example, genetics tests based on comparisons between data for the west and east of sub-area 1. However while complete mixing may lead to all methods of detecting stock structure having low power, the plausibility of this was considered fairly low given the behaviour of most large whales. Hypothesis tests based on comparisons for approximately the same area in sub-area 1 found no significant differences among years which suggest that if two sub-stocks mix in sub-area 1, there is little difference in the distribution proportion among years. Although the data set encompasses only four years, such a lack of variation in distribution proportions among years seems unlikely given the known behaviour of whales. In principle evidence for hypotheses 4 could be obtained by testing for deviation from Hardy-Weinberg equilibrium within sub-areas 1W and 1E because such deviations provide evidence of non-random mating as well as selection or migration, i.e. when genetically two different populations are being sampled. Analyses of nuclear markers for Bryde's whales in sub-area 1 have been conducted and these analyses provide no evidence for the significant deviations in Hardy-Weinberg equilibrium within sub-areas 1W and 1E which would provide support for multiple sub-stocks.

Statistical power: The Workshop received a paper, which evaluated the power to detect population structure using the chi-square test and Fisher Exact test under an island model in which population differentiation is controlled using a single parameter, F_{st}. Statistical power of the genetic analysis in sub-area 1 was found to be high for moderate sample sizes and quite small values for Fst, while it was higher for microsatellite data than for mtDNA.

[e]The sub-committee examined the sightings data and agreed that it revealed no evidence of a discontinuity in distribution within sub-areas 1 and 2. A similar conclusion was reached with respect to catch distribution. Discontinuity in the commercial catches identified in earlier meetings merely reflected operational constraints. Evidence of spatial discontinuity would be viewed as positive evidence for multiple stocks, but absence of discontinuity is viewed as neutral information, as there is no expectation that their prey would have a discontinuous distribution. Therefore, multiple stocks could exist without spatial discontinuity.

[f]External body proportion data (three features) and several biological parameters (body length, pregnancy rate, length at sexual maturity, seasonality in breeding) had been examined using data from past commercial whaling. Although operational differences (e.g. different minimum length limits for coastal and pelagic whaling) meant that some comparisons could not be made, the authors of these analyses concluded that there were no differences that could not be attributed to operational factors. Evidence of differences in biological parameters would be viewed as positive evidence for multiple stocks, but absence of differences does not provide positive evidence for a single stock, because it is not necessary for separate populations to diverge in their biological parameters, as these are often constrained by their ecology.

[g]Mark-recapture analysis revealed movement of animals within sub-area 1. A very limited number of marks were placed in sub-area 2 and while none has been recovered in sub-area 1, the sample sizes for this sub-area are sufficiently small that even if there is mixing between sub-areas 1 and 2, zero recaptures would not be highly unlikely.

[h]Mark-recapture data are available mainly for sub-area 1.

[i]One of the possible explanation for the differences observed in age distribution between sub-area 1W and 1E+2 is that these differences are real. Other possible explanations were geographical segregation by age or non-representativeness of the samples, perhaps as the result of unreadability of certain earplugs, inaccuracy in length determination, or inter-reader differences in ageing.

[j]There was no consensus on this verdict. The different views hinged on different interpretations on an appropriate entry given that there were alternative explanations for the observation in question.

It should be noted that a substantial number of genetic samples have been accumulated since the *Implementation* of Bryde's whale in 2007. For example larger sample sizes are now available for Sub-areas 1W and 1E, from JARPNII, dedicated sighting and IWC POWER surveys. This allows new analyses to be conducted to evaluate the plausibility of Hypothesis 4, which propose two stocks within sub-area 1. In addition, genetic samples are now available for Sub-area 2 from the IWC POWER surveys. Genetic analyses of such samples would allow the evaluation of plausibility of Hypotheses 2 and 3, which propose two stocks in those sub-areas.

Therefore the following sub-objective related to Bryde's whale, which is relevant in the context of the RMP *Implementation*, was defined.

Objective 3, Sub-objective 3:
To investigate the plausibility of i) stock sub-division within Sub-area 1 as proposed under Hypothesis 4, and ii) sub-division between Sub-areas 1 and 2 as proposed under Hypotheses 2 and 3, using all genetic samples available from different source till 2014, and different genetic markers included satellite tracking.

Relevant documents: SC/F16/JR44, JR45.

<u>Sei whale</u>
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*. (SC/F16/JR47-48), 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, 2015b). 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, 2015b).

The sub-objective related to sei whale is the following:

Objective 3, Sub-objective 4:
To investigate the plausibility of a single stock of sei whale in the pelagic regions of the North Pacific ('North Pacific pelagic'), using all genetic samples available from different sources till 2014, and different genetic markers.

Relevant documents: SC/F16/JR46-48.

Other species
There are a number of genetic samples collected under JARPNII from sperm whale and North Pacific right whales. The number of samples is small and then, detailed analyses on stock structure were not possible. However, genetic studies based on microsatellite and mtDNA were conducted on these two species to investigate levels of genetic diversity and the utility of such genetic markers for future studies on stock structure (see Documents SC/F16/JR49-51).

2.4 Brief outline of the research area and analytical methodology
Research area
The research area is on the Pacific side of Japan and covers the IWC SC management sub-areas 7, 8 and 9 (Figure 1). The research area on the Pacific side of Japan (*e.g*. coast of Tohoku and southern Hokkaido) can be considered as Japan's richest fishing grounds and provided an ideal area to study the interaction between cetaceans and fisheries, and can be considered as a 'hot-spot' area for cetacean/fisheries interaction (see Annex 2 for more details of the research area).

For the main objective of JARPNII (feeding ecology and ecosystem studies), two components are considered: coastal and offshore. The coastal component involves two localities: the coast of Tohoku (off Sanriku) covered in spring and the coast of southern Hokkaido (off Kushiro) covered in fall (see SC/F16/JR3). This corresponds to a part of sub-area 7 (Figure 1). The offshore component is covered in spring-summer.

As mentioned above, the coastal waters off northern Japan can be considered as Japan's richest fishing grounds and provide an ideal area to study the interaction between cetaceans and fisheries. The offshore component involves sub-areas 7 (offshore), 8 and 9 (see SC/F16/JR4) (Figure 1). Although the interaction between fisheries and cetacean is less marked in offshore waters, an important amount of information for modeling purposes can be obtained from those waters, especially from large whales that feed on prey species widely distributed in both coastal and offshore waters.

Analytical methodology
Objective 1. Feeding ecology and ecosystem studies
This is the main objective of the JARPN II. Several kinds of input data for the ecosystem modeling exercise have been obtained through JARPNII research *e.g.* abundance and distribution of large whales, prey composition and consumption of common minke, Bryde's, sei and sperm whales, prey habitat (Japanese anchovy, Pacific saury, copepod and krill) and prey preference of whales. In addition, other data for input to such models related to other predator and prey species were obtained from the literature.

Oceanography
Study of changes in oceanographic conditions in the period of JARPN II (2000-2013) is underway using outputs from ocean models such as the Fisheries Research Agency-Regional Ocean Modeling System (FRA-ROMS). In addition, oceanographic data obtained from artificial satellites such as sea surface temperature (SST), sea surface height (SSH) and chlorophyll-a concentrations are being used as input parameters of species distribution models (SDMs) and ecosystem models.

Whale's distribution

Sighting and effort data obtained through systematic surveys in sub-areas 7, 8 and 9, north of 35ºN in spring-summer have been examined to study the distribution pattern of large whales. The spatial and temporal pattern of distribution of large whales such as blue, fin, humpback and North Pacific right whales in the JARPN II research area is being studied by investigating the monthly changes in density index (number of whale sighted by 100 nm) by one degree square in each sub-area.

Spatial distribution of common minke, sei and Bryde's whales in the period of JARPNII (2002-2013) is being studied using sighting data and environmental data (*e.g.* sea surface temperature, SST). A generalized additive model (GAM) is being used as a SDM.

Whale abundance

This is being studied using sighting data collected by dedicated sighting surveys in each research sub-area and application of the Line Transect Method, in a manner similar to the IWC POWER surveys. It should be understood that abundance estimation was conducted with the aims of prey consumption estimation and of ecosystem modeling, and refers to the number of whales present in a particular area and at a particular season.

Prey consumption by whales

Estimates of prey consumption of whales are being made using a methodology similar to that used in Norwegian surveys (Haug *et al*., 1995a, b) through estimation of daily consumption from the standard metabolic rate (SMR). To account for the uncertainty in the estimates, a Monte Carlo simulation approach is used. Uncertainties in whale abundance estimates, body weight of whales, daily prey consumption, energetic content of prey species, assimilation efficiency and the ratio of low/high feeding intake of whales are taken into account.

Nutritional condition of whales

This is being studied by the measurements of blubber thickness, girth and fat weight. A regression model with some covariates will be used for analyses. Nutritional condition as feeding success, prey species from stomach contents and oceanographic conditions are being considered in a monitoring program involving decadal time series.

Prey preferences of cetaceans

Prey preference of whales in small-scale areas was reported previously by Murase *et al.* (SC/F16/JR21) and Watanabe *et al.* (SC/F16/JR20). The concurrent prey species survey was designed mainly with common minke, sei and Bryde's whales in mind as predators, and prey species including Japanese anchovy, Pacific saury, copepod and Euphausiid.

Ecosystem Modeling

In developing the modeling work, information and suggestions from FAO workshops on modeling (FAO, 2008; Plaganyi, 2007), as well the application of models to specific cases, *e.g*. to evaluate the interactions between common minke whale and important fish resources in the eastern North Atlantic (Schweder *et al*., 2000), have been taken into account.

In line with the conclusion from FAO (2008) and IWC (2008) that there is no one single correct model, and that the greatest benefits are to be obtained by considering a number of models that may be of quite different forms, JARPN II is developing different kinds of models:

Ecopath (a static, mass-balanced snapshot of the system) with Ecosim (a time dynamic simulation module for policy exploration) (Christensen *et al*., 2005) represents a large range of species and interactions and addresses broad-scale questions related to the structure of the ecosystem. EwE is a software composed of two main components namely Ecopath and Ecosim. Ecopath is for trophic mass balance (biomass and flow) modeling while Ecosim is for dynamic modeling based on Ecopath. Ecopath in the western North Pacific in the early 1980's is being constructed. The constructed Ecopath in the early 1980's is then being fitted to available time series data (*e.g.* catch history of small pelagic fish) to see whether a credible fit will be able to be obtained. Ecopath in 2010's is also being constructed and it will be compared with the Ecosim results in 2010's.

For the coastal component of JARPN II (Sanriku), a Bayesian delay-difference model will be employed to investigate the effect of consumption by the common minke whales on the population of sandlance. Development of a Minimum Realistic Model (MRM)-type model will be attempted for the offshore component of JARPNII to see if the main prey species of large whales of our interests change according to their prey availabilities and to incorporate the information of energy takes into the population dynamic models.

Objective 2. Monitoring environmental pollutants in cetaceans and the marine ecosystem (pattern of accumulation of pollutants in cetaceans, bioaccumulation process of pollutants through the food chain and relationships between chemical pollutants and cetacean health).

Studies related to this objective have been conducted to understand the biogeochemical cycle of pollutants. Analysis of Hg in biological tissues of predators and prey species is being conducted using the CV-AAS (Cold Vapor Atomic Absorption Spectrophotometry) method. Analyses of PCB in biological tissues and atmospheric samples were made using the GC-MS (Gas Chromatography – Mass Spectrometry) method.

In order to understand the biogeochemical cycle of pollutants, the bioaccumulation factors (increase in concentration of a pollutant from one link in a food chain to another) is being calculated (see Kelly *et al*., 2008 as an example of this kind of analysis).

Objective 3. Stock structure of large whales-common minke whale

Occurrence of J stock like animals in sub-area 7
Analysis of genetic variation at 16 microsatellite loci coupled with a Bayesian method implemented in the computer program STRUCTURE has allowed the separation of samples of minke whales obtained through JARPN and JARPN II in sub-area 7 into two genetically distinct stocks, i.e. the J stock and O stock. Spatial and temporal distribution of J stock animals is being investigated. For comparative purposes, this analysis is being conducted for minke whales sampled in sub-areas 8 and 9 as well. Occurrence of the J stock animals in sub-area 7 is being also investigated based on flipper color pattern and morphometrics.

Stock identity of 'O' stock common minke whales in sub-areas 7, 8 and 9
In the case of genetic techniques, the extent of genetic differentiation of minke whales in those sub-areas is being examined by standard hypothesis testing, phylogenetic, and Discriminant Analysis of Principal Component (DAPC). Both bi-parental (16 microsatellite loci) as well maternal (mtDNA control region sequences) genetic markers are being used. In the case of non-genetic techniques, morphometric differentiation of O stock animal minke whales in sub-areas 7, 8 and 9 is being investigated by Analysis of Covariance (ANCOVA) of ten external measurements.

Stock identity in Bryde's and sei whales is being studied using genetic methods similar to those used in the case of the common minke whale.

Others
Basic information from earplugs on the age characteristics of common minke whales in the western North Pacific is investigated. Some biological parameters such as the natural mortality rate and growth curve are estimated by using the age data.

3. DATA OBTAINED BY JARPNII AND DATA AVAILABILITY

Data obtained in JARPNII (Annex 3) have been available to the international scientific community under established data access protocols. Annex 4 shows the data access protocol of the Institute of Cetacean Research (ICR).

The data is available for research collaboration with ICR under data access protocols of ICR (http://www.icrwhale.org/pdf/appendix2.pdf) and IWC (Procedure B), outside the context of the IWC SC review Workshop. Data are commonly stored in Excel files.

4. RESULTS OF THE RESEARCH UNDER JARPNII AND FUTURE CONSIDERATIONS

4.1 Executive summary

General

- JARPNII was conducted in the western North Pacific between 2000 and 2014. It followed the previous JARPN (1994-1999). The JARPNII had three main objectives (Feeding ecology and ecosystem studies, monitoring environmental pollutants in cetaceans and the marine ecosystem, and stock structure of large whales) and several sub-objectives under each main objective.

- The JARPN and JARPNII collected, in a systematic manner, data and samples from whales, whale's prey species and the environment during a period of 20 years.

- A combination of lethal (biological data from sampled common minke, Bryde's, sei and sperm whales) and non-lethal (sighting, oceanographic, preys, biopsy, satellite tags) in the comprehensive large-scale program, allowed the acquisition of an unbiased, widely collected, large data base from all parts of the ecosystem that was not available from previous commercial catches. This is one of the most comprehensive data set on whales and its environment in the world.

- The long-term program provided a great opportunity to systematically monitor long-term natural variability of biotic and abiotic factors in the marine ecosystem of the western North Pacific.

- The program provided results useful for conservation and management of whales and the ecosystem as well as other results not directly related to conservation and management.

Feeding ecology and ecosystem studies

- Feeding ecology and ecosystem studies under JARPNII were based on a large and comprehensive data/sample set, and it provided both qualitative and quantitative information of feeding ecology that will allow the application of ecosystem-based, multi-species approaches for management of fisheries resources in the western North Pacific.

Oceanography

- Oceanographic conditions in the JARPNII research area were examined using FRA-ROMS data. This is an ocean forecast system developed by Fisheries Research Agency (FRA) based on Regional Ocean Modeling System (ROMS). The results indicated that overall oceanographic conditions were relatively stable during the JARPNII period, although year to year variation and spatial heterogeneity of distribution of water types were observed.

Whale distribution and abundance

- 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 all species shifted their distribution toward the north as season progress (from spring to summer), but the extent of the shift was different among whale species. 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 number of whales distributed in the research area was estimated using the Line Transect method and IWC SC standard methodology. This was done for common minke, Bryde's, sei, blue, fin, humpback, North Pacific right and sperm whales. Numbers obtained are not representative of the abundance of each stock but they represent the number of animals distributed in the research area at specific research periods. The numbers obtained were used for the estimation of prey consumption in common minke, Bryde's and sei whales, and as input for the ecosystem modelling (all species).

Prey consumption by whales and biomass estimation of 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. These estimates on prey consumption are useful as input data in ecosystem models.

- The total seasonal prey consumptions during May-September in two periods (2000-2007 and 2008-2013) by common minke, Bryde's and sei whales in offshore waters were 1.1 and 1.2 million tons, respectively. Consumption of Japanese anchovy, mackerels and Pacific saury by the three whale species was 674-724 thousand tons, 43-70 thousand tons and 48-56 thousand tons, respectively.

- The consumption of Japanese anchovy, mackerels and Pacific saury by these three whale species in offshore waters in the two periods was equivalent to 22-48%, 5-66%, and 2-7% of the biomass of these fish resources.

- Spatial estimation of prey consumption by sei whales in the JARPNII survey area was estimated. The results indicated that spatial distribution of sei whales at meso scale were largely determined by oceanographic conditions such as SST.

- In Sanriku waters, the consumption of sandlance by common minke whale in two years before the tsunami corresponded to 30-40% of the fisheries catch on this fish resource. Consumption of fish resources by common minke whale in Kushiro waters corresponded to approximately 2-3% of the fisheries catch on these resources.

- In offshore waters, basin-scale distribution pattern and biomass estimation of Japanese anchovy were examined using a quantitative echo sounder. To take account of the spatial coverage of the survey each year, the most reliable biomass estimate of Japanese anchovy for this region was 3.4 million tons.

- In coastal waters off Sanriku, the biomass of sand lance based on echo sounder surveys in four years ranged from 2,827 and 28,340 tons. This result suggested that movement of common minke whales into Sendai Bay could be related to availability of sand lance during spring season.

<u>Prey preference including feeding habit</u>

- In offshore waters, the prey preferences of baleen whales was 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 preys 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 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 the local environments.

- The results of diving behavior of sei whales by acoustic devices indicated that sei whales did not feed on prey in deep scattering layers at night. It revealed that sei whales changed their diving behavior in response to availability of their prey in daytime. This information is useful to address some uncertainties in the estimation of prey consumption of sei whales.

- A small but widely distributed sample of sperm whales was examined for stomach contents. A total of 28 species of cephalopods and six species of fish were found in the stomach contents. The results suggested that sperm whale likely to move along different oceanographic waters, feeding on variety of prey species. The commercially important Neon flying squid *O. bartrami* was not important prey of sperm whales in spring and summer.

Body condition of whales

- The annual trend in energy storage in sei, Bryde's and common minke whales during the JARPNII period were examined statistically considering several explanatory variables. These were oceanography data, sampling location, biological parameter, stock identification and body condition indicators. Body condition of sei whales increased while that of common minke whales decreased in the research period. No temporal trend was observed in the body condition of Bryde's whales. This information can be used as a 'reality check' of the stock trend outputs from ecosystem models.

Ecosystem modeling

- Marine ecosystem of the western North Pacific from 1994 to 2013 (20 years) was modelled using a whole ecosystem model, Ecopath with Ecosim (EwE). The model presented to the previous review meeting was improved based on the recommendations and suggestions by the Panel. 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 proportion is sensitive to the model assumption.

- Based on JARPNII results, future study on feeding ecology of baleen whales and ecosystem modelling should pursuit such an integrated approach among oceanography, whale and prey species abundance and distribution, and feeding habit of whales (see Section 4.3).

