SC/66a/Rep/6

Report of the Expert Panel to review the proposal by Japan for NEWREP-A, 7-10 February 2015, Tokyo, Japan

International Whaling Commission

INTERNATIONAL WHALING COMMISSION

Report of the Expert Panel to review the proposal by Japan for NEWREP-A

Executive Summary (taken from Item 8)

The Panel recognised the considerable work that had been undertaken by the proponents in developing the NEWREP-A proposal. However, as summarised under Items 8.1-8.7 and detailed in the body of the report, the present proposal contains insufficient information for the Panel complete a full review. The Panel has made a number of important **recommendations** for additional work that the Panel believes are **essential to be completed** before a full review of the programme under Annex P and Resolution 2014-5 can be completed. The recommended analyses can be conducted with existing samples/data and new non-lethal sampling efforts.

In terms of timelines, the Panel recognises the value in maintaining long-term datasets. However, the Panel **agrees** that if there is a short (e.g. 2-3 year) gap in the existing series to enable the recommended analyses to be completed related to fully quantifying and prioritising sub-objectives and determining appropriate techniques (lethal or non-lethal), this will not have serious consequences for monitoring change. The Panel therefore **agrees** that the recommendations in Table 1 should be completed and the results evaluated before there is a final conclusion on lethal techniques and sample sizes. This consideration does not affect the non-lethal components of the proposal, which can be undertaken without discontinuation of the current research. The Panel’s view on the need for new samples and/or data feasibility, relevance, and contributions to the RMP, scientific research and conservation and management for aspects of Primary Objective I and II are summarised in Tables 2 and 3, respectively.

In summary, with the information presented in the proposal, the Panel was not able to determine whether lethal sampling is necessary to achieve the two major objectives; therefore, the current proposal does not demonstrate the need for lethal sampling to achieve those objectives.

The Workshop was held in the Toyomi Center Building, Tokyo from 7-10 February 2015.

1 INTRODUCTORY ITEMS

1.1 Chair's opening remarks

The Workshop was chaired by Palka, ex-Chair of the IWC Scientific Committee. She explained that normally the chair of Special Permit review Workshops was the present Scientific Committee Chair, who at this time is Kitakado. However, since Kitakado was a member of the proponents, the Scientific Committee agreed that the previous Committee Chair would be an appropriate chair for this review Workshop. Palka then welcomed the Panel members, observers and Japanese proponents to Tokyo and thanked the Fisheries Agency of Japan for hosting the Workshop. Morishita, the IWC Commissioner for Japan, also welcomed the Panel and all participants.

The Chair noted that this is the first review of a new Special Permit under the 'Annex P' process and thus the terms of reference differ from reviews of final or ongoing Special Permit programmes. The Chair also noted that the Commission passed Resolution 2014-5 that identified additional issues that the Scientific Committee should provide advice on. Although the instructions in Resolution 2014-5 are to the Scientific Committee, the Panel will also provide advice on these issues.

The Chair explained that she would follow the previous Workshop format i.e. two types of sessions:

(1) open sessions where a limited number of scientists associated with the proposal present the programme and answer questions from the Panel – this would also be open to observers; and

(2) closed sessions where only the Panel members discuss the proposal and develop their report.

She referred to the 'Annex P' guidelines which state that Scientific Committee observers will 'not normally participate in discussions unless invited to do so by the Chair under special circumstances'. She was pleased to note that six papers from Committee members had been submitted to the Workshop and that most of the authors of those papers were present at the Workshop. Several of these papers were presented by the authors and they provided valuable input into the Panel's discussions.

1.2 Objectives of the Workshop

The Terms of Reference for new proposals as stated in 'Annex P' are: "The primary objective of the expert Workshop will be to review the proposal in the light of the stated objectives, following the guidelines in the *pro forma* provided by the Secretariat. In particular, the Panel shall:

(1) comment briefly on the perceived importance of the stated primary objectives from a scientific perspective and for the purposes of conservation and management, noting particularly its relevance to the work of the Scientific Committee;

(2) provide advice and suggestions on components of the programme that might be achieved using non-lethal methods, including, where appropriate, power analyses and time-frames;

(3) determine whether the proposed field and analytical methods are likely to achieve the stated quantified objectives within the proposed time-frame, where appropriate, commenting on sample size and time-frame considerations;

(4) provide advice on the likely effects of the catches on the stock or stocks involved under various scenarios of length of the programme – this will include *inter alia* examination of abundance estimates provided and may involve a different analysis to that provided in the original proposal, including assumptions that short permit proposals may be projected further into the future; and

(5) review the proposed intermediary targets and suggest when an intermediate review or reviews should take place."