Monitoring environmental pollutants in cetaceans and the marine ecosystem

- Studies on pollutants of large whales under JARPNII were based on a comprehensive data/sample set, and involved the analysis of different pollutants (Hg, PCB and pesticides) on different components of the ecosystem (whales, whale's prey species and air/water). In the case of whales several ancillary biological data were available (biological parameter, age, sex, sexual maturity, stock).

Pattern of accumulation of pollutants in cetaceans

- To investigate pattern of accumulation of pollutants in the food web, whales are suited as biological indicators of environmental conditions because they are long-lived animals with ability of long-distance migration.

- 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 stabilized 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.

Bioaccumulation process of pollutants through the food chain

- To investigate the bioaccumulation process of pollutants through the food chain, the relationship between PCB and Hg levels in baleen whales and their main prey species were examined.

- The analysis of the relationship between total Hg levels in whale tissue and main prey species in whale's stomach 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.

Relationships between chemical pollutants and cetacean health

- JARPNII conducted toxicological studies to assess the effects of pollutant levels on cetaceans' health.

- 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

- Studies on stock structure of large whales under JARPNII were based on a large and comprehensive data/sample set, and involved the use of both genetics (mtDNA control region sequences and microsatellite DNA) and non-genetic (morphometric, satellite tracking).

- Regarding to genetics, the combination of large sample sizes and powerful genetic markers was an appropriate tool to examine stock structure in weakly differentiated populations.

Common minke whale

- The program was able to monitor the O and J stock common minke whales around Japanese waters. 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 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 sub-structuring into OW and OE. Based on these results, the plausibility of stock structure hypotheses used in the RMP *ISTs* should be re-evaluated.

- 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.

Bryde's whale

- Results of genetic analyses showed no significant heterogeneity between whales in sub-areas 1W and 1E. Results suggested genetic differentiation between whales in sub-area 1 and sub-area 2. This information is useful for the IWC SC RMP *ISTs* of Bryde's whales in the western North Pacific. Based on these results, the plausibility of stock structure hypotheses used in the RMP *ISTs* should be re-evaluated.

Sei whale

- Results of the genetic analysis confirmed the view of a single stock of sei whale in pelagic regions of the North Pacific. This information is useful for the IWC SC's in depth assessment of this species in the North Pacific.

Others

- Information on the genetic diversity and utility of genetic markers for future studies on stock structure in the sperm whale, was obtained.

- Information on genetic diversity in the endangered North Pacific right whales, as well the genetic relationship between North Pacific and southern (Antarctic Area IV) right whales, was obtained.

Others

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

- Advance in ageing of western North Pacific sei whales based on earplugs, were made. Readability of all samples was 63%. Different studies based on age data are being planned.

- JARPN/JARPNII genetic samples were used in several published genetic studies to investigate phylogenetic relationship among large whales using different genetic markers.

- JARPN/JARPNII biological samples were used in several published studies on physiology and reproductive biology of common minke, Bryde's and sei whales.

4.2 Detailed results

Objective 1: Feeding ecology and Ecosystem studies

Oceanographic conditions

Objective 1, Sub-objective 1:
Investigate the oceanographic conditions that are relevant for the understanding of prey species's distribution and abundance in the research area.

SC/F16/JR5 examined oceanographic conditions in the offshore component of JARPNII survey area using FRA-ROMs data. FRA-ROMS is an ocean forecast system developed by Fisheries Research Agency (FRA) based on Regional Ocean Modeling System (ROMS). Changes in area (km^2) of four water types (Oyashio, cold, warm and Kuroshio) by each month (April-September) in JARPNII survey area from 2000 to 2013 was investigated. There was no statistical significant trend for the area except the cold water in September. Negative values of annual mean the Pacific Decadal Oscillation (PDO) index were dominant in the period from 2000 to 2013. Generally, sea surface temperature in the western North Pacific is high in the negative phase of the PDO. The results of this study indicated that overall oceanographic conditions in the JARPNII survey area from 2000 to 2013 were relatively stable although year to year variations and spatial heterogeneity of distribution of water types were observed.

SC/F16/JR6 examined oceanographic conditions in the survey area of JARPNII coastal component off Kushiro were study by using FRA-ROMs data. FRA-ROMs is an ocean forecast system developed by Fisheries Research Agency (FRA) based on Regional Ocean Modeling System (ROMS). Spatial distributions of four water types (Oyashio, cold, warm and Kuroshio) around Kushiro in September from 2000 to 2013 was qualitatively investigated using the data. Oyashio was dominant water type in subsurface in the survey area. Mean water temperate at 10 water depth in the survey in September was generally decreased from 2000 to 2004 then increased to 2006. It decreased again to 2009. It was relatively stable from 2009 to 2013. Spatial distribution of water temperate at 10 m depth was highly variable form year to year.

Distribution and abundance of whales

Objective 1, Sub-objective 2:
To investigate the distribution pattern of baleen whales in the research area and the possible factors affecting such pattern.

SC/F16/JR7 examined seasonal spatial distributions of common minke, sei and Bryde's whales in the JARPNII survey area from 2002 to 2013 by using generalized additive models (GAM). All species shifted their distribution area toward the north of the survey area as season progress but the extents were different among species. Relative abundance of common minke whales was high in coastal area of Japan. Relative abundance of sei whales was high in the offshore area of the survey area where SST was moderate within the area. Relative abundance of Bryde's whales was high in the southern part of the survey area where SST was high. The results suggested that spatial distributions of three baleen whale species were segregated in the JARPNII survey area although some overlaps were occurred. Extent of direct competition (*e.g.* competitive exclusion of feeding area) could be minimal among the species but indirect competition for prey might be occurs as they share same prey species.

SC/F16/JR8 examined the distribution of sei whales in the subarctic-subtropical transition area of the western North Pacific is important summer feeding grounds of sei whales. The oceanographic structure and circulation of this area are largely determined by strong oceanic fronts and associated geostrophic currents, namely the Polar Front (PF), Subarctic Front (SAF) and Kuroshio Extension Front (KEF). The relationship between the distribution of sei whales and oceanographic fronts was investigated using a generalized additive model (GAM), and the cetacean sighting survey data and oceanographic observations in July from 2000 to 2007 were used in the analysis. The number of individual sei whales was used as the response variable while the distances from the PF, SAF, and KEF to the whales were used as explanatory variables along with the longitude values. Sei whales were concentrated north and south of the SAF and the areas from 250 to 300 km north and from 100 to 200 km south of the SAF were estimated as high-density areas of sei whales. The entire inter-frontal zone between the PF and SAF featured ane levated concentration of sei whales, and the area south of the PF and along the SAF was identified as an important feeding ground of sei whales in July from 2000 to 2007.

SC/F16/JR9 examined the monthly distribution pattern of blue, fin, humpback and North Pacific right whales from May to September in the western North Pacific based on JARPN and JARPN II (1994-2014) sighting data. A total of 269,728.1 n.miles were surveyed. Among four species, fin whales were most frequently sighted, and next were blue, humpback and right whales in order. Northward migration pattern of whales were observed for these species. Blue whales were mainly distributed north of 35 ^{O}N and east of 157 ^{O}E (374 schools and 508 individuals; Mean schools size (Mss) was 1.36 individuals including 23 mother and calf pairs). The DI of this species was 0.19. A high density area was observed north of 45 ^{O}N between 157 ^{O}E-170 ^{O}E. Surface temperature (ST) ranged from 3.0 to 25.8 ^{O}C. Fin whales were mainly sighted between 150E and 170E (799 schools and 1,125 individuals; Mss: 1.41, including 37 mother and calf pairs). Distribution patterns were similar to blue whales. DI of this species was 0.42. A high density area was observed north of 45 ^{O}N. The ST ranged from 2.9 to 26.9 ^{O}C. Humpback whales were mainly distributed north of 37 ^{O}N (492 schools and 685 individuals; Mss: 1.39, including 42 mother and calf pairs). DI was 0.25. The ST ranged from 2.8 to 24.1 ^{O}C. Right whale was the rarest baleen whale species sighted in the research area. They were mainly distributed north of 40 ^{O}N (48 sch. and 68 ind.; Mss: 1.42, including 9 mother and calf pairs. The DI was 0.03. Surface temperature ranged from 2.7 to 17.0 ^{O}C. Based on the additional data during 2008 to 2014, distribution pattern of these species during May to August are more obvious and these new information will contribute to marine ecosystem studies in the western North Pacific where information has been lacking since the cessation of commercial whaling. Further continuation of the systematic sighting surveys including in foreign EEZ areas are required to improve information on seasonal distribution of baleen whales.

SC/F16/JR10 examined the habitat differentiation between sei and Bryde's whales in the western North Pacific. Data were obtained from May to August 2004 and 2005. This study examined the relationship between oceanographic features derived from satellite data and the distribution of sei and Bryde's whales using basic statistics. We investigated oceanographic features including sea surface temperature (SST), sea surface chlorophyll a (Chl-*a*), sea surface height anomalies (SSHAs), and depth of the habitat. These two whale species used habitats with different SST, Chl-*a*, and SSHA ranges. The 0.25 mg m^{-3} Chl-*a* contour (similar to the definition of the Transition Zone Chlorophyll Front) was a good indicator that separated the habitats of sei and Bryde's whales. Then generalized linear models were used to model the probabilities that the whale species would be present in a habitat and to estimate their habitat distribution throughout the study area as a function of environmental variables. The potential habitats of the two species were clearly divided, and the boundary moved north with seasonal progression.

Objective 1, Sub-objective 3:
To estimate abundance of baleen and sperm whales using JARPNII sighting data and standard IWC SC methodology.

SC/F16/JR11 examined the number of western North Pacific common minke whales distributed in JARPN II coastal survey areas. In order to examine an impact of common minke whales on Japanese fisheries in Kushiro and Sanriku regions through estimating the amount of prey consumed by minke whales or using an ecosystem model, it was required to estimate the number of the common minke whales distributed in each of the survey areas during the JARPN II survey periods. Because it was considered that the impact of the minke was important in the operation area of the coastal fishery, the number of the common minke was estimated .The estimated number off Kushiro were 461 and 433 in early (May-June) and late season (July-September) in 2012, respectively. The estimated number off Sanriku in the early season was 124 in 2012. Note that these numbers are not abundance estimates of the minke whale stock in the areas because the sighting data we used for the estimation covered only a part of the stock distribution.

SC/F16/JR12 examined the number of western North Pacific common minke, Bryde's and sei whales in the JARPN II offshore survey area. In order to examine an impact of large whales, such as common minke, Bryde's and sei whales on Japanese fisheries through estimating the amount of prey consumed by these whales or using ecosystem models, it was required to estimate the number of these whales in the JARPN II survey area (sub-areas 7, 8 and 9 excluding foreign EEZ). Considering the migration pattern of these whales in the area suggested by previous analysis, the number of the whales needed to be estimated separately for the early and late seasons for each of the whale species. The estimates were 3,629 (in 2009) and 2,122 (in 2011 and 2012) in the early and 3,080 (in 2008) in the late season for the common minke assuming g(0) = 0.789, 2,957 (in 2009) and 1,857 (in 2011 and 2012) in the early and 13,306 (in 2008) in the late season for the Bryde's whales, 4,734 (in 2009) and 2,988 (in 2011 and 2012) in the early and 5,086 (in 2008) in the late season for the sei whales, assuming g(0)=1. It is important to note that these estimates should not be used for assessment because the estimated figures represent only a part of the population considered.

SC/F16/JR13 examined the number of blue, fin, humpback and North Pacific right whales in the JARPN II offshore survey area based on 2008-2014 JARPNII surveys. The numbers are to be used for prey consumption estimation and ecosystem modellings in the western North Pacific. Given that the area is migration corridor of the whales, the numbers were estimated for early season (May-June) and late season (July-Sep.). The estimates were 38 (in 2009) and 161 (in 2011 and 2012) in the early and 958 (in 2008) in the late season for blue whales, 413 (in 2009) and 1,369 (in 2011 and 2012) in the early and 3,958 (in 2008) in the late season for the fin whales, 1,136 (in 2009) and 1,921 (in 2011 and 2012) in the early and 392 (in 2008) in the late season for the humpback whales, 1,150 (in 2011 and 2012) in early season and 417 (in 2008) in late season for the North Pacific right whales. It is important to note that these estimates should not be used for assessment because the estimated figures represent only a part of the population considered.

SC/F16/JR14 examined the number of sperm whales in the JARPN II offshore survey area based on 2008-2014 JARPNII surveys. The numbers are to be used for prey consumption estimation and ecosystem modellings in the western North Pacific. Given that the area is migration corridor of the whales, the numbers were estimated for early season (May-June) and late season (July-Sep.). The estimates were 11,459 (in 2009) and 11,652 (in 2011 and 2012) in the early and 10,843 (in 2008) in the late season for the sperm whales. It is important to note that these estimates should not be used for assessment because the estimated figures represent only a part of the population considered.

Prey consumption by whales

Objective 1, Sub-objective 4:
To estimate the prey consumption by baleen whales using JARPNII data and samples, and taking into account the uncertainties identified at the 2009 JARPNII review.

SC/F16/JR15 estimated the prey consumption by common minke, Bryde's and sei whales in the western North Pacific. Prey species of whales were identified by examining their stomach contents, and the amount of prey consumed in the research area was estimated by using information on prey consumption *per capita* and the numbers of whales distributed. There were seasonal and geographical changes in the preys consumed in each whale species. The extent of differences of estimates of consumptions among several models was 2.4-3.6 times. Based on the results obtained by three equations combined and Monte Carlo simulations, the daily prey consumptions *per capita* of common minke whales were 86-94kg and 83-94kg for immature male and female; and 129-141kg and 158-166kg for mature male and female, respectively. The daily prey consumptions *per capita* of Bryde's whales were 419-434kg and 417-428kg for immature male and female; and 577-637kg and 642-707kg for mature male and female, respectively. The daily prey consumptions *per capita* of sei whales were 397-421kg and 436-468kg for immature male and female; and 524-539kg and 610-647kg for mature male and female, respectively. The CVs of the daily prey consumption consumed by whales *per capita* were in the range 0.2-0.3. The seasonal prey consumption during May-September in two periods (2000-2007, 2008-2013) by three baleen whale species were 1.1 and 1.2 million tons, respectively. The prey consumption of Japanese anchovy, mackerels and Pacific saury by three baleen whale species in the two periods were estimated as 674-724 thousand tons, 43-70 thousand tons and 48-56 thousand tons, respectively. The CVs of the seasonal prey consumption consumed by whales were in the range 0.3-0.4. These values were equivalent to 22-48%, 5-66% and 2-7% of the biomass of each fish resources in the western North Pacific.

SC/F16/JR16 examined the preliminary attempt of spatial estimation of prey consumption by sei whales in the JARPNII survey area using data obtained from 2002 to 2013. Two levels of models are constructed to achieve the goal. Firstly, relative abundance of sei whales in relation with oceanographic conditions is estimated by using a generalized additive model (GAM). Secondary, amount of prey consumed by a sei whale in relation with oceanographic conditions is also estimated by using GAM. Finally, prey consumption of sei whales in the JARPNII survey area is calculated as the product of these two models. Data obtained from 2002 to 2013 are used in the analysis. Spatial distribution of prey consumption shifted toward north as the season progress. Estimated amount of prey consumption by sei whales using the spatial model was comparable to estimates based on traditional methods (Tamura *et al.,* 2016: SC/F16/JR15). SST was selected as environmental covariates in the first and second models. However, the shape of functional form for the first level model (prey consumption) was relatively flat in comparison with the second level model (abundance). The results indicated that spatial distribution of sei whales at meso scale were largely determined by oceanographic conditions such as SST. Sei whales could then search for their prey with the optimal oceanographic conditions as indicated by feeding behaviour study (Ishii *et al.*, 2016: SC/F16/JR25). Future study on feeding ecology of baleen whales should pursuit such an integrated approach further.

Impact of prey consumption by whales on fisheries resources

Objective 1, Sub-objective 5:
To evaluate the feeding impact by whales on fisheries resources using JARPNII data and samples, and information from commercial fisheries and other research sources in coastal areas.

SC/F16/JR17 estimated the prey consumption by common minke whales off Sanriku and Kushiro regions. Prey species of whales were identified by examining their stomach contents, and the amount of prey consumed in the research area was estimated by using information on prey consumption *per capita* and the numbers of whales distributed. In the Sanriku region, based on the results obtained by three equations combined and Monte Carlo simulations, the daily prey consumptions *per capita* of common minke whales were 98kg and 106kg for immature male and female; and 166kg and 223kg for mature male and female, respectively. The CVs was around 0.3. The seasonal consumption of total preys by common minke whales were 4,234 tons, 1,822 tons and 850 tons in 2005, 2006 and 2012 seasons, respectively. The CVs was around 0.2. The seasonal consumption of Japanese sand lance were 3,709 tons, 1,522 tons and 656 tons in 2005, 2006 and 2012 seasons, respectively. It corresponded to 30-40% of the fisheries catch on this fish resource in two years before the tsunami. In the Kushiro region the daily prey consumptions *per capita* of common minke whales were 82kg and 81kg for immature male and female; and 116kg and 155kg for mature male and female, respectively. The CVs was around 0.2. The seasonal consumptions of total preys by common minke whales were in the range 782-3,469 tons during the period 2002-2012. The CVs were in the range 0.2-0.3. The seasonal consumption of Pacific saury and walleye Pollock were 0-843 tons and 85-1,546 tons, respectively. It corresponded to approximately 2-3% of the fisheries catch on these resources in Kushiro.

Biomass estimation of whale's prey species

Objective 1, Sub-objective 6:
To estimate prey abundance using JARPNII data, complemented with information available from other sources.

SC/F16/JR18 examined basin-scale distribution pattern and biomass estimation of Japanese anchovy in the western North Pacific using a quantitative echosounder. This was the first attempt at such a study in this region. Data were collected in summer from 2004 to 2007. The biomass was estimated using data collected at 38 kHz. Species compositions in the backscatterings from pelagic fish were assigned based on the results of trawl hauls taking account of sea surface temperature (SST). Japanese anchovy tended to be high density to the west of 153°E and were distributed in an SST range of 9–24 °C. Although the temporal and spatial coverage of the survey differed each year, at least 1.5–3.4 million tons of Japanese anchovy were present in the survey area between 2004 and 2007. To take account of the spatial coverage of the survey each year, the most reliable biomass estimate for this region in the time period was 3.4 million tons (coefficient of variation 0.22).

SC/F16/JR19 examined estimation of prey species biomass based on 2008 and 2009 JARPNII acoustic surveys around the Sanriku region. The survey was conducted concurrently with a sampling survey of common minke whales. Five stratified blocks were surveyed. Zigzag tracklines were set in the blocks. A trawler type RV, *Takuyo-maru*, conducted the survey. Acoustic data were recorded continuously along tracklines by a quantitative echo sounder. Samplings using a midwater trawl net were conducted to identify species and size compositions of acoustic backscatterings. Vertical oceanographic conditions were recorded by using a CTD. Subsurface oceanographic conditions were recorded continuously along tracklines. The total biomass estimation of sand lance adult were 8,076t, sand lance juvenile were 1,237t, Japanese anchovy were 0.18t in block B and C in 2008, respectively. The total biomass estimation of sand lance adult were 2,512t, sand lance juvenile were 315t, Japanese anchovy were 0.64t in block B and C in 2009, respectively. It was not possible to evaluate any trend in sand lance and Japanese anchovy abundance with just two surveys conducted in small areas. However sand lance and Japanese anchovy estimates were used to compare sand lance and Japanese anchovy consumption by large whales and as input data for the development of ecosystem models for this area.

Prey preference of whales

Objective 1, Sub-objective 7:
To investigate the prey preference of whales in offshore areas, using JARPNII data and samples.

SC/F16/JR20 examined habitat and prey selection of common minke, sei, and Bryde's whales in mesoscale during summer in the subarctic and transition regions of the western North Pacific. The characteristics of the distribution areas and stomach contents of them in relation to oceanographic and prey environments in summer. Common minke whales were distributed within subarctic regions and the northernmost region of the transitional domain, coinciding with the main habitat of the preferred prey, Pacific saury. Sei whales were mainly found in the northernmost part of the transition zone and showed prey preference for Japanese anchovy, which was significantly more abundant in the main distribution area of the whale than in its adjacent areas. ''Hot spot'' of Bryde's whales were found in several regions of the transition zone between the subarctic boundary and the Kuroshio front. This whale species preferred Japanese anchovy as prey, for which the distribution area the whale than in the adjacent areas. These results indicate that the summer distributions of Pacific saury and Japanese anchovy greatly influence the distributions of these whale species, suggesting that the whale's habitat selection is closely related to their prey selection.

SC/F16/JR21 examined the prey selection of common minke and Bryde's whales in the western North Pacific in 2000 and 2001. Whale sighting and sampling surveys and prey surveys using quantitative echosounder and mid-water trawl were carried out concurrently in the study. Biomasses of Japanese anchovy, walleye pollock and krill, which were major prey species of common minke and Bryde's whales, were estimated using an echosounder. The results suggested that common minke whale showed prey selection for Japanese anchovy while they seemed to avoid krill in both the offshore and coastal regions and walleye pollock in the continental shelf region. Selection for shoaling pelagic fish was similar to that in the eastern North Atlantic. Bryde's whale showed selection for Japanese anchovy in August 2000 and July 2001, while it showed prey selection for krill in May and June in 2001.

SC/F16/JR22 examined Prey preferences of common minke, Bryde's and sei whales in offshore component of JARPNII from 2002 to 2007 using data from the concurrent surveys of cetacean sampling and prey of cetaceans. The surveys were conducted as a part of the offshore component of JARPN II from 2002 to 2007. A prey preference index, Manly's α, was used in the analysis. The sum of Manly's α for all prey species is 1 and prey species with large values of Manly's α indicates preference for it. Minke whales showed preference toward pelagic fishes as previously reported. Bryde's whales showed preference for anchovy. Sei whales showed preference for copepods. Although the prey of three baleen whale species overlapped, Manly's α suggested their trophic niches were different from each other. Minke and sei whales coexisted in same survey blocks but their prey utilization patterns were different.

Feeding habit of whales

Objective 1, Sub-objective 8:
To investigate feeding habit of baleen and toothed whale species in the research area, and the environmental factors involved in determining such habits.

SC/F16/JR23 examined the feeding ecology and its decadal change in common minke, sei and Bryde's whales in the western North Pacific. Stomach contents from sei, Bryde's and common minke whales in May-October during 2000-2013 off the Pacific coast of Japan were examined. Stomach contents analysis showed that the three whale species are highly dependent on small pelagic fish, i.e. Japanese anchovy, Pacific saury and mackerels in addition to copepods and euphausiids. The trend of food compositions in the three baleen whales differ among whale species and sei whale showed drastic change of pelagic fish from the main prey Japanese anchovy in early 2000s to mackerels and Japanese sardine. This synchronized with the catch record of pacific stocks in Japanese fishery. The change of prey composition is preferable for sei whale from the results of increase in body condition trend. Copepods and euphausiids are also important prey species for sei whales and steadily available in the blooming period. Bryde’s whale has more simple prey composition with Anchovy and euphausiids as main prey species and the composition of two main prey species are highly variable among years and no remarkable change since 2000-2013. Food composition in common minke whale at offshore (east of 150°E) showed anchovy and saury are the majority species but the composition differ among years. Among three whale species, sei whale distributes at the most widely in latitude through Kuroshio extension to north of subarctic front feeding at the variety of prey species in the JARPNII study area where abundant pelagic fish carried by Kuroshio-current and *Neocalanus* copepods in booming season are available. The change of food composition in sei whale likely to change the water temperature it occurs and its school size.

SC/F16/JR24 examined the relationship between maturity and feeding habit of common minke whales in the coastal region off Kushiro. A total of seven dominant preys, including one species of krill (Pacific krill), one of squids (Japanese common squid) and five of fishes (Japanese anchovy, Japanese sardine, chub mackerel, Pacific saury and walleye Pollock) were identified in 589 stomachs of minke whales. Differences in feeding habits between immature and mature whales in the coastal waters off Kushiro in autumn suggested previously, could be confirmed. These results suggested that migration and prey preference of common minke whales in the coastal waters off Kushiro in autumn possibly differed with their maturity stage. Feeding strategy of common minke whales might change to adapt the local environments. Differences can be explained by the trade-offs of cost of foraging activity for prey and/or energy demands between immature and mature whales.

SC/F16/JR25 examined the feeding behaviour of sei whale observed in JARPNII. Diving behaviour of sei whales and vertical distribution of their prey were recorded simultaneously in 2013 JARPN II to study their feeding behaviour at micro scale. This was the first attempt of this kind of observation targeting on this species. Small acoustic time depth transmitters (pingers) were attached to two sei whales and their behaviors were recorded for 10.2 and 32.0 hours, respectively. Vertical distributions and densities (volume backscattering strength, SV) of their prey were recorded by an echosounder following swimming path of the individuals. The diving behaviour deeper than 10 m was classified into two shapes (U-shape, V-shape). It was assumed that U-shape was related to feeding behaviour, especially lung feeding, while V-shape was related to other behaviour. Sei whales showed diel patterns in mean diving depth (day: 19 ± 14 m, 16 ± 10 m, night: 12 ± 5 m, 10 ± 5 m). Dense scattering layers (presumably zooplankton) were observed around 40 m during the daytime, and they migrated closer to the surface in the evening. Diving depth of the whales followed the changes in the scattering layers (i.e. diving depth was same as depth of scattering layers). U-shape diving was associated with higher SV values than V-shape diving in daytime. Frequency of U-shape diving increased around dusk. The results suggested that sei whales frequently lunged to prey around dusk. First-Passage Time (FPT) of sei whales as an indicator of foraging was calculated using the cruise track as a proxy of horizontal movement of tagged individuals. Large FPT can be considered as foraging behaviour. PPT were increased around dusk which was corresponding to increase in U-shape diving. Combining these results, it could be said sei whales actively fed on prey around dusk. Swimming depth of the whales was shallower than 10m after sunset while deep scattering layers (presumably myctophids) were migrated from below 60 m to around 30 m. The results might indicate that they did not fed on prey in deep scattering layers at night. However, it could not preclude a possibility that sei whales fed on prey near surface in night because data on behaviour and prey distribution near surface could not recorded by the acoustic devices (pinger and echosounder) used in the study. The results of this study revealed that sei whales changed their diving behaviour in response to availability of their prey in daytime.

SC/F16/JR26 examined the feeding habits of sperm whales (*Physeter macrocephalus*) in the western North Pacific in spring and summer. The 56 stomach contents of fifty six sperm whales examined from May to September of the years 2000 to 2013. A total of 49 undigested and half-digested prey items were found, including 28 species of cephalopods and six species of fish. The Index of Relative Importance (IRI) showed that *Belonella borealis* and *Histioteuthis* spp. were the dominant prey in the Subarctic Region, while *B. borealis* and *Galiteuthis phyllura* were the dominant prey in the Transitional Domain. *B. borealis* and *Taningia danae* were the dominant prey in the Northern part of the Transition Zone, while *T. danae* and *Histioteuthis* spp. were the dominant prey in the Southern part of the Transition Zone. In the Kuroshio Zone, *T. danae* and *Octopoteuthis* spp. were the dominant preys. The composition of prey items changed in relation to transitional change between north and south. Canonical Correspondence Analysis (CCA) indicated that environmental and biological factors significantly contributed to the prey composition of sperm whales. This study demonstrated that sperm whales moved along waters with different oceanographic conditions, feeding on a variety of prey species. Larger whales tend to feed at offshore waters. This flexibility and different size distribution in sperm whale seems to be important to maintain large body size and large abundance in the western North Pacific. The commercially important Neon flying squid *O. bartrami* was not an important prey of sperm whales in spring and summer.

Body condition indicators of whales

Objective 1, Sub-objective 9:
To investigate the yearly trend in body condition indicators of baleen whales using JARPNII data and samples.

SC/F16/JR27 examined the annual trend in energy storage in sei, Bryde's and common minke whales during the JARPN II period. Regression analyses showed that blubber thickness in sei whales have been increasing during the JARPN II period. The increase per year is estimated at approximately 0.1 cm for mid-lateral blubber thickness. "Body length" and "Date" were included in the best model at 5% level, while no year effects were included in the best model for other blubber thickness and girth measurements. The blubber thickness for mid-lateral probably be most sensitive for detecting energy storage. In Bryde's and minke whales, no significant trends have been observed in the regression analyses. This increase trend of body condition indicators and the recent change of prey composition suggest food availability has been changed to a favorable for sei whale in the study area.

Ecosystem modelling

Objective 1, Sub-objective 10:
To develop several ecosystem models, in both coastal and offshore areas, using JARPNII data and samples as input. Output of the models are likely to provide information on i) the ecosystem structure, ii) effects of prey availability and consumption on the population dynamics of common and sei whales with consideration of levels of energy intakes, iii) predation impacts of common minke whales consumption on sandlance stock off Sanriku.

SC/F16/JR28 exercised ecosystem modelling in the western North Pacific from 1994 to2013 using Ecopath with Ecosim (EwE). Firstly, Ecopath in 2013 is constructed as available data for the modelling is relative rich. Ecopath in 1994 is then constructed based on the model in 2013. Finally, Ecosim is constructed based on Ecopath in 1994 using available time series data from 1994 to 2013. Regime of the period is relative stable in comparison with the past. A series of pre-balance diagnostics, "PREBAL" (Link, 2010) is conducted for both the 2013 and 1994 models to evaluate the initial satanic energy budget of Ecopath. An ecosystem network analysis indicator, mixed trophic impact (MTI) is used to assess the positive or negative effect of changes in the biomass of a species/group on the biomass of the other species/groups in the steady state ecosystem. Order of Trophic level (TL) of baleen whales is as follows (from high to low): common minke (4.1), Bryde's (3.9), sei (3.7), humpback (3.5), fin (3.3) and blue (3.2) whales. These species are in intermediate TL in the ecosystem. MTIs suggested that changes in biomass of forage fish impact most of species/groups from low to high trophic levels. Baleen whales impact forage fish negatively but the magnitude is weak. The Ecosim model with forced biomass trends of 4 forage fish species (Japanese sardine and anchovy, and chub and spotted mackerels) having 10 predator and prey search blocks attain the lowest AIC. Estimated trends of biomasses and total mortality by using the model are reasonably fitted to input time series data especially for cetaceans targeted by JARPNII. Overall results appear to be reasonable but it is still preliminary largely because of incompleteness of input data. Following are points to be improved in the further excises: (1) consistency of spatial resolution of input data, (2) development of regional models within our EwE area, (3) collection of diet composition data in regular interval, (4) resolution and quality of data on non-commercial and lower trophic level species and (5) evaluation of the sensitivity of Ecopath models to input data.

SC/F16/JR29 conducted a statistical analysis to assess predation impacts of the common minke whales on the sand lance population off Sanriku region. A state-space delay-difference model, which is a two-stage population dynamics model with a stock-recruitment relationship, was used for the sand lance population to employ two independent time series indices for the juvenile and mature population sizes as well as catch and age-composition data. Predation impacts on the sand lance were assessed through minke whales' consumption expressed as a functional response. To take into account several stochastic flexibilities such as process errors, a Bayesian method was used to estimate the parameters and latent variables in the model. The 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 proportion is sensitive to the model assumption.

Objective 2: Monitoring Environmental Pollutant in Cetacean and the Marine Ecosystem

i) Pattern of accumulation of pollutants in cetaceans and ii) Bioaccumulation process of pollutants through the food chain

Objective 2, Sub-objective 1:
To investigate pattern of accumulation of pollutants in cetaceans and their food items.

SC/F16/JR30 examined the yearly changes of total Hg of common minke whales from sub-areas 7 (period 1996-2012), 8 (period 1996-2009), 9 (period 1994-2013), off Kushiro (period 2002-2014) and off Sanriku (period 2003-2014), sei whales from sub-area 9 (period 2002-2014) and Bryde's whales from sub-areas 8 and 9 (period 2002-2013). The multiple regression analysis was carried out. The data included adjustment for confounders, sampling years, sampling longitude, latitude, sampling date, body length, blubber thickness and main prey species. No significant correlations with sampling years were observed in almost all whales, while significant correlations with sampling year and main food item were observed in minke whales from sub-areas 7 and 9 and sei whales from sub-area 9. It is indicated that yearly changes of total Hg in latter would could be effected by changes of their play species. The result was suggested that background levels of total Hg stabilized in the western North Pacific during 1994-2014.

SC/F16/JR31 examined the yearly changes of PCBs of common minke whales from sub-areas 7 (period 2002-2012), 8 (period 2002-2009), 9 (period 2002-2013), off Kushiro (period 2002-2014) and off Sanriku (period 2003-2014) from the western North Pacific. The multiple regression analysis was carried out. Data included adjustment for confounders, sampling years, sampling longitude, latitude, sampling date, body length, blubber thickness and main prey species. No significant correlations between with year and food items were observed in all areas. It is suggested that PCB levels in minke whales from the western North Pacific stabilized during 2002-2014.

SC/F16/JR32 examined the patterns of PCB congeners, DDT isomers, HCH isomers, HCB and CHL isomers in the blubber of 5 mature males of each of common minke, sei and Bryde's whales taken from the western North Pacific in 2012. For comparison, those compounds were also determined in the blubber of 5 mature males of Antarctic minke whales taken from Antarctic Area V in 2010/11. Concentrations of PCBs were highest among organochlorines in the whales from the western North Pacific, whereas they were lower than concentrations of HCB, DDTs and CHLs in Antarctic minke whales from the Antarctic Ocean. Principal Component Analysis showed differences of trophic level and habitat of PCB congener profiles in the whales. Over 4 chlorinated chlorobiphenyl (CB) congeners in the studied whales contributed to the difference of trophic levels, and the CB-32, 16 and 25 contributed to the geographical difference. The main component isomers from pesticide products originating in DDTs and HCHs were comparatively lower, and those originating in CHLs were not detected in the whales from the western North Pacific. These results suggest that in the western North Pacific, a great deal of time would have passed from the release of DDTs, HCHs and CHLs into the environment.

SC/F16/JR33 examined differences of total Hg concentrations in muscle and liver of J- and O-stocks of common minke whales from the waters off Sanriku. Concentrations of total Hg in muscle and liver of 35 O- and 24 J-stock immature minke whales taken in the 2012 and 2013 JARPN II surveys were measured. Multiple linear regression analyses of total Hg concentrations of the whales were carried out. These included adjustment for confounders, age index, sex, stock, blubber thickness and year. Stock had no discernible effect. These findings suggest that there is no stock-dependent difference of total Hg exposure risk for the minke whales from off Sanriku.

SC/F16/JR34 examined the pollutants status of sperm whales in the western North Pacific. Total Hg, PCBs, DDTs, HCHs, HCB and CHLs were determined in samples of sperm whales in the period 2001-2013. Mean concentrations of total Hg in muscle of sperm whales in the periods 2001-2005 and 2011-2013 were 1.9 and 1.5 (ppm wet wt.), respectively. No significant difference was observed in their total Hg levels between the two periods. Mean concentrations of PCBs, DDTs, HCHs, HCB and CHLs in blubber samples in 2012 were 1.9, 0.74, 0.040, 0.077 and 0.65 (µg/g fat wt.), respectively. Levels of total Hg in muscle samples of sperm whales in the present study were slightly lower than those from Ayukawa, Japan in 1978 and 1979, and from the southern North Sea in 1994 and 1995. Levels of organochlorines, except for CHLs, in sperm whales from the western North Pacific were similar or lower than those in sperm whales from the middle latitudes of the northern hemisphere nearby human activity. In addition, there is no evidence that levels of total Hg in muscle of sperm whales increased in the period of 1970s to 2000s.

Objective 2, Sub-objective 2:
To investigate bioaccumulation process of pollutants through the food chain.

SC/F16/JR30 examined the yearly changes of total Hg of common minke whales from sub-areas 7, 8, 9, off Kushiro and off Sanriku, sei whales from sub-area 9 and Bryde's whales from sub-areas 8 and 9. The multiple regression analysis was carried out. Data included adjustment for confounders, sampling years, sampling longitude, latitude, sampling date, body length, blubber thickness and main prey species. No significant correlations between total Hg and sampling years were observed in almost all whales except for minke whales from sub-areas 7 and 9 and sei whales from sub-area 9. Total Hg levels in minke whales from sub-areas 7 and 9 and sei whales from sub-area 9 were simultaneously correlated with main food items. These findings suggest that yearly changes of total Hg in common minke whales from the western North Pacific could be effected by changes of their play species.

SC/F16/JR31 examined the yearly changes of PCBs of common minke whales from sub-area 7, 8, 9, off Kushiro and off Sanriku from the western North Pacific. The multiple regression analysis was carried out. Data included adjustment for confounders, sampling years, sampling longitude, latitude, sampling date, body length, blubber thickness and main prey species. No significant correlations between with year and main prey species were observed in all areas, while significant correlations with body length, blubber thickness and sampling date. Therefore, total Hg levels in baleen whales would be easily received with the influences of the changes of food items, than the PCBs levels. The difference between total Hg and PCBs could be attributed to their persistency in whale body.

<u>iii) Relationship between chemical pollutants and cetacean health</u>

Objective 2, Sub-objective 3:
To investigate the relationship between chemical pollutants and cetacean health.

SC/F16/JR35 examined the health risk of radioisotopes (RIs) for the large whales from the western North Pacific. From 11 March 2011 onward, RIs were released to the marine environment from the Nuclear Power Plant in Fukushima following an earthquake and tsunami. To assess the presence of these RIs in the large whales from the western North Pacific, the I131, Cs134 and Cs137 levels in muscle samples of 53 common minke, 16 Bryde's, 32 sei and 3 sperm whales from JARPN II surveys were measured in the period of JARPN II (2011-2015). I131 was not detected in muscle samples of all large whales, except for two minke whales from off Kushiro in 2012. Ranges of Cs134 + Cs137 concentrations in minke, sei, Bryde's and sperm whales were ND-31, ND-9.8, ND-7.1 and ND-0.59 Bq/kg wet wt., respectively. The radioisotope levels in all whales examined have been decreasing since 2011, and were also extremely lower than the radiation safety threshold for humans. Therefore, risk of acute toxicity levels for I131, Cs134 and Cs137 would be extremely low in the large whales from the western North Pacific.