In the first operative paragraph of Resolution 2014-5, the Commission "instructs the Scientific Committee, in its review of new and existing special permit research programmes, to provide advice to the Commission on:

(a) whether the design and implementation of the programme, including sample sizes, are reasonable in relation to achieving the programme's stated research objectives;

(b) whether the elements of the research that rely on lethally obtained data are likely to lead to improvements in the conservation and management of whales;

(c) whether the objectives of the research could be achieved by non-lethal means or whether there are reasonably equivalent objectives that could be achieved non-lethally;

(d) whether the scale of lethal sampling is reasonable in relation to the programme's stated research objectives, and non-lethal alternatives are not feasible to either replace or reduce the scale of lethal sampling proposed; and

(e) such other matters as the Scientific Committee considers relevant to the programme, having regard to the decision of the International Court of Justice, including the methodology used to select sample sizes, a comparison of the target sample sizes and the actual take, the timeframe associated with a programme, the programme's scientific output; and the degree to which a programme coordinates its activities with related research projects."

1.3 Overview of process for providing advice to the Commission

The first component of the process is the present small specialist Workshop (which, according to Annex P, is to be held at least 100 days before the Scientific Committee meeting). This Workshop is to be composed of a limited number of invited experts chosen by a Standing Steering Group (SSG), a limited number of proponent scientists, primarily to present the proposal and answer points of clarification; and a limited number of observers. Based on the field work and analytical methods stated in the proposal, in accordance with Annex P, the SSG drew up a shortlist of potential Panel members. Final selection was governed by availability (many of the potential nominated members were unable to attend), the need for balance (including between Scientific Committee and non-Scientific Committee members) and the available funds. The final Panel is listed in Annex A and comprised of three scientists who had never participated in the Scientific Committee, one scientist who had infrequently and not recently participated in Scientific Committee meetings and four regular members of the Scientific Committee; this was in addition to the Workshop Chair and Head of Science. In addition to the Panel members that participated in person at the meeting in Tokyo, Dr. Jonathan Watkins, from the British Antarctic Survey in the UK, provided feedback on the krill survey aspects of the NEWREP proposal.

Nine members of the Scientific Committee attended as observers; their names are given in Annex A, as are the names of the proponent scientists who attended the open sessions.

The report of the Workshop is to be made available to the proponents by 3 March 2015, 80 days before the Scientific Committee meeting. The proponents are able to comment on the Panel report and to revise documents for submission to the Scientific Committee in light of comments within the Panel's report. Then the final Panel report, associated comments from proponents and any additional documents developed as a result of recommendations are then to be made available to the Scientific Committee by 13 April 2015. The Scientific Committee may make additional comments during its Annual Meeting. Then the final Panel report, comments by proponents and comments by the Scientific Committee itself will be sent to the Commission.

1.4 Available documents

In addition to the NEWREP-A proposal submitted to the IWC by the Government of Japan, the documents made available to the Workshop were papers from Scientific Committee members, SC/F15/SP01 – SC/F15/SP06, and papers from the proponents that were in response to the Scientific Committee papers SC/F15/SP07 – SC/F15/SP11. The list of documents is given as Annex B. The proponents and some of the observers that had submitted documents prepared PowerPoint presentations on the major topics. It was agreed that with permission of the authors, these presentations would be made available to observers as well as Panel members but would be treated in a confidential manner.

1.5 Structure of report

For most items in the report, the first section is a summary of the relevant part of the NEWREP-A by the proponents – the Panel has not edited those sections and they represent the views of the proponents only; these sections are shown in a different font. The final sections of each item represent the comments and conclusions of the Panel. The only exception to this is Item 8, which presents the overall conclusions of the Panel alone.

2 CONSIDERATION OF OBJECTIVES AND SUB-OBJECTIVES AND THE RELATIONSHIP AMONGST THEM

A general overview of the NEWREP-A proposal as presented by the proponents is given as Annex C.

2.1 Primary objective 1 – RMP-related

2.1.1 Presentation by proponents

The rational of the Main ('Primary') Objective I "Improvements in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales' is given in section 2.1 of the NEWREP-A plan. The plan highlights the significance of this objective by describing (i) the adoption of commercial whaling moratorium and introduction of the RMP; (ii) the basic idea of RMP catch limits for the Antarctic minke whales; and (iii) the necessity of improvement in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales.

Regarding to (i) the plan notes that "the Commercial Whaling Moratorium" was established by adopting Paragraph 10(e) of the Schedule of the ICRW in 1982. Its text reads: "Notwithstanding the other provisions of paragraph 10, catch limits for the killing for commercial purposes of whales from all stocks for the 1986 coastal and the 1985/86 pelagic seasons and thereafter shall be zero. 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."

During discussions at the IWC that resulted in the establishment of the commercial whaling moratorium, it was argued that the scientific information for the management of whales was uncertain and therefore scientific knowledge should be accumulated while suspending all commercial whaling. This