SC/F16/JR36 examined the effects of OCs on the transcriptome in the common minke whale of the JARPN II samples. A hepatic oligo array of this species where 985 unique oligo nucleotides were spotted and further analyzed the relationship between the OC levels and gene expression profiles of liver tissues. The stepwise multiple linear regression analysis identified 32 genes that correlated with hepatic OC levels. The mRNA expression levels of seven cytochrome P450 (CYP) genes, CYP1A1, 1A2, 2C78, 2E1, 3A72, 4A35, and 4V6 showed no clear correlations with the concentration of each OC, suggesting that the accumulated OCs in the liver did not reach levels that could alter CYP expression.

SC/F16/JR37 examined variations in the amino acid residues of the V region of 19 toothed and 7 baleen whale species, covering almost all cetacean genera. Three - dimensional (3D) models of them were generated in a homology model using the crystal structure of the marmoset signaling lymphocyte activation molecule and measles virus H protein complex as a template. Among the cetacean species studied, variations were found at six of the residues. Bottlenose and striped dolphins have substitutions at five positions (E68G, I74V, R90H, V126I, and Q130H) compared with those of baleen whales. Three residues (at positions 68, 90 and 130) were found to alternate electric charges, possibly causing changes in affinity for the virus. This study shows a new approach based on receptor structure for assessing potential vulnerability to viral infection. This method may be useful for assessing the risk of morbillivirus infection in wildlife.

Objective 3: Stock structure of large whales

i) Common minke whale

Objective 3, Sub-objective 1:
Monitoring of the spatial and temporal distribution of J stock on both west and east coasts of Japan using genetics and non-genetics approaches, and all sources of samples available e.g. JARPN, JARPNII and by-catches.

SC/F16/JR38 examined a total of 4,275 western North Pacific common minke whales were examined with a set of 16 microsatellite DNA loci and the program STRUCTURE to assign individual to either J or O stocks. Samples were available from JARPN/JARPNII (1994-2014; n= 2,637)), and by-catches (2001-2014; n= 1,638), from different management sub-areas (SA) around Japan. Results of the Bayesian clustering analysis confirmed that the whales came from two genetically differentiated stocks, J and O stocks. The number of unassigned individuals ('unknown') decreased with the increase in the number of microsatellite loci used, and they were widely distributed. By using 16 loci, more than 90% of the individual whales were assigned to either stocks. Almost all of the individuals collected from the Sea of Japan side (SA6 and SA10E) belonged to the J Stock, whereas almost all of the individuals from the offshore North Pacific (east of SA7WR) belonged to the O stock. Intermediate areas (SA7CN, 7CS and SA11) contained individuals from both stocks. The SA2 was mainly occupied by the J stock. In SA2 the J stock was predominant (around 80% in proportion) around the year. In SA7CS and SA7CN the proportion of the J stock increase in autumn/winter and decrease in spring/summer. A phylogenetic tree of mtDNA haplotypes showed several clades but none supported by high bootstrap values. There was no stock-specific clade although most of the individuals assigned to the J stock shared a same clade. Most of the individuals assigned to the O stocks share clades where the J stock individuals were less frequent. The unknown samples were widely distributed through the clades.

SC/F16/JR39 focused on the unique white patch on the flipper of the common minke whale to differentiate between J and O stocks. Animals collected from JARPNII research during 2012 and 2013 were used; assignment of individual whales to the O and J stocks was based on microsatellite analysis (n = 220). The morphological differences in the size and pattern of the white patch on the flipper of each whale was examined. The length of the white patch along the anterior (ventral) margin of the flipper tends to be proportionally larger in O stock animals. The pattern of the boundary area of the white patch named as the "Grayish Accessary Layer (GAL)" was remarkably different between stocks. Of the total animals with "no GAL" type, 94% were J stock. Conversely, of the total animals with GAL expanding over the half the flipper width, 98% were O stock. It is concluded that there were clear morphological differences in the body color pattern of the flipper between J and O stocks.

Objective 3, Sub-objective 2:
Using genetic and non-genetic data from JARPN and JARPN II, investigate whether or not the sub-division of the O stock into Ow and Oe is plausible. The genetic analysis should include those approaches mentioned as providing support for the existence of the Ow (e.g. PCA analyses).

SC/F16/JR40 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 SC/F16/JR39. 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 SC/F16/JR38 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.

SC/F16/JR41 examined stock structure of western North Pacific common minke whales by using external measurement data collected during 1994 and 2014 JARPN and JARPNII surveys. Most of the analyses conducted followed recommendations from the 2009 JARPNII review workshop. 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 study provided no evidences 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.

SC/F16/JR42 described an experiment on satellite tracking conducted on common minke whales in the Pacific side of Japan, specifically in coastal water off Hokkaido in autumn 2010. Using a handy air gun, a satellite tag (Argos transmitter) was attached on one common minke whale on 13 September (estimated body size: 7.8m). The movement of the whale was tracked for a period of 27 days. The whale stayed in the coastal waters off Kushiro, for at least four weeks in the autumn season. The JARPNII review workshop in 2009 had recommended satellite tracking experiments on the whale species studied, as a long-term task. This study started such experiments in the common minke whale. Further satellite tracking experiments have the potential to elucidate whether or not a coastal-resident stock of common minke whale occur in waters off Hokkaido (OW) as proposed by one of the current stock structure hypotheses.

In SC/F16/JR43 the catch-at-age data for minke whales in the western North Pacific provided by the JARPN/JARPNII were used to refine existing RMP *ISTs* in a simple way, so as to investigate the relative plausibility of the single- and two stock hypotheses for the O stock 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 (Ow and Oe) with them because of the relative absence of particularly younger whales in a supposedly separate discrete Oe stock. The analysis demonstrated 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.

ii) Bryde's whale

Objective 3, Sub-objective 3:
To investigate the plausibility of i) stock sub-division within Sub-area 1 as proposed under Hypothesis 4, and ii) sub-division between Sub-areas 1 and 2 as proposed under Hypotheses 2 and 3, using all genetic samples available from different source till 2014, and different genetic markers included satellite tracking.

SC/F16/JR44 examined a total of 1,019 and 1,026 samples of North Pacific Bryde's whales with microsatellite DNA (17 loci) and mitochondrial DNA sequencing (299bp), respectively, to examine the plausibility of four stock structure hypotheses used by the IWC SC during the 2007 RMP *Implementation*. Samples were from different sources: JARPNII (catches), Japanese dedicated sighting surveys (biopsy); IWC/POWER surveys (biopsy) and past commercial whaling (catches). No significant genetic heterogeneity was found between the Western and Eastern Sectors of sub-area 1, a result supported by high statistical power. However both genetic markers showed significant differences (for males, females and sexes combined) between sub-areas 1 and 2. Phylogenetic analysis of mtDNA haplotypes revealed no subarea-specific clades. It is proposed that a longitudinal sector around 180° could represent a hard boundary or a transition area where the two stocks mix. Based on these results, it is suggested that the plausibility of the stock structure hypotheses for western North Pacific Bryde's whale used in the 2007 *Implementation* whale should be re-examined. The results of this study suggest that the two-stock hypotheses (Hypotheses 2 and 3) could be more plausible than the one-stock hypothesis (Hypothesis 1) and the three-stock hypothesis (Hypothesis 4).

SC/F16/JR45 reported the movement of two individual Bryde's whales using satellite-monitored radio tags in offshore waters of the western North Pacific (sub-area 1). One whale was recorded for 13 days 4 hours 57 minutes from 13 to 26 July 2006. The other whale was recorded for 20 days 5 hours 5 minutes from 24 July to 13 August 2008. It has been documented that the subarctic-subtropical transition area (around 40°S) is one of the feeding areas of Bryde's whales in summer. However, the results of this study revealed that some Bryde's whales move from the subarctic-subtropical transition area to the sub-tropical area even in summer. This study provided the first information on continuous movement of Bryde's whales in the offshore western North Pacific in summer. The JARPNII review workshop in 2009 had recommended satellite tracking experiments on the whale species studied, as a long-term task. This study started such experiments in the Bryde's whale. Further satellite tracking experiments have the potential compliment the genetic studies on stock structure in sub-areas 1 and 2.

iii) Sei whale

Objective 3, Sub-objective 4:
To investigate the plausibility of a single stock of sei whale in the pelagic regions of the North Pacific ('North Pacific pelagic'), using all genetic samples available from different sources till 2014, and different genetic markers.

SC/F16/JR46 examined genetically a total of 1,554 sei whales with mtDNA control region sequencing (487bp) and microsatellite DNA (17 loci) to investigate population genetic structure of this species in the North Pacific. Samples were available from different sources, JARPNII (catches) (2002-2014), POWER (biopsy) (2010-2012) and past commercial (catches) (1972-73). For the heterogeneity test two longitudinal sectors were defined in the North Pacific: Western and Eastern at 180°, which covered this ocean basin widely from approximately 145°E to 135°W. No significant spatial genetic heterogeneity was found by the two genetic markers. A phylogenetic tree of 82 mtDNA haplotypes showed several clusters, but none was supported by high bootstrap values. Whales from both Western and Eastern sectors were widely distributed through the clusters. Taken as a whole, the genetic information in this study is consistent with the view that the oceanic regions of the North Pacific is occupied by a single stock of sei whale.

SC/F16/JR47 used microsatellite DNA markers to analyze samples of sei whales collected widely from the North Pacific at the same time of the year in order to test spatial genetic heterogeneity in this ocean basin. Although we have been reporting results of the genetic studies on the North Pacific sei whales to previous IWC/SC meetings, this study is the first to utilize temporally similar (collected at the same year), yet geographically very different, samples (covered west-end to east-end of the North Pacific). This study used samples collected from the northwestern (JARPNII), northcentral (POWER), and northeastern (POWER) areas of the North Pacific in the same summer seasons in 2010, 2011 and 2012. No evidences of significant genetic differences between the samples from JARPNII and POWER in each of the three years were found. Each yearly sample was then combined as JARPNII as well as POWER samples, respectively. No significant genetic differences were detected between these two samples. We used genotypic profiles of each whale in the POWER biopsy samples to find any cases of matching to the individuals in the JARPNII samples, no matching was found at all. In conclusion, this study failed to demonstrate evidence of multiple stocks of sei whales in the North Pacific.

SC/F16/JR48 presented a review of past studies on sei whales in order to describe stock structure hypotheses for the species in the North Pacific. A number of evidence obtained from different kinds of the analyses using mark-recapture, sighting, catch history, and genetic data shed light on patterns of distribution and migration of the sei whales, facilitating the hypothesis development. The mark-recapture data indicated that whales from the same breeding area distribute widely in the feeding area over almost the entire North Pacific. Although historical catch data from commercial whaling era had shown heterogeneous distribution of the sei whales, genetic evidence indicated no temporal and spatial genetic differences among the whales obtained from the entire North Pacific. The heterogeneous catch distribution appeared to reflect non-random operations of the commercial whaling as well as patchy distribution of their prey species. Overall, based on the series of the available evidence we propose a single stock hypothesis for sei whales in the North Pacific.

iv) Other species and analyses

Sperm whale
SC/F16/JR49 examined genetic variation at 15 microsatellite DNA loci and mitochondrial DNA (mtDNA) control region sequences (338bp) in sperm whales collected during JARPNII from 2000 to 2013 in order to examine the effectiveness of these genetic markers for studies of stock structure in this species. Analyses of mtDNA and microsatellite markers in a total of 56 sperm whales (16 males; 40 females) confirmed that these genetic markers were variable enough to explore stock structure of sperm whales. The overall heterozygosity over 15 loci was 0.730 while the nucleotide and haplotype diversity were 0.0038 and 0.7188, respectively. Statistical tests found no evidence of deviation from the expected Hardy-Weinberg genotypic proportion at all of the 15 microsatellite loci. At this point, no signal of multiple stocks of sperm whale in the western North Pacific off Japan was detected.

North Pacific right whale
SC/F16/JR50 examined genetic variation at 14 microsatellite DNA loci and mitochondrial DNA (mtDNA) control region sequences (275bp) in right whales from the western North Pacific and Antarctic Area IV. Genetic analyses were based on biopsy samples collected during the surveys of the JARPNII in 2011 and 2012 (n=15), and JARPAII in 1993/94-2009/10 (n=67). The overall heterozygosity was 0.630 and 0.650 for North Pacific and

southern right whales, respectively, while the nucleotide diversity/haplotype diversity were 0.0222/0.9048 and 0.0234/0.7743, respectively. Statistical tests found no evidence of deviation from the expected Hardy-Weinberg genotypic proportion in each of the oceanic basins. The Kimura's two parameter net interpopulational distance was 0.0358 (mtDNA) while the Nei's genetic distance (Da) was 0.7582 (microsatellite DNA), between North Pacific and southern right whale. A phylogenetic tree separated mtDNA haplotypes of the North Pacific, North Atlantic and southern right whales.

Mismatch distribution
SC/F16/JR51 examined the distribution of the number of nucleotide substitutions between all pairs of individuals within western North Pacific O and J stock common minke, Bryde's, sei and right whales, to investigate whether the pattern of distribution is indicative of exponential population growth (in evolutionary terms), and thus of non-equilibrium. According to Slatkin and Hudson (1991), unimodality of the frequency distribution is indicative of exponential population growth, and this pattern was found in the O stock common minke and sei whales. In contrast multimode pattern in the frequency distribution was found in the J stock common, Bryde's and right whales, which is inconsistent with exponential population expansion.

Other results

SC/F16/JR52 examined the feasibility of a new technique of incorporating gelatin in order to collect earplugs for age assessment of common minke whale. Frozen sectioning and histology of the earplug core were also used as methods to improve age estimation. Earplugs were collected by filling the space in the external auditory meatus with gelatin, hardening the gelatin, earplug and its fragments, by spraying with cooling gas, and removing the earplug embedded in gelatin. In 174 trials with common minke whales in the western North Pacific of coastal waters of Japan in 2007–2009, it was revealed that embedding earplugs with gelatin minimized breakage and protected the neonatal line (NL). This method was particularly effective in younger animals. As a result, the readability was improved. The histological sections were also examined. The sections were sliced using the Kawamoto specialized frozen sectioning technique, and stained them separately with toluidine blue, haematoxylin and eosin, Sudan III, Sudan VII, and alizarin red Sto display a clearer core surface image of the growth layers. The histological sections stained with alizarin red S provided the clearest images, in which both dark and pale laminations, could be easily identified. This suggested a close relationship with the seasonal changes in calcium intake from feeding. Earlier age estimation methods focused on fat content in the growth layers; however, we found potential for an improvement in the readability of unclear growth layers when focusing on calcium.

SC/F16/JR53 examined age reading from the earplugs in the common minke whale from the western North Pacific. Under JARPN and JARPNII surveys, all earplugs of common minke whales were carefully collected and effort was made to read growth layers. This study provided basic information of earplug readability and age composition of North Pacific common minke whales collected from 1994 to 2013. Age readability was 45.2% and 41.2% for males and females, respectively. Readability of mature animals (49.2% for male and 59.0% for female) was higher than immature animals (35.4% for male and 34.7% for female) in both sexes. From inter-reader calibration experiment, the age reading outcomes of two readers appeared similar. Differences were observed in body length and age distribution of common minke whales between coastal and offshore areas. Whales of less than five years old were dominant in the coastal area. On the other hand, males of more than six years old were dominant in the offshore area. Result of age distribution supported the segregation of common minke whales by sex and maturity status in western North Pacific, as suggested previously.

SC/F16/JR54 reviewed the changes made in JARPNII design following the ICJ Judgment. The overall research objectives, the research area and research methodology remained the same as those specified in the original JARPNII research plan. The voluntary review resulted in the reprioritization of research focus as well as recalculation of sample sizes. The survey concentrated on the study of interactions between whales and fisheries in the coastal area and interactions among whale species in the offshore area as well as a contribution to the management of whales. Sampling of sperm and common minke whales in the offshore component of JARPNII was suspended because their role in the study focus seemed to be limited. Sei whale sample size of 100 (as in the original plan) of which 10 were studied using only non-lethal methods. Bryde's whale sample size of 50 (as in the original plan) of which 25 were studied using only non-lethal methods. A study for verifying the feasibility of non-lethal methods, such as biopsy sampling and feces collection, for the objectives of JARPNII has been carried out during 2014 to 2016 JARPNII surveys.

SC/F16/JR55 reported the progress of age determination of sei whales collected during 2002 to 2013 JARPNII surveys, based on earplugs reading. Earplugs were collected carefully from all whales sampled and laboratory work was carried out to count growth layers. Readability of sexually-immature sei whale earplugs was 52.8% for males and 49.2% for females. Readability of mature animal was higher than immature, 71.0% and 64.5% for males and females, respectively. Readability of all samples was 63.0%. Studies on spatial and temporal segregation, feeding ecology and population dynamics of western North Pacific sei whales will be conducted in the future, based on age data.

4.3 Integration of results and considerations for future research

Figures 2, 3 and 4 showed a schematic representation of the research components under Objectives 1, 2 and 3 of JARPNII, respectively. Results of each component (and sub-objectives) were summarized in sections 4.1 and 4.2. In this section an integration of those components is attempted in the context of i) whale management under the RMP, and ii) ecosystem and multi-species management.

As noted earlier, responses to the original scientific questions on ecosystem can derive from both research conducted under individual components as well from the outputs from the ecosystem models under Objective 1.

Integration among components is important to understand and summarize the achievements of JARPNII in the context of conservation and management of fisheries resources including whales and ecosystem in the western North Pacific, and to identify what need to be achieved in the future.

Whale management under the RMP

The main target species for the studies on stock structure under the JARPNII were the common minke, Bryde's and sei whales. Common minke and Bryde's whales are species on which the RMP *ISTs* have been applied while the sei whale is still under the in-depth assessment started recently by the IWC SC. Sei whale is a target species for applying the RMP *ISTs* in the near future. Description of stock structure is a key piece of information for the application of the RMP to calculate a catch limit for future commercial whaling.

Other key pieces of information for the application of the RMP is abundance and the productivity of the stock (MSYR). JARPNII conducted systematic sighting surveys for the aim of abundance estimates. On the other hand ageing based on earplugs reading has proved useful in the case of the common minke and sei whale (see SC/F16/JR53 and SC/F16/JR55, respectively). This means that biological parameters useful for the RMP *Implementation* such as MSYR could be estimated in the near future. Ideally, abundance and biological parameters should be estimated on a stock by stock basis.

There are two main areas for integration in the context of information relevant for the RMP:

i) Dynamics of the stocks

For management purposes it is important to monitor the spatial and temporal changes in the distribution of the stocks, and the reasons involved. In cases of multiple stocks, for example the case of the common minke (J and O stocks) and Bryde's (sub-areas 1 and 2), it is also important to monitor their interactions through the time.

One of the possible mechanisms for the isolation of stocks is the fidelity to feeding and breeding areas. Under this perspective it make sense to study the dynamics of stocks in conjunction with the dynamics of their prey species, and the oceanographic process involved. While under JARPNII plausible hypotheses on stock structure in large whale have been proposed, a delineation of a process to monitor the dynamics of the stocks through the time in the context of environmental variables has not been feasible yet. Such information would be valuable in evaluating sub-areas and formulating catch scenarios under the RMP.

For such aim an integration among Objective 1, Sub-objectives 1-2 (oceanography, distribution) and Objective 3, Sub-objectives 1-3 (stock structure) is required.

ii) Estimation of abundance and biological parameters on a stock basis

The abundance estimates of large whales presented at this workshop have been made on a sub-area basis. This is because the main reason for such estimates has been to provide information on the number of whales in sub-areas for the estimation of whale's prey consumption. For assessment and management purposes what is important is the estimation of abundance and trend on a stock basis, not on a sub-area basis.

Some assessments of common minke, Bryde's and sei whales have been carried out in the past considering plausible stock structure hypothesis, mainly in the context of the analyses on the effects on the stocks. In the future, however, assessments should be carried out considering the more plausible hypotheses on stock structure of the main three baleen whale species, as concluded under the JARPNII research. Future sighting surveys should be planned in accordance with what has been learnt on the geographical and temporal distribution of stocks under JARPNII.

Development of ageing techniques in common minke and sei whale allows for the estimation of biological parameters useful for assessment, on a stock by stock basis for those species. For example estimation of biological parameters including MSYR, could be attempted separately for J and O stocks in the near future. In the case of the Bryde's whale, the ageing technique should be further developed so that suitable age information can be obtained for this species as well. If so, the estimation of biological parameters should be carried out on the basis of the two stocks identified by the JARPNII research. Such kind of refined assessment for North Pacific baleen whales will reduce the uncertainty in some key parameters used in the RMP *Implementation*.

For such aim an integration among Objective 1, Sub-objectives 3 (whale abundance), research on biological parameters (see section 4.2-Others), and Objective 3, Sub-objectives 1-3 (stock structure) is required.

It should be noted that the RMP is a single-species management procedure. Output from the ecosystem modeling work has the potential to incorporate the effects arising from the inter-species interaction into the RMP, such as possible changes in carrying capacity for whale species in the western North Pacific, which is not considered in the RMP currently. This is a new area for integration of results from JARPNII, and is closely related to the marine ecosystem and multi-species management.

The above would require an integration among Objective 1, Sub-objectives 10 (ecosystem modelling), and sub-objectives related to the RMP, e.g. research on biological parameters (see section 4.2-Others), and Objective 3, Sub-objectives 1-3 (stock structure).

Ecosystem and multi-species management

Suggestions from the 2009 review workshop

There are several suggestions for integration of research components from the 2009 JARPNII review workshop. Progress on the integration work is reported here.

The 2009 workshop made some suggestions for integration as following:

'To combine the oceanographic data, prey distribution and sighting survey data statistically to investigate how prey and whale distributions are associated with oceanographic conditions, and how whale distributions are related to distribution of prey' (IWC, 2010 409pp).

'To combine data on prey distributions as observed in the area where the whales were caught with the diet of the whales (referred to as the micro scale) statistically to evaluate how well the whale diet reflects prey availability in the area where it was caught' (IWC, 2010 409pp).

'In the long term, to more fully understand the preferred habitat, prey preferences, niche separation of different species, functional responses, and spatial and temporal trends in local abundance and other biological factors (such as blubber thickness, pollutants, presence of scars, and stock structure), the oceanographic data collected on the cruises (bottom depth, water column temperature, salinity, and density) and satellite derived data such as SST, chlorophyll, and sea surface height be integrated into future analyses' (IWC, 2010 409pp).

The analyses above were recommended as medium to long term. The recommendation was addressed to some extent in published documents (SC/F16/20-21), a document presented to the 2009 review workshop (SC/J09/JR18) and documents presented to this workshop (SC/F16/JR7, SC/F16/JR16 and SC/F16/JR27). All these studies but JR7, J16 and JR27 were conducted at the mesoscale.

The works above involved the integration among several sub-objectives of objective 1.

Integrations relevant to ecosystem multi-species management

The main outputs on whale feeding habits and prey consumption studies under the JARPNII were on the following topics: i) trend of prey compositions in three baleen whale species; ii) prey consumption by whales with improved level of statistical precision; and iii) prey preference of cetaceans using integrated approach.

To further advance those researches, integration of different components is necessary.

In the case of i) trend in prey composition analysis, an integration between the information of oceanography (Objective 1, Sub-objective 1), prey abundance (Objective 1, Sub-objective 6), distribution and feeding habit of whales (Objective 1, Sub-objectives 2, 8), is necessary. Such integration has been already attempted in previous studies, but this kind of integrative analyses require long-term surveys considering the regime shift (decadal period).

In the case of ii) prey consumption by whales with improved level of statistical precision, an integration between the analyses of prey consumed (Objective 1, Sub-objective 4) with the number of whales distributed in the research area (Objective 1, Sub-objective 3), is necessary. In particular more coordination is required for the surveys on whale stomach contents and sighting for abundance estimation.

In the case of iii) prey preference, further integration between the information on oceanography (Objective 1, Sub-objective 1), prey abundance (Objective 1, Sub-objective 6), distribution (Objective 1, Sub-objective 2) and feeding habit (Objective 1, Sub-objective 8) of whales is also necessary. This requires long-term micro-scale data obtained by concurrent prey and whale sighting/sampling surveys in the future.

Regarding modelling, firstly it should be clarified that the development of ecosystem models is not a final goal of JARPNII. What is important is the output of the ecosystem models and how the output can assist in the management of the marine living resources in the western North Pacific ecosystem.

The output of the ecosystem models developed under the JARPNII have contributed to understand i) the ecosystem structure, and ii) the predation impacts of common minke whales consumption on sand lance stock in the coastal area off Sanriku.

In the long term, to fully understand the above issues, spatial and temporal trends in local abundance and feeding habit in each whale and prey species, and other biological factors of whales (such as sex and sexual maturity status, population dynamics of whales and stock structure information), fisheries data (fishing catch, fishing ground, mortality and productivity of fishes), oceanographic data (water temperature and salinity) and satellite derived data such as SST, chlorophyll, and sea surface height should be integrated more rigorously in future studies.

Ecosystem modelling using Ecopath with Ecosim (EwE) presented to this meeting (Objective 1, Sub-objective 10) addressed spatial heterogeneity and temporal biomass dynamics in some extent but the results were not perfect. Spatial resolution considered in the model was coarse (only 3 blocks were considered). Spatial modeling of such distribution and prey consumption of whales (Objective 1, Sub-objective 4) should be integrated to develop more detailed ecosystem models. Integration or coupling with other ecosystem models such as individual based ecosystem models (Okunishi *et al*., 2012) and SEAPODYM (Lehodey *et al*., 2011) developed around Japan should also be considered for further work.

Results of Basin scale EwE model in the western North Pacific were presented to this meeting. This kind of exercise has its own merit to understand the overall structure of the large marine ecosystem (LME). However, it might overlook small scale ecological interactions. Outputs of a regional model in the southern part of coastal Oyashio (Yonezaki *et al*., 2015) were used in the present study. Development of regional ecosystem models in other areas such as in coastal Kuroshio area and northern part of coastal Oyashio area (e.g. off Kushiro) is required to understand the details. These regional ecosystem models will be served as sub-blocks of the ecosystem model at the LME scale. Time series fitting from 1994 to 2013 was attempted in the EwE model presented to this meeting. However, ecological drivers of regime shift (Objective 1, Sub-objective 8) in the western North Pacific could not be tested as it appeared that the regime in that period was relatively stable (Objective 1, Sub-objective 1). Such examination can be done by using past data and the results would be useful. However, preparation of appropriate data (e.g. biomass and diet compositions) is difficult. Continuation of collection of data for ecosystem models are important to investigate causes of such ecological changes. Monitoring of ecosystem is a basis for management of fisheries resources and it is the main concept of JARPNII. Although JARPNII will be terminated as a program, similar researches should be continued as a routine of fisheries surveys, in an integrated manner.

The ecosystem model has been proved to be a useful approach to examine the impact on the sandlance by consumption of common minke whales (Objective 1, Sub-objective 10). The consumption by common minke whales should be taken into account for the fishery management of Japanese sandlance off Sanriku region. On the other hand, the complexity of the Kushiro region (different prey species involved, decadal changes in prey composition, several fisheries involved) was revealed by several researches under JARPNII. This complexity precluded to use of ecosystem modeling in this region. For fisheries management in Kushiro region, ecosystem model should be developed to incorporate such complexity in the future. Integration of information from several sub-objectives of objective 1 will be required for such development.

A different kind of MRM-type ecosystem model is being developed for offshore waters of the western North Pacific. It is an age-structured population model aimed to evaluate the effects of prey availability and consumption on the population dynamics of common minke and sei whales with a consideration of levels of energy steps. This model is being developed in conjunction with progress made on the earplug-based ageing technique for those species (SC/F16/JR53, 55).

5. SUMMARY RESPONSE TO RELEVANT TOR OF THE JARPNII REVIEW WORKSHOP SPECIFIED IN ANNEX P

Assess the extent of the programme's scientific output, and whether this is appropriate in light of the stated research objectives and the time elapsed

Scientific outputs of JARPNII were summarized under items 4.1 and 4.2. These outputs were directly related (and summarized) to the main objectives and sub-objectives of JARPNII. Documents SC/F16/JR5-29 addressed the sub-objectives of main objective 1. Documents SC/F16/JR30-37 addressed the sub-objectives of main objective 2, and Documents SC/F16/JR38-49 addressed the sub-objectives of main objective 3. Apart from these, there were some published papers addressing these objectives as well (see Annex 1).

Assess the degree to which the programme coordinated or continues to coordinate its activities with related research projects

Research activities under the JARPNII were coordinate (and continue being coordinated) with several research institutions that carry out similar investigations. Figures 9-12 are diagrams showing the coordination and collaboration among research institutions with regard the research conducted by JARPNII under the main three objectives as well as other research not directly related to those objectives.

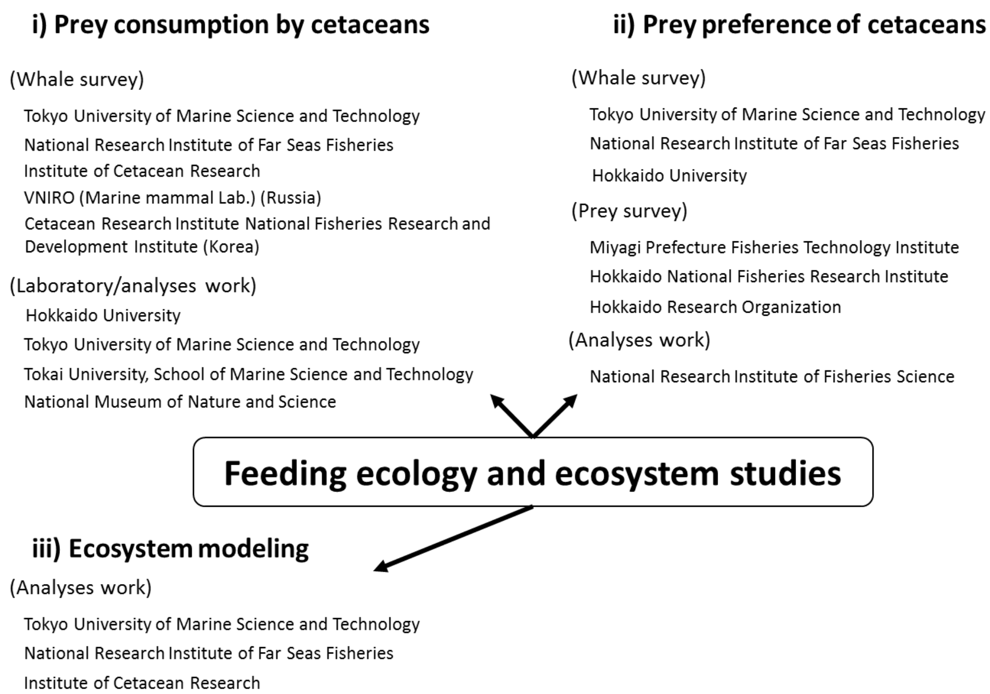

Figure 9. Coordination and collaboration among research institutions related to objective 1 of JARPNII.

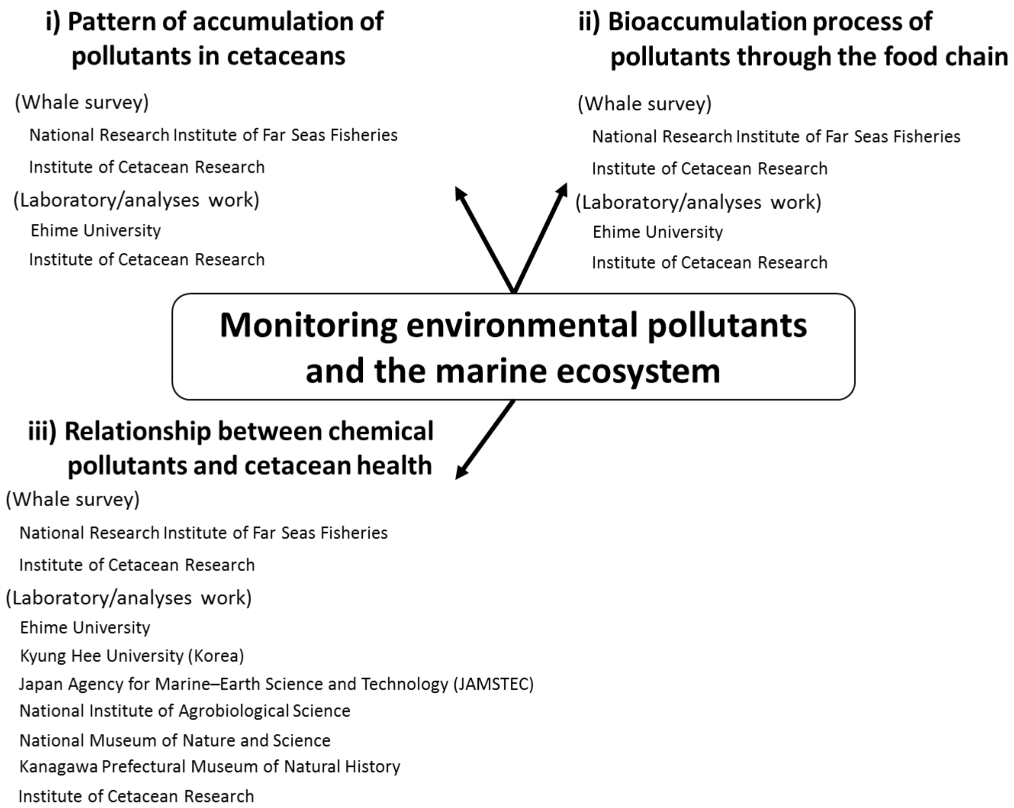

Figure 10. Coordination and collaboration among research institutions related to objective 2 of JARPNII.

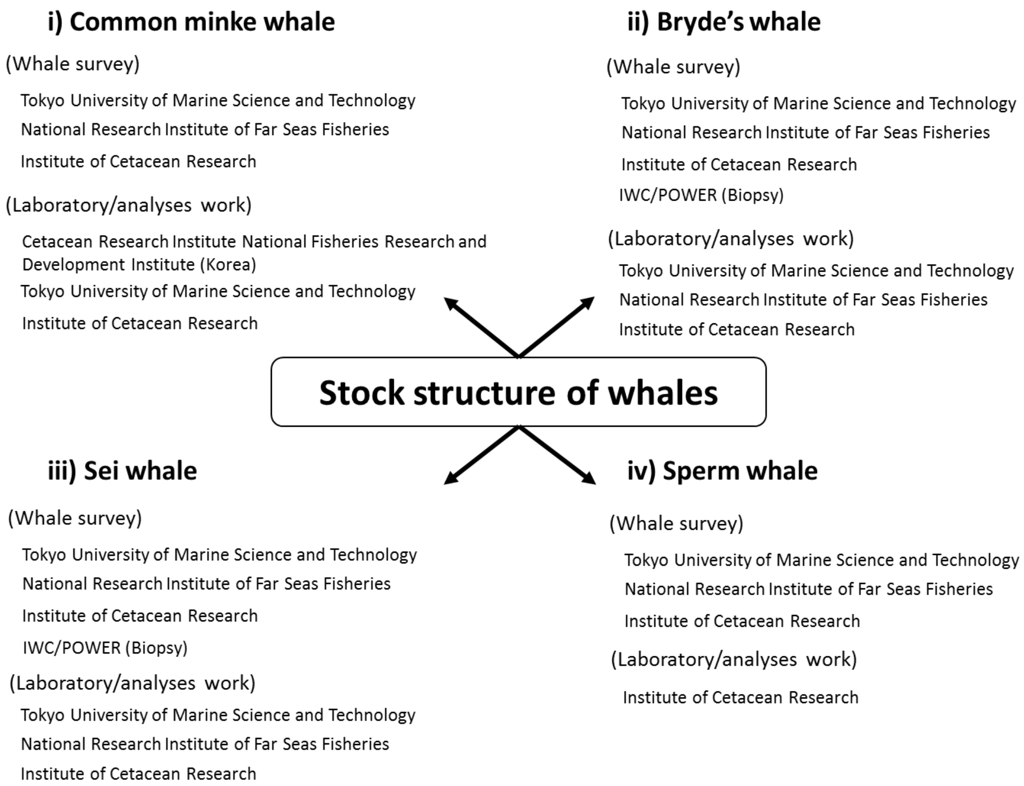

Figure 11. Coordination and collaboration among research institutions related to objective 3 of JARPNII.

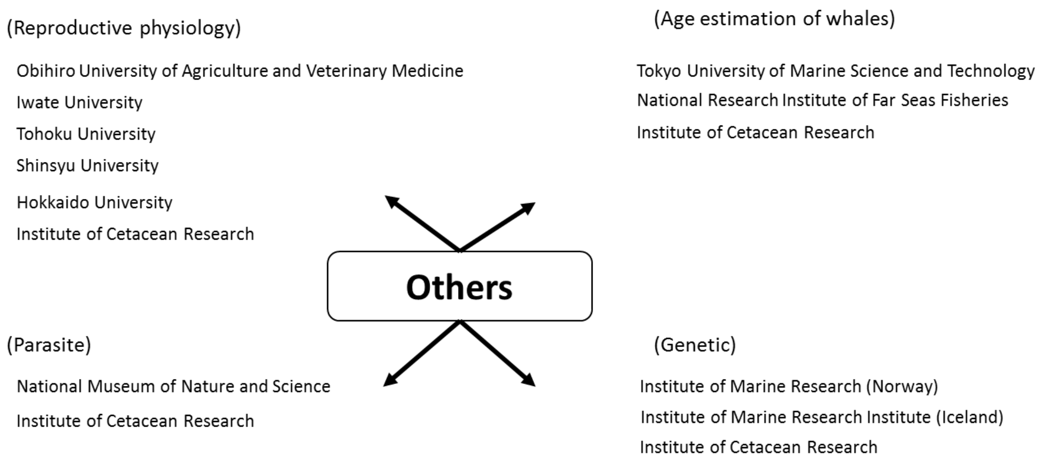

Figure 12. Coordination and collaboration among research institutions related to other research needs.

Evaluate how well the initial, or revised, objectives of the research have been met, and for broad categories of objectives 1 and 2, include the extent to which results have led to demonstrated improvements in the conservation and management of whales

Based on the results summarized under items 4.1 and 4.2 it is considered that the main objectives and sub-objectives have been met to a reasonable extent. This means that the main original questions under each main objectives have been responded to a reasonable extent. As it is natural in science, scientific results by JARPNII brought new scientific questions. The aspects not fully addressed under JARPNII and the new emerging scientific questions should be addressed in future.

JARPNII research conducted under main objective 1 is relevant for assisting the development of management policy of fisheries resources based on ecosystem consideration. One example of this is the output from the ecosystem modeling work related to an assessment of the interaction of common minke whale and a fishery resource, the sandlance.

JARPNII research conducted under main objective 2 is relevant for management as any decreasing trend in whale stock could be related to negative health effect on whales by environmental pollutants, and JARPNII has evaluated such possibility.

JARPNII research conducted under main objective 3 is relevant for the development of RMP *ISTs* in the case of the common minke and Bryde's whale, and for the in-depth assessment of North Pacific sei whale being conducted by the IWC SC. In the near future, information on stock structure can assist the development of RMP *ISTs* for North Pacific sei whale.

Evaluate other contributions to important research and information needs that were not part of the original set of objectives of the research program

Important information on ageing techniques in the North Pacific common minke and sei whales was obtained through JARPNII research.

Biopsy sampling of the North Pacific right whales enabled the study of the level of genetic diversity in this endangered species.

Genetic samples from common minke whales obtained during the JARPNII have contributed to international collaborative studies on movement and hybridization among minke whale species and sub-species (Annex 1).

A number of published studies on physiology, reproductive biology and phylogeny of baleen whales were conducted based on JARPNII samples and data (Annex 1).

6. ACKNOWLEDGEMENTS

We thank scientists and crew members that participated in the JARPN and JARPNII field surveys as well those involved in laboratory and analytical work under these challenging research programs. They made possible the attainment of a very comprehensive data/sample sets as well of a substantial amount of new information on whales and the ecosystem in the western North Pacific. We also thank H. Moronuki and N. Okazoe (Fisheries Agency of Japan) for useful comments offered during the writing of this paper.

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Annex 1

List of documents for the JARPN II Review Workshop

Primary documents

Framework and methodology documents

SC/F16/JR1. Tamura, T., Kishiro, T., Bando, T., Yasunaga, G., Murase, H., Kitakado, T and Pastene, L.A. The Japanese Whale Research Program under Special Permit in the western North Pacific Phase-II (JARPN II): results and conclusions in the context of the three main objectives, and scientific considerations for future research.

SC/F16/JR2. Matsuoka, K., Hakamada, T. And Miyashita, T. Methodology and procedure of the dedicated sighting surveys in JARPN II (2008-2013) - Offshore component -.

SC/F16/JR3. Kishiro, T., Yoshida, H., Yasunaga, G., Bando, T., Mogoe, T. and Kato, H. Methodology and survey procedure under the JARPN II – coastal component of Sanriku and Kushiro-, during 2008 to 2014, with special emphasis on whale sampling procedures.

SC/F16/JR4. Bando, T., Yasunaga, G., Tamura, T., Matsuoka, K., Murase, H., Kishiro, T. and Miyashita, T. Methodology and survey procedures under the JARPN II - offshore component- during 2008 to 2014 with special emphasis on whale sampling procedures.

Objective 1: Feeding ecology and ecosystem studies

<u>*Oceanographic conditions*</u>

SC/F16/JR5. Okazaki, M., Masujima, M., Murase, H. and Morinaga, K. Oceanographic conditions in the JARPNII survey area from 2000 to 2013 using FRA-ROMS data.

SC/F16/JR6. Okazaki, M., Masujima, M., Murase, H. and Morinaga, K. Oceanographic conditions in the survey area of JARPNII coastal component off Kushiro in September from 2000 to 2013 using FRA-ROMS data.

<u>*Distribution and abundance of whales*</u>

SC/F16/JR7. Murase, H., Hakamada, T., Sasaki, H., Matsuoka, K. and Kitakado, T. Seasonal spatial distributions of common minke, sei and Bryde's whales in the JARPNII survey area from 2002 to 2013.

SC/F16/JR8. Murase, H., Hakamada, T., Matsuoka, K., Nishiwaki, S., Inagake, D., Okazaki, M., Toji, N. and Kitakado, T. Distribution of sei whales (*Balaenoptera borealis*) in the subarctic-sub-tropical transition area of the western North Pacific in relation to oceanic fronts. *Deep-Sea Research II* 107: 22-28, 2014.

SC/F16/JR9. Matsuoka, K., Hakamada, T. and Miyashita, T. Distribution of blue (*Balaenoptera musculus*), fin (*B. physalus*), humpback (*Megaptera novaeangliae*) and north Pacific right (*Eubalaena japonica*) whales in the western North Pacific based on JARPN and JARPN II surveys (1994 to 2014).

SC/F16/JR10. Sasaki, H., Murase, H., Kiwada, H., Matsuoka, K., Mitani, Y. and Saitoh, S. Habitat differentiation between sei (*Balaenoptera borealis*) and Bryde's whales (*B. brydei*) in the western North Pacific. *Fish. Oceanogr*. 22 (6): 496-508, 2013.

SC/F16/JR11. Hakamada, T. Matsuoka, K., Kishiro, T. and Miyashita, T. The number of western North Pacific common minke whales (*Balaenoptera acutorostrata*) distributed in JARPNII coastal survey areas.

SC/F16/JR12. Hakamada, T. and Matsuoka, K. The number of western North Pacific common minke, Bryde's and sei whales distributed in JARPNII offshore survey area.

SC/F16/JR13. Hakamada, T. and Matsuoka, K. The number of blue, fin, humpback, North Pacific right whales in the western North Pacific in the JARPN II offshore survey area.

SC/F16/JR14. Hakamada, T. and Matsuoka, K. The number of sperm whales in the western North Pacific in the JARPN II offshore survey area.

Prey consumption by whales

SC/F16/JR15. Tamura, T., Konishi, K. and Isoda, T. Updated estimation of prey consumption by sei, Bryde's and common minke whales in the western North Pacific.

SC/F16/JR16. Tamura, T., Murase, H., Sasaki, H. and Kitakado, T. Preliminary attempt of spatial estimation of prey consumption by sei whales in the JARPNII survey area using data obtained from 2002 to 2013.

Impact of prey consumption by whales on fisheries resources

SC/F16/JR17. Tamura, T., Kishiro, T., Yoshida, H., Konishi, K., Yasunaga, G., Bando, T., Saeki, M., Onodera, K., Mitsuhashi, M., Yamashita, Y., Funamoto, T. and Kato, H. Updated prey consumption by common minke whales and interaction with fisheries in coastal areas.

Biomass estimation of whale's prey species

SC/F16/JR18. Murase, H., Kawabata, A., Kubota, H., Nakagami, M., Amakasu, K., Abe, K., Miyashita, K. and Oozeki, Y. Basin-scale distribution pattern and biomass estimation of Japanese anchovy *Engraulis japonicas* in the western North Pacific. *Fish. Sci*. 78: 761-773, 2012.

SC/F16/JR19. Wada, A., Onodera, K., Saeki, M. and Tamura, T. Estimation of prey species biomass in the Sanriku region based on 2008 and 2009 JARPNII acoustic surveys.

Prey preference

SC/F16/JR20. Watanabe, H., Okazaki, M., Tamura, T., Konishi, K., Inagake, D., Bando, T., Kiwada, H. and Miyashita, T. Habitat and prey selection of common minke, sei, and Bryde's whales in mesoscale during summer in the subarctic and transition regions of the western North Pacific. *Fish. Sci.* 78:557-67, 2012.

SC/F16/JR21. Murase, H., Tamura, T., Kiwada, H., Fujise, Y., Watanabe, H., Ohizumi, H., Yonezaki, S., Okamura, H. and Kawahara, S. Prey selection of common minke (*Balaenoptera acutorostrata*) and Bryde's (*Balaenoptera edeni*) whales in the western North Pacific in 2000 and 2001. *Fish. Oceanogr.* 16 (2): 186-201, 2007.

SC/F16/JR22. Murase, H., Tamura, T., Isoda, T., Okamoto, R., Yonezaki, S., Watanabe, H., Matsukura, R., Miyashita, K., Kiwada, H., Matsuoka, K., Nishiwaki, S., Inagake, D., Okazaki, M., Okamura, H., Fujise, Y. and Kawahara, S. Prey preferences of common minke (*Balaenoptera acutorostrata*), Bryde's (*B. edeni*) and sei (*B. borealis*) whales in offshore component of JARPNII from 2002 to 2007. Document SC/J09/JR18.

Feeding habit of whales

SC/F16/JR23. Konishi, K. Isoda, T. and Tamura, T. Decadal change of feeding ecology in sei, Bryde's and common minke whales in the offshore of the Western North Pacific.

SC/F16/JR24. Tamura, T., Kishiro, T., Yoshida, H., Konishi, K. and Kato, H. Relationship between feeding habit and maturity status of common minke whale off Kushiro.

SC/F16/JR25. Ishii, M., Murase, H., Fukuda, Y., Sawada, K., Sasakura, T., Tamura, T., Bando, T., Matsuoka, K., Shinohara, A., Nakatsuka, S., Katsumata, N., Miyashita, K. and Mitani, Y. A short note on feeding behavior of sei whales observed in JARPNII.

SC/F16/JR26. Isoda, T., Tamura, T., Konishi, K., Ohizumi, H. and Kubodera, T. Feeding habits of sperm whale (*Physeter macrocephalus*) in the western North Pacific in spring and summer.

Body condition indicators of whales

SC/F16/JR27. Konishi, K. Analyses of body condition in sei, Bryde's and common minke whales in the western North Pacific with JARPN and JARPNII dataset.

Ecosystem modeling

SC/F16/JR28. Murase, H., Tamura, T., Hakamada, T., Watari, S., Okazaki, M., Kiyofuji, H., Yonezaki, S. And

Kitakado, T. Ecosystem modelling in the western North Pacific from 1994 to2013 using Ecopath with Ecosim (EwE): some preliminary results.

SC/F16/JR29. Kitakado, T., Murase, H., Tamura, T. Predation impacts on sand lance population by consumption of common minke whales off Sanriku region.

Objective 2: Monitoring environmental pollutants in cetaceans and the marine ecosystem

i) Pattern of accumulation of pollutants in cetaceans and ii) Bioaccumulation process of pollutants through the food chain

SC/F16/JR30. Yasunaga, G. and Fujise, Y. Temporal trend of Total Hg levels in three baleen whale species based on JARPNII data for the period 1994-2014.

SC/F16/JR31. Yasunaga, G. and Fujise, Y. Yasunaga, G. and Fujise, Y. Temporal trend of PCB levels in common minke whales from the western North Pacific for the period 2002-2014.

SC/F16/JR32. Yasunaga, G. and Fujise, Y. Accumulation features of POPs of baleen whales in the western North Pacific based on samples collected during the 2012 JARPNII survey.

SC/F16/JR33. Yasunaga, G. and Fujise, Y. Comparison of total Hg levels in O and J type stock of common minke whales based on JARPN II coastal samples collected in 2012 and 2013.

SC/F16/JR34. Yasunaga, G. and Fujise, Y. A note on POPs and Hg accumulation in sperm whale based on JARPNII samples collected during 2001-2013.

iii) Relationship between chemical pollutants and cetacean health

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Annex 2:

Brief outline of the research area, target species and sample size of JARPN II

Research area of JARPN II

In the western North Pacific, there are numerous fronts and water masses (Figure 1). The Kuroshio Current, which is one of the strongest west-boundary currents of the subtropical gyre, flows northward from the offshore area of the Philippines to the waters off Japan with warm high-salinity water. It turns eastwards off the Pacific side of Japan as the Kuroshio Extension. On the other hand the Oyashio Current flows southward along the Kurile Islands with cold low-salinity water. It branches into two flows off northern Japan. The Kuroshio and the Oyashio flow eastward, and the area between the Kuroshio Extension and Oyashio east of Japan is usually called the Kuroshio-Oyashio Inter-frontal Zone or simply the Transition Zone. It is well-known that these areas have a high productivity and are feeding grounds for highly migratory species such as Pacific saury, skipjack tuna and baleen whales.

The research area of JARPN II covered the Kuroshio, the Oyashio and the Transition Zone (Figures 1). It also covers part of sub-areas 7, 8 and 9 used by the IWC for management purposes, see Figure 2).

The research area for the feeding ecology study in the full JARPN II was extended eastward to 170ºE to cover the geographical distribution of fisheries resources caught by Japanese fisheries. In particular, Pacific saury is distributed in sub-areas 8 and 9 in summer just before they are recruited to the fishery in autumn (Sugisaki and Kurita, 2004). The eastward extension of the research area was also important for more detailed studies on stock structure of the target species that allowed us to investigate additional structure in offshore waters.

Time frame of JARPN II

The full JARPN II research plan was designed as a long term research program of undetermined duration (Government of Japan, 2002a). The habitats of marine living resources around Japan are quite diversified and their relationships are very dynamics. The long term research is necessary to investigate these complex relationships and the fluctuations of biological processes in time so that ecosystem models can be adjusted for such fluctuations. Annual fluctuations in abundance, distribution, prey consumption, prey species, etc., are large. Therefore long-term monitoring of these and other environmental variables involved is necessary. In order to incorporate the results into the ongoing surveys, however, the research plan included a comprehensive review following completion of the first six years of the research. The time frame of JARPN II is as follows:

2000-2001: Feasibility study (Government of Japan, 2000; 2002b)
2002-2007: First full research period (Government of Japan, 2002a)
After 2007: Comprehensive review and output for fisheries resource management in the western North Pacific
2008-2013: Research plan of second period improved by taking into account results of the first period

Target whale species and rational for sample sizes in the whale survey component
The JARPN II started with two feasibility surveys in the spring/summer seasons of years 2000 and 2001. The research plan for the two-year feasibility study was presented to the 2000 Meeting of the IWC SC as Document SC/52/O1 (Government of Japan, 2000).

The target species and sample sizes for the feasibility study were the common minke whale (*Balaenoptera acutorostrata*, n=100), Bryde's whale (*B. edeni*, n=50) and the sperm whale (*Physeter macrocephalus*, n=10). These species were chosen for sampling because they occupy an important niche in the pelagic zone of the North Pacific and because their populations are relatively abundant (Government of Japan, 2000). Regarding the sperm whales previous reports showed that this species fed mainly on neon flying squids around the Joban area (sub-area 7) in winter (Okutani et al., 1976). The abundance of sperm whales was estimated to be 102,000 (Kato and Miyashita, 1998). Under the assumption that the neon flying squid was 5 % of their prey consumption, the total consumption was estimated to be eight hundred thousand tons, equivalent to roughly eight times the total estimated recent neon flying squid fisheries catch in the western North Pacific. There was therefore a need to collect more data on the food habits of sperm whales to investigate the role of this species in the ecosystem, in particular to evaluate the impact of their consumption on neon flying squids.

The two-year JARPN II feasibility surveys were conducted in order to make the full JARPN II successful by i) examining the performance and practicability of the concurrent whale and prey surveys using a total of six research vessels, and ii) assessing whether such concurrent surveys provide enough data to determine prey preferences. The feasibility study was also conducted to evaluate the performance of the whale survey under the situation when the number of target species increased from one in the JARPN to three in the JARPN II (Government of Japan, 2000). This evaluation was important given the practical and logistical problems involved when the number of target species is increased.

A comprehensive report of the results of the two-year feasibility study was presented to the 2002 IWC/SC Meeting as Document SC/54/O17 (Government of Japan, 2002b). The report of the feasibility study concluded that the concurrent prey and whale surveys were feasible and that information on feeding ecology of Bryde's and sperm whales could be obtained in the same way as it had been obtained for minke whales (Government of Japan, 2002b). Given these positive results the full 'Research Plan for Cetaceans Studies in the Western North Pacific under Special Permit (JARPN II) was implemented from 2002. The full research plan of JARPN II plan was presented to the IWC SC in 2002 as Document SC/54/O2 (Government of Japan, 2002a).

The target species and sample sizes for the full JARPN II were the common minke whale (n=100 pelagic; 50 coastal), Bryde's whale (n=50), sei whale (*B. borealis*, n=50) and the sperm whale (n=10).

This research plan involved two new components:

a) Sampling of 50 sei whales.
b) Sampling of 50 common minke whales by small type whaling catcher boats in coastal waters as a two-year feasibility study (50 whales to be sampled each in fall 2002 and spring 2003, respectively)

Abundance (biomass) and ecological niche in the western North Pacific were two criteria for choosing the sei whale as a target species of JARPN II. Their biomass is larger than those of the common minke and Bryde's whales, and the past information indicated that they feed on schooling fish and squid as well as krill in the JARPN II research area and on copepods in the Northern North Pacific (Government of Japan, 2002a).

The coastal component for common minke whales was necessary to cover the temporal (late autumn, early spring) and spatial gaps in sampling, which cannot be covered by the pelagic research base Nisshin Maru (Government of Japan, 2002a).

It should be noted that some elements of the full JARPN II were defined as feasibility studies *e.g.* sampling of minke whale under the coastal component in 2002 and 2003 to investigate the feasibility of sampling using small catcher boats. The sample size for minke whales in the coastal component was also considered as preliminary and further calculation should be made after new data were obtained in the two-year feasibility survey were accumulated. Also the sperm whale sampling to investigate the relationship and impact of sperm whales on the surface ecosystem was still considered as a feasibility study (Government of Japan, 2002a).

Considerations related to the feasibility components of the JARPN II were presented to the IWC SC Meeting in 2004 as Document SC/56/O2 (Government of Japan, 2004a). It was concluded that research surveys using small type whaling catcher boats was feasible. Furthermore geographical and/or temporal variations of prey species of the minke whales revealed during the feasibility coastal surveys were considered to re-calculate the sample sizes of minke whales for the coastal component of the research. Also data on stomach content of sei whales collected in the 2002 and 2003 surveys were used to calculate sample size of this species using the new information on stomach contents. Finally it was decided to keep the sampling of a small number of sperm whales, which was useful at least for qualitative studies on feeding ecology of this species (Government of Japan, 2004a).

Based on these considerations a revised research plan for cetacean studies in the western North Pacific under Special Permit was presented to the same meeting as Document SC/56/O1 (Government of Japan, 2004b). The objectives of the research were the same as specified in Government of Japan (2002b), but the following new research elements were added:

a) Sample size for the minke whale in the coastal component was increased to 120, with 60 each in spring and autumn, respectively (in 2004, 60 animals would be sampled in fall and from 2005, 60 each in spring and fall, respectively).
b) Sample size for sei whales was increased to 100.

Rational for sample size of common minke whales:

During the feasibility study (2000-2001) the sample size was calculated for estimating their prey consumption with good precision (CV equal to, or less than 0.2) using the method developed by Norwegian scientists during their feeding ecology study of common minke whales in the North Atlantic (Government of Norway, 1992). Data on prey consumption obtained during the JARPN in sub-area 7 (Figure 2) was used. Data was divided into two, based on seasons - spring and summer. Two types of data were used for the calculation: number of whales feeding on each of the prey species (krill, Pacific saury and Japanese anchovy), and average stomach contents weight with its standard deviation. On the basis of these estimations a sample size of 100 animals for the total research area (sub-areas 7, 8 and 9, Figure 2) was determined (Government of Japan, 2000).

For the full JARPN II a similar procedure was used but this time using a larger data set. A sample size of 100 animals was determined for the offshore research area (Government of Japan, 2002a). The sample size for the coastal minke whale component was calculated using a similar procedure with and data obtained in the Sanriku region and coastal region of Hokkaido in 2000 and 2001. A sample size of 50 animals was determined for the inshore part of sub-area 7 (Government of Japan, 2002a).

Results of the 2002 (fall, Kushiro) and 2003 (spring, Sanriku) coastal surveys revealed geographical and temporal changes of prey species of minke whales. Required sample size was then recalculated with these data to secure statistical accuracy for constructing ecosystem models. Based on these results the revised JARPN II research plan concluded that the coastal survey component would be conducted twice a year and that 60 whales would be sampled in early and late seasons, respectively, beginning with the survey in the fall 2004 (Government of Japan, 2004a; 2004b) .

Rational for sample size of Bryde's whales:

A similar procedure as that used for the minke whale was used to calculate the necessary sample size for Bryde's whales in order to obtain statistically reasonable results. Calculation for the feasibility study was based on data on prey consumption obtained during the period of commercial whaling. Preliminary sample size of 50 was determined (Government of Japan, 2000). During the full research plan recalculations were conducted based on data on consumption collected during the feasibility studies. A sample size of 50 was determined (Government of Japan, 2002a).

Rational for sample size of sei whales:

Calculation of sample size for this species in the full JARPN II was made using a similar procedure as above with data on prey consumption from the Bryde's whale. A sample size of 50 was determined. Given the scarcity of consumption data for this species, the calculation of sample size was considered as preliminary (Government of Japan, 2002a).

In the revised plan sample size was recalculated using data from the 2002 and 2003 surveys to secure statistical accuracy for constructing ecosystem models. New calculation of sample size for sei whales using data from these two surveys showed that at least 100 sei whales per year were required for estimating prey consumption with sufficient precision (CV=0.2). The sample size of sei whale increased because the study in 2002 and 2003 indicated that a wider variety of prey species was consumed by the sei whale than had been known in the past (Government of Japan, 2004a; 2004b).

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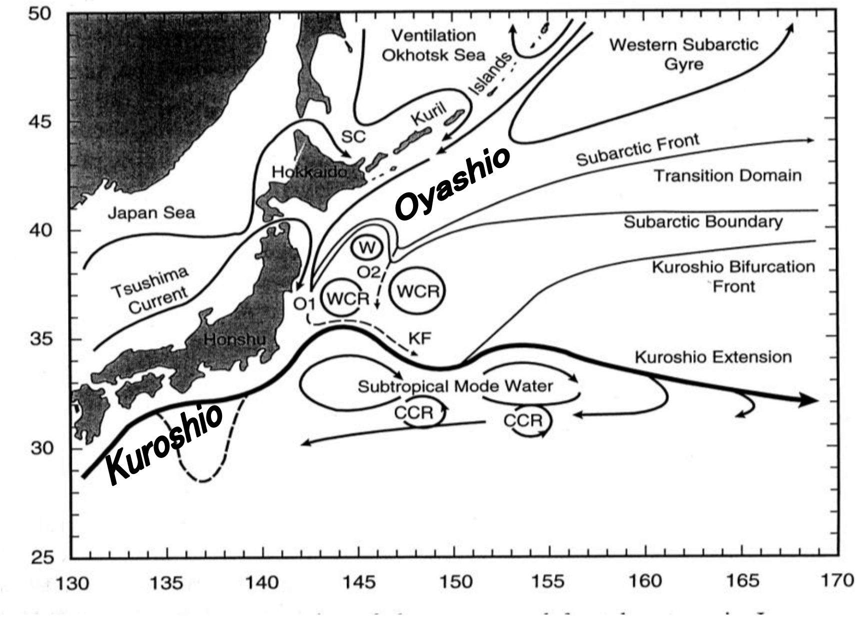

Figure 1: Schematic representation of the current and frontal systems in the western North Pacific (Yasuda *et al*., 1996; modified from Endo, 2000). SC: Soya Current, TW, O1: Oyashio first branch, O2: Oyashio second branch, WCR: warm core ring, CCR: cold core ring, KF: Kuroshio Front.

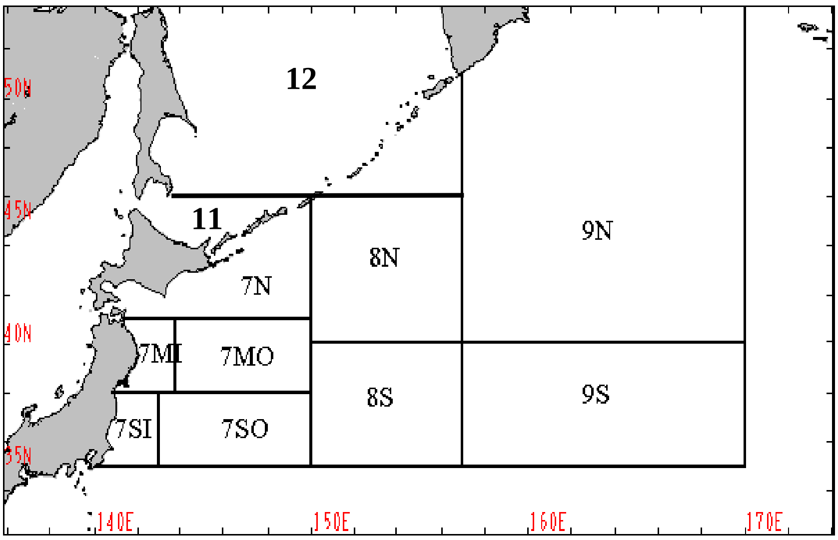

Figure 2: The research area and strata for the full-scale JARPN II surveys.

Annex 3:

A summary of samples/data collected by JARPN II (2000-2014)

Some samples and data obtained by JARPN II are not related to the main research objectives of JARPN II or to other main research need, and these items are not listed here but they are available for research collaboration with ICR under data access protocols of ICR (http://www.icrwhale.org/pdf/appendix2.pdf), outside the context of the IWC SC review workshop.

The table below shows the research items and sample sizes by each item for the period 2000-2014.

1. Outline of the data

I-1. SIGHTING DATA-Offshore components (SV+SSV)

Data	Sample size
Weather data (no. observations)	85,219
Effort data (Searching distance (n. miles))	202,403
Sighting data (no. of school)	15,594
Angle and distance experiments	6,031
Photo-ID blue whales (no. of schools photographed)	107
Photo-ID humpback whales (no. of schools photographed)	65
Photo-ID North Pacific right whales (no. of schools photographed)	50

I-2. SIGHTING DATA-Coastal components (Sanriku)(SV)

Data	Sample size
Weather data (no. observations)	1,008
Effort data (Searching distance (n. miles))	3,048
Sighting data (no. of school)	110
Angle and distance experiments	88

I-3. SIGHTING DATA-Coastal component (Kushiro SV)

Data	Sample size
Weather data (no. observations)	2,150
Effort data (Searching distance (n. miles))	5,155
Sighting data (no. of school)	353
Angle and distance experiments	112

I-4. SIGHTING DATA-Coastal component (Sanriku)(SSV)

Data	Sample size
Weather data (no. observations)	4,769
Effort data (n. miles)	32,665
Sighting data (no. of school)	642

I-5. SIGHTING DATA-Coastal components (Kushiro)(SSV)

Data	Sample size
Weather data (no. observations)	4,847
Effort data (n. miles)	33,378
Sighting data (no. of school)	985

Note 1=Sighting data (no. of school) are on baleen, sperm, and killer whales.
Note 2=Sighting data of the coastal components surveyed by SSVs were not obtained by strict line transect surveys.
Note 3=Sighting data on sei and Bryde's whales obtained during IWC/POWER would be available depending on progress of data validation by the IWC Secretariat.

II-1. BIOLOGICAL DATA - Common minke whale (Offshore component)

Data and sample	Sample size		
	Male	Female	Total
Sampling date	861	121	982
Sampling location	861	121	982
Body length	861	121	982
Body proportion (19 measurements)	861	121	982
Skull (length and width)	847	119	966
Body scar record	861	121	982
Record of external body characters	861	121	982
Sex	861	121	982
Body weight	861	121	982
Organ weight	180	29	209
Blubber thickness (5 points)	861	121	982
Girth	861	121	982
Maturity stage	861	121	982
Corpora albicantia and lutea (presence/absence only)	-	15	15
Corpora albicantia and lutea (presence/absence and number)	-	106	106
Lactation condition	-	121	121
Testis weight	861	-	861
Stomach contents (IWS format)	861	121	982
Stomach contents weight	861	121	982
Main prey species in stomach contents	861	121	982
Freshness of stomach contents	861	121	982
Energy contents of prey species	-	-	16
Foetus number, sex, body length, body weight	-	-	51
Aspartic acid isomers ratios (lens of fetus)*			13
Age (from Ear plug)**	409	55	464
Total PCB concentrations (blubber)	546	0	546
Total Hg concentrations (muscle)	680	0	680
PCBs, DDTs, HCB, HCHs and CHLs concentrations (blubber)	5	0	5
I-131, Cs-134 and Cs-137 concentrations (muscle)	8	2	10
Mitochondrial DNA control region sequences	855	121	976
Nuclear DNA microsatellite (16 loci)	855	121	976

*: Analysis of samples is ongoing.
**: 2000-2013.

II-2. BIOLOGICAL DATA - Sei whale (Offshore component)

Data and sample	Sample size		
	Male	Female	Total
Sampling date	551	623	1,174
Sampling location	551	623	1,174
Body length	551	623	1,174
Body proportion (19 measurements)	551	623	1,174
Skull (length and width)	534	603	1,137
Sex	551	623	1,174
Body weight	551	623	1,174
Organ weight	77	104	181
Blubber thickness (5 points)	551	623	1,174
Girth	551	623	1,174
Maturity stage	551	623	1,174
Corpora albicantia and lutea (presence/absence only)	-	205	205
Corpora albicantia and lutea (presence/absence and number)	-	418	418
Lactation condition	-	623	623
Testis weight	551	-	551
Stomach contents (IWS format)	551	623	1,174
Stomach contents weight	551	623	1,174
Main prey species in stomach contents	551	623	1,174
Freshness of stomach contents	551	623	1,174
Energy contents of prey species	-	-	20

Prey species estimating by next generation sequencing (NGS)	8	2	10
Behavioral data using acoustic tags			2
Foetus number, sex, body length, body weight	-	-	366
Age (from Ear plug)*	335	348	683
Total Hg concentrations (muscle)	160	-	160
PCBs, DDTs, HCB, HCHs and CHLs concentrations (blubber)	5	0	5
I-131, Cs-134 and Cs-137 concentrations (muscle)	12	13	25
Mitochondrial DNA control region sequences	551	622	1,173
Nuclear DNA microsatellite (16 loci)	551	623	1,174

*: 2002-2013.

II-3. BIOLOGICAL DATA - Bryde's whale (Offshore component)

Data and sample	Sample size		
	Male	Female	Total
Sampling date	289	391	680
Sampling location	289	391	680
Body length	289	391	680
Body proportion (19 measurements)	289	391	680
Skull (length and width)	278	375	653
Sex	289	391	680
Body weight	289	391	680
Organ weight	60	77	137
Blubber thickness (5 points)	289	391	680
Girth	289	391	680
Maturity stage	289	391	680
Corpora albicantia and lutea (presence/absence only)	-	87	87
Corpora albicantia and lutea (presence/absence and number)	-	304	304
Lactation condition	-	391	391
Testis weight	289	-	289
Stomach contents (IWS format)	289	391	680
Stomach contents weight	289	391	680
Main prey species in stomach contents	289	391	680
Freshness of stomach contents	289	391	680
Energy contents of prey species	-	-	13
Prey species estimating by next generation sequencing (NGS)	2	4	6
Foetus number, sex, body length, body weight	-	-	169
Total Hg concentrations (muscle)	49	0	49
PCBs, DDTs, HCB, HCHs and CHLs concentrations (blubber)	5	0	5
I-131, Cs-134 and Cs-137 concentrations (muscle)	6	7	13
Mitochondrial DNA control region sequences	284	387	671
Nuclear DNA microsatellite (16 loci)	289	391	680

II-4. BIOLOGICAL DATA - Sperm whale (Offshore component)

Data and sample	Sample size		
	Male	Female	Total
Sampling date	16	40	56
Sampling location	16	40	56
Body length	16	40	56
Body proportion (18 measurements)	16	40	56
Skull (length and width)	16	38	54
Sex	16	40	56
Body weight	16	40	56
Organ weight	10	26	36
Blubber thickness (11 points)	16	40	56
Girth	16	40	56
Maturity stage	13	40	53
Corpora albicantia and lutea (number)	-	40	40
Lactation condition	-	40	40
Testis weight	16	-	16
Stomach contents (IWS format)	16	40	56
Stomach contents weight	16	40	56
Main prey species in stomach contents	16	40	56
Freshness of stomach contents	16	40	56

Energy contents of prey species	-	-	10
Foetus number, sex, body length, body weight	-	-	10
Age (from tooth)*	4	19	23
Total Hg concentrations (muscle)	1	4	5
PCBs, DDTs, HCB, HCHs and CHLs concentrations (blubber)	1	2	3
I-131, Cs-134 and Cs-137 concentrations (muscle)	1	2	3
Mitochondrial DNA control region sequences	16	40	56
Nuclear DNA microsatellite (15 loci)	16	40	56

*: 2000-2013.

II-5. BIOLOGICAL DATA - Common minke whale (Coastal component-Sanriku)

Data and sample	Sample size		
	Male	Female	Total
Sampling date	221	295	516
Sampling location	221	295	516
Body length	221	295	516
Body proportion (19 measurements)	221	295	516
Skull (length and width)	215	286	501
Body scar record	221	295	516
Sex	221	295	516
Body weight	221	295	516
Organ weight	7	10	17
Blubber thickness (5 points)	221	295	516
Girth	221	295	516
Maturity stage	221	295	516
Corpora albicantia and lutea (number)	-	295	295
Lactation condition	-	295	295
Testis weight	219	-	219
Stomach contents (IWS format)	221	295	516
Stomach contents weight*	205	281	486
Main prey species in stomach contents	221	295	516
Freshness of stomach contents	221	295	516
Energy contents of prey species	-	-	3
Prey species estimating by next generation sequencing (NGS)	1	2	3
Foetus number, sex, body length, body weight	-	-	44
Age (from Ear plug)**	94	123	217
Aspartic acid isomers ratios (lens)***	46	48	94
Total Hg concentrations (muscle)	195	48	280
Total Hg concentrations (liver)	46	48	94
PCBs, DDTs, HCB, HCHs and CHLs concentrations (blubber)	5	0	5
I-131, Cs-134 and Cs-137 concentrations (muscle)	7	6	13
Mitochondrial DNA control region sequences	221	295	516
Nuclear DNA microsatellite (16 loci)	221	295	516

* : 2003-2013. Analysis of 2014 samples is ongoing.
**: 2003-2013.
***: Analysis of samples is ongoing.

II-6. BIOLOGICAL DATA - Common minke whale (Coastal component-Kushiro)

Data and sample	Sample size		
	Male	Female	Total
Sampling date	438	219	657
Sampling location	438	219	657
Body length	438	219	657
Body proportion (19 measurements)	438	219	657
Skull (length and width)	430	215	645
Body scar record	438	219	657
Sex	438	219	657
Body weight	438	219	657
Organ weight	17	8	25
Blubber thickness (5 points)	438	219	657

Girth	438	219	657
Maturity stage	438	219	657
Corpora albicantia and lutea (number)	-	219	211
Lactation condition	-	219	211
Testis weight	438	-	429
Stomach contents (IWS format)	438	219	657
Stomach contents weight*	403	203	606
Main prey species in stomach contents	438	219	657
Freshness of stomach contents	438	219	657
Energy contents of prey species	-	-	3
Prey species estimating by next generation sequencing (NGS)	3	3	6
Foetus number, sex, body length, body weight	-	-	14
Age (from Ear plug)**	172	78	250
Total Hg concentrations (muscle)	377	0	377
PCBs, DDTs, HCB, HCHs and CHLs concentrations (blubber)	5	0	5
I-131, Cs-134 and Cs-137 concentrations (muscle)	12	13	25
Mitochondrial DNA control region sequences	438	219	657
Nuclear DNA microsatellite (16 loci)	438	218	656

* : 2002-2013. Analysis of 2014 samples is ongoing.
**: 2002-2013.

III. POLLUTANT DATA (Environmental and prey species samples)-Offshore components

Data and sample	Sample size
Total Hg concentrations (krill)	8
Total Hg concentrations (fishes)	19

IV-1. OCEANOGRAPHIC DATA- Offshore components

Data and sample	Sample size
Temperature & salinity (XCTD survey)	47
Temperature & salinity (CTD survey)	761
Midwater trawl (# of hawls)	262
MOTH trawl (# of hawls)	16
MOCNESS (# of hawls)	36
IKMT (# of hawls)	34
NORPAC (# of hawls)	254
Other nets (VMPS, Ring, BONGO) (# of hawls)	36
Echo sounder (2002-2007: km)	12,838
Echo sounder (2008-2013: n.miles)	8,098

Others nets: VMPS 12, ring net 8, BONGO net 16

Note 4=2008 cruise: *Shunyo-Maru* and *Kaiko-Maru*; 2009, 2012, 2013 cruises: *Shunyo-Maru*; 2010, 2011 cruises: *Hokko-Maru*.

IV-2. OCEANOGRAPHIC DATA- Coastal components (Sanriku)

Data and sample	Sample size
Temperature & salinity (XCTD survey)	11
Temperature & salinity (CTD survey)	325
Midwater trawl (no. of hawls)	109
Bongo net (no. of hawls)	5
IKMT (no. of hawls)	17
Sampling by fishing (no. of stations)	2
Echo sounder (2005 and 2006 seasons: km)	277.5
Echo sounder (2008 and 2009 seasons: n.miles)	354.3

IV-3. OCEANOGRAPHIC DATA- Coastal components (Kushiro)

Data and sample	Sample size
Temperature & salinity (CTD survey)	109

Midwater trawl (no. of hawls)	133
IKMT (no. of hawls)	6

V-1. GENETIC DATA- North Pacific right whale

Data and sample	Sample size
Mitochondrial DNA sequences	20

Note 5= Data of some items for common minke whales are also available for the JARPN period (1994-1999), which were reviewed by the IWC SC in 2000 (IWC, 2001).

Note 6= Genetic data from other sources have been used to complement the previous genetic analyses on stock structure of baleen whales. These data would be also available for the review.

Annex 4:
Protocol for access to samples/data from the Institute of Cetacean Research (ICR), Tokyo, Japan, under Procedure B (Item 3)

INTRODUCTION

This protocol has been developed in the context of Procedure B of the IWC Scientific Committee's rules for data availability adopted at the 55th Annual Meeting (IWC, 2004a). Procedure B applies to data required for analyses deemed important in providing advice to the Committee other than catch limits. Conditions for data recipients (repeated below) as specified in the rules for data availability are applicable.

It was agreed that the Committee shall specify the nature of the work and the data required during the meeting at which the recommendation is made, to the fullest extent possible in the time available at the meeting and in accord with the published protocol. Requests to the ICR for data under Procedure B of the Scientific Committee's rules for data availability shall be submitted by the Data Availability Group assisted by a nominated member of ICR.

It was also agreed that if the correct process is followed, the data owners will normally approve the applications within a 'specified time period'; in this case ICR agrees that it will respond within two weeks of receiving an application.

FORMAT OF THE APPLICATION

The format for the application is based on the revised application for catch-at-age analyses agreed by all members of the Scientific Committee at the end of the Scientific Committee meeting in 2003 (IWC, 2004b, Appendix.10).

(a) *Title* of the proposal, giving the broad subject of the proposed analyses.

(b) *Investigators:* the full name and affiliation of the principal investigator(s) and co-investigator(s) should be provided. This should include at least one scientist from ICR.

(c) *Objectives and rationale of the study* as specified by the by the Scientific Committee along with the appropriate reference to the report(s) of the Scientific Committee. This will include the reasons why the proposed analyses are important and how they fit into previous work.

(d) *Data to be used* will include a general description of all data to be used as well as data held by ICR. For the ICR-held data, the precise requirements will be given, including the level of disaggregation.

(e) *Description of the methods* likely to be used. The level of detail must be in accordance with the level of novelty of the proposed methods and the particular research questions they will address. References to similar analyses should be included where available.

(f) *Schedule of the work:* this should include estimated times for the various analyses to be carried out and an indication of which investigators will collaborate on individual components. If the project is a long-term project, annual progress reports will be required by ICR and the Scientific Committee.

(g) *Output of the research:* this will follow the rules for publication agreed at the Scientific Committee meeting and given below. ICR may consider requests for less stringent conditions (*e.g.* presentations at non-IWC scientific meetings, publications, etc.). Such requests should be detailed here.

CONSIDERATION OF THE PROPOSAL

If an application has been approved by the whole Scientific Committee at an annual meeting, it will normally be approved by ICR. However, the final decision will always remain the prerogative of ICR. ICR may request reviews by an internal review group and/or external experts. The following factors will be taken in to account by ICR when considering applications.

(a) *Priority*: highest priority for analysis/research of samples/data produced by Japan's Whale Research Programs under Special Permit, will be for the scientists that collected and obtained the data in any particular field.

(b) *Suitability of the requested data in the context of the proposed methods and the objectives of the research.*

(c) *Level of co-operation with ICR scientists.*

The response to an application for data will be communicated by the ICR's Director General to the Data Availability Group and may include requests for further information. If the research proposal is accepted, ICR will nominate a scientist, (normally one of the co-investigators) who shall be responsible for making the necessary arrangements to provide the required samples/data.

Agreed Scientific Committee conditions for data recipients

Applications deemed suitable under Procedure A or Procedure B below are granted under the following conditions:

(1) Data shall not be transmitted to third parties.

(2) Papers may only be submitted to a Committee meeting in accordance with the time restrictions given below. Such papers must not include the raw data or the data in a form in more detail than is necessary to understand the analysis.

(3) Papers must carry a restriction on citation except in the context of IWC meetings.

(4) Data owners are offered co-authorship.

(5) Publication rights remain strictly with the data owner.

(6) Data shall be returned, to the Secretariat or the data owner as appropriate, immediately after the meeting at which the paper is submitted and any copies destroyed, unless an extension is granted.

(7) Data requesters sign a form agreeing to the above conditions. Such forms will be held by the data owner and the Secretariat. In the case of Procedure B, the Data Availability Group will sign the agreement on the Committee's behalf and ensure that the conditions of any agreement are met by any individual scientists involved in the analysis.

(8) In the event of a breach of the conditions in (6), serious sanctions [to be determined] will apply.

Literature cited

International Whaling Commission. 2004a. Report of the Scientific Committee. *J. Cetacean Res. Manage*. (Suppl.) 6: 57-8.

International Whaling Commission. 2004b. Report of the Scientific Committee. Annex G. report of the Sub-committee on the comprehensive assessment of whale stocks – In-depth assessments. *J. Cetacean Res. Manage*. (Suppl.) 6: 224-245.

Annex 5:

Summary of the work carried out by Japanese scientists in response to several recommendations and suggestions on JARPNII research offered by the 2009 JARPNII review workshop (IWC, 2010).

Recommendation or suggestion	Response status
1. Feeding ecology and ecosystem studies	
Whale abundance and distribution issue	
1. Using the sightings data collected over the 1994-2007 period for the variety of large whales, the Panel **recommends** investigation of whether these data can be used to provide information on trends.	Geographic coverage of JARPNII survey was not always the same among the years. For this reason, it would be necessary to pool sighting data to obtain full geographical coverage to examine abundance trend. Possible approach may be that in SC/F16/JR9, in which sighting data were stratified by periods of 7-9 years.
2. It also **recommends** that the photo-identification data be worked up and comparisons made with catalogues elsewhere in the North Pacific.	Photo-identification data for blue, humpback and North Pacific right whales have been collected during JARPNII surveys. The number of the collected photo-ID data were provided in Annex 3. Collaboration between Russian and Japanese scientists is being prepared to conduct preliminary analysis of photo-id data for North Pacific right whales. Also analysis of photo-id data for blue and humpback whales will be conducted, and data from IWC-POWER surveys will be incorporated (in collaboration with IWC-POWER specialists).
3. Panel **recommends** that increased effort to obtain better estimates should be a high priority.	After 2009 survey, design was made so that research areas were covered with sufficient effort by the dedicated sighting surveys. However, this depended on logistic aspects, for example on the availability of survey vessels.
Prey consumption by cetaceans	
4. Panel **recommends** that additional analyses be undertaken to identify the greatest sources of uncertainty and to determine appropriate sampling and analytical strategies to address them.	Uncertainties in the number of whales distributed in the research area, body weight of whales, consumption models, and energy content of prey species, assimilation efficiency and the ratio of low/high feeding intake of whales were taken into account in the updated estimation (SC/F16/JR15, 17).
5. The Panel **recommends** that as part of the treatment of uncertainty, the analyses of the JARPN II data should: (a) incorporate the use of several reasonable models and include the range of possible results in reporting their work; (b) use that range in subsequent analyses (including any ecosystem modelling) that employ these daily/annual consumption estimates and (c) undertake sensitivity analyses for the range of parameter values used in the consumption equations.	Addressed in SC/F16/JR15, 17. See also response to recommendation 4.
Medium and long term	
6. Combine the oceanographic data, prey distributions and sighting survey data statistically to investigate how prey and whale distributions are associated with oceanographic conditions, and how whale distributions are related to distributions of prey–in this regard the sei whale example spatial modelling approach given in SC/J09/JR36 needs to be refined and extended further.	The analyses were recommended as medium to long term. The recommendation was addressed to some extent in published documents (SC/F16/20-21), a document presented to the 2009 review workshop (SC/J09/JR18) and documents presented to this workshop (SC/F16/JR7, SC/F16/JR16 and SC/F16/JR27). All these studies but JR7, J16 and JR27 were conducted at the mesoscale.
7. Combine data on prey distributions as observed in the area where the whales were caught with the diet of the whales (referred to as the micro scale) statistically to evaluate how well the whale diet reflects prey availability in the area where it was caught.	Response to recommendation 6 above is also relevant here.
8. Compare results from the approaches	Not addressed yet.

listed above with the results on selectivity already produced and presented at the workshop.	
Ecosystem modelling	
9. Considerably more resources must be allocated to the modelling work – without this, the likelihood that the objective of the programme will be reached in a reasonable timeframe will be minimal. The models developed should be used to identify the areas of uncertainty with the greatest impact on model outputs of relevance to management, and hence to guide the prioritisation of future data collection and the associated sample size/sampling design.	Regarding the collection of data, collaboration with specialists in other disciplines (*e.g.* oceanography, pelagic fish and highly migratory fish [sharks and tunas]) has been strengthened for EwE modelling.
10. A wider range of models needs to be considered if the objectives of the programme are to be met. Further work should aim towards fitting dynamic models to time series of data, especially abundance indices.	Results of two modeling exercises were presented here (SC/F16/JR28-29) and a third one (MRM) is being considered for the near future. Time series data from 1994 to 2013 was fitted in Ecosim to estimate vulnerability parameters which is one of important parameters in the model.
11. The area covered by JARPNII is not spatially homogeneous, and serious consideration should be given to developing separate models for three regions distinguished by the inshore or shelf region, the sub-Arctic oceanic region of the Oyashio current and the sub-tropical region of the Oyashio and Kuroshio transition zone.	A quasi sub-model structure is established in EwE considering bottom topography and oceanography of the modelled area.
12. There is a need to take much wider account of uncertainty at all stages of the modelling process, including that associated with the prey consumption rates of whales	Uncertainty is not addressed fully in EwE although vulnerability parameters are estimated in Ecosim. In SC/F16/JR29, both observation and process errors were accounted for using a Bayesian state-space delay-difference model, and estimation uncertainty was of course addressed in posterior distributions for unknown and latent variables as in usual way.
13. The importance, ultimately, of developing models which incorporate natural variability in dynamic processes was emphasised, although it was recognised that this might not be possible for certain ecosystem modelling 'packages'. This is in addition to taking account of uncertainty in model structure and parameter values. The complexity of ecosystems and the difficulty of modelling species interactions adequately might mean that management actions based on such models are more likely to induce unexpected instabilities than current single-species based approaches; this suggests a more cautious approach will be needed on the part of decision makers.	A climate index, the Pacific Decadal Oscillation (PDO) index, is initially considered whether it can be used as forcing function in Ecosim. However, it is not considered in actual modelling because it appear that influence of PDO on biomass dynamics in the modelling period (1994-2013) is not strong. But it is still on the to-do list in the further modelling especially if the modelling period is expanded to the past.
14. If there are other predators making individual contributions to sand lance natural mortality of similar size to that estimated for minke whales, their explicit inclusion in this model must be considered. It agrees that Type I functional relationships are unrealistic and need not be considered further. As noted earlier, any results presented	Type II functional response is employed in the state-space delay-difference model in SC/F16/JR29, but any predator other than common minke whales has not been taken into account for the assessment of predation impact because of its potentially biggest consumption in the region.

should distinguish yields of the prey species to predators and the fishery.	
15. It is important to concentrate first on improving the Ecopath component of this EwE analysis before moving on to the next step of extending the modelling effort from a static to a dynamic model such as Ecosim.	A series of pre-balance diagnostics, "PREBAL" (Link, 2010) is conducted for both the 2013 and 1994 models to evaluate the initial satanic energy budget of Ecopath before Ecosim modelling is conducted.
16. The species included in the Ecopath analysis should be reviewed giving attention to Ecopath models developed for other regions; in particular the inclusion of gelatinous zooplankton should be considered. Furthermore the values of the parameters of this Ecopath analysis should be compared with values for those others, with attention directed towards any instances of major discrepancies.	Because EwE mainly focuses on offshore instead of coastal area, it appears that gelatinous zooplankton is not key species. In addition, such data are scarce so far. Presented EwE modelling mainly focus on interaction between forage fish and their predators and the number of predators in the model is increased from the previous one. Values of basic parameters are compared with other models qualitatively.
17. The need to rebalance the Ecopath model. Alternative approaches to doing so should be considered. For example, rather than use values for some parameters drawn from other regions, placing a bound on some relationship (e.g. P/C<0.6) may lead to an improved result overall.	A series of pre-balance diagnostics, "PREBAL" (Link, 2010) is conducted for both the 2013 and 1994 models to evaluate the initial satanic energy budget of Ecopath before Ecosim modelling is conducted.
18. Further analyses must take full account of the uncertainties associated with model inputs e.g. using Ecoranger	Ecoranger is not used in the modelling as its development is little so far.
19. Further work on MRM approaches is encouraged and should focus in particular on fitting such models to time series of data.	In a MRM off Sanriku region, various kinds of time series data such as CPUE, catch series and age composition were used for fitting the model. The model is considered as an integrated model, where weighting to likelihood components is influential to the results. At this moment, this issue has not been dealt well in the paper, but different effective sample sizes will be used to check the sensitivity/robustness
Oceanography	
20. The salinity CTD data must be corrected/calibrated using the water samples that were simultaneously collected with the CTD data.	In principle, the salinity data recorded under JARPNII were calibrated. Quality checks are carried out for input data of the FRA-ROMS.
21. The authors incorporate into the index of density, the sightability of detected groups (e.g. effective strip half widths that include appropriate covariates such as weather conditions). As for all modelling exercises, it is important to test whether the chosen model is an improvement over a null, uninformative model and to validate the model results. Approaches to such validation could include: comparison of the modelled results not only with index of densities from the present study but also with data that were collected from other years (e.g. JARPN or other survey data) and exploration of cross-validation type techniques.	In abundance estimation using standard method (i.e. design based method), Beaufort Sea State was used as a covariate of detection function. Beaufort Sea State was selected as one of covariates for some of species (see SC/F16/JR11-14). SC/F16/JR7 conducted Generalized Additive Model (GAM) for relative abundance estimation of the common minke, sei and Bryde's whales. Model selection was conducted based on GCV scores. Sea surface temperature (SST) and seafloor depth was selected as covariates of the GAM for the common minke and sei whales. SST, sea surface height anomaly (SSHa), sea surface chlorophyll-a concentration (Chl-a) and the seafloor depth were selected for the GAM for Bryde's whales.
22. More of these types of analyses (including using other appropriate modelling techniques such as GAMs or logistic regressions) be conducted.	GLM and GAM has been considered and some of the results were published in scientific literatures. Spatial distributions of common minke, sei and Bryde's are attempted and the results are presented to this meeting (SC/F16/JR7). Furthermore, prey consumption of sei whales is preliminary estimated (SC/F16/JR16).
Others	
23. JARPNII data be pooled or	Several of the analyses in the documents presented to this

compared with other datasets (e.g. JARPN I or other historical surveys) when possible. This will increase the sample size and increase the possibility of data covering periods of changing relationships (e.g. previous regime changes), thus allowing patterns to be detected.	workshop used pooled data from JARPN and JARPNII.
24. In the long term, to more fully understand the preferred habitat, prey preferences, niche separation of different species, functional response, and spatial and temporal trends in local abundance and other biological factors (such as blubber thickness, pollutants, presence of scars, and stock structure), the oceanographic data collected on the cruises (bottom depth, water column temperature, salinity, and density) and satellite derived data, such as SST, chlorophyll, and sea surface height be integrated into future analyses.	The analyses were also recommended as medium to long term. The recommendation was addressed to some extent in published documents (SC/F16/20-21), a document presented to the 2009 review workshop (SC/J09/JR18) and documents presented to this workshop (SC/F16/JR7, SC/F16/JR16 and SC/F16/JR27). All these studies but JR7, JR16 and JR27 were conducted at the mesoscale.
2. Monitoring environmental pollutants in cetaceans and the marine ecosystem	
1. Study based on balanced , structured study design with a specific number of individuals sampled within each strata	In the pollutant studies, the number of samples and strata (location, period, sex, and maturity) examined was carefully considered in function of the objective of the study.
2. Tissues should be archived for future retrospective analyses	All tissues and organs such as muscle, liver, kidney and blubber of all whales sampled by JARPNII were stored at -20ºC. Unfortunately a substantial number of samples were lost after the 2001 earthquake and tsunami.
3. Include age as an additional covariate for the interpretation of results	Age was incorporate as a covariate in the analyses conducted in SC/F16/JR33.
4. Include coastal J stock bycaught minke whales in future studies	Samples from by-catch are available only for genetic analyses and such samples are not suitable for pollutant analyses. However J stock animals (24) sampled by JARPNII in Sanriku were used for pollutant analysis (Hg) (see SC/F16/JR33).
5. Include data on stable isotope ratios and fatty acid profiles from a variety of tissues	Samples from JARPN/JARPNII have not been analyzed for stable isotope ratios and fatty acid yet (logistic reasons). Future analyses are being considered.
6. Air and water samples obtained could have been useful in a 'fate and behaviour' study	This was already addressed in SC/J09/JR24. However such kind of analyses have been stopped because logistical reasons.
7. Conduct simple mass balance studies (input-output estimates)	Preliminary attempts were made but results were not satisfactorily at this stage. Further attempts will be made in future.
8. Contaminant results should eventually be linked to the prey consumption studies	Addressed in SC/F16/JR30 and SC/F16/JR31.
3. Stock structure	
Simple issues	
1. Brief description of procedures to ensure data quality	Addressed in document SC/65b/DNA1. The IWC SC welcomed this document and agreed that it responded appropriately to the recommendation.
2.Include estimate of genetic divergence	Addressed in papers presented to the IWC SC after 2009. See also SC/F16/JR40 for common minke whales; SC/F16/JR44 for Bryde's whale; SC/F16/JR46 for sei whales.
3. P values and divergence estimates should be reported for all loci combined than for each locus separately	Addressed in papers presented to the IWC SC after 2009. See also SC/F16/JR40 for common minke whales; SC/F16/JR44 for Bryde's whale; SC/F16/JR46 for sei whales.
4. Use alternative procedure to Bonferroni corrections in case of multiple testing	The recommended False Discovery Rate (FDR) was used in all population genetic structure papers presented to this workshop.

5. Provide more details on the analyses involving the program STRUCTURE	More details were provided in papers presented to the IWC SC after 2009. See also SC/F16/JR38 for the application of the STRUCTURE program to individual assignment to J and O stocks common minke whale.
6. Include a brief discussion on experimental design with respect to sampling	Sampling design in JARPNII was made mainly in the context of main objective 1. For the key species, samples obtained by JARPNII were examined for stock structure purposes based on the IWC SC's designed sub-areas used for management purpose.
More extensive matters	
7. Redo the analyses based on the Boundary Rank analysis	In discussion at the IWC SC after 2009, this task was not assigned to JARPNII workers.
8. Integrate samples from Korea bycatches into the datasets	Samples from Korean bycatches were incorporated in several genetic studies presented to the IWC SC after 2009.
9. Assessment of power using simulated data should be undertaken	See SC/F16/JR40 for O stock minke whale; SC/F16/JR44 for Bryde's whale.
10. Tests for population genetic equilibrium should be undertaken	Preliminary analyses presented in SC/F16/JR51.
11. Estimations of divergence between samples partitions should be undertaken using non-equilibrium approaches	Not addressed yet. Will be addressed in future following the discussions on JR51.
12. Effort to detect pairs of individuals that are related	Work has been started but results are not available for this workshop.
13. Multivariate analyses of morphological data could be informative with respect to stock structure; use a principle component (or similar) analysis of individuals that does not require *a priori* decisions about group membership	Addressed in SC/F16/JR41.
14. Use of contaminant data as part of an integrative study of stock structure	Previous studies showed that DDT levels in whales could be informative of stock structure. In recent years and for logistic reasons, samples have not been analyzed with DDT in appropriate numbers for stock structure studies.
Longer term	
15. Effort to attach satellite tags to minke whales	Work has been started. Successful experiment were conducted for North Pacific Bryde's (SC/F16/JR45) and common minke (SC/F16/JR42) whales.
4. Others	
1. Development of refined, more quantified sub-objectives for each component of the programme	Addressed in this paper.

References

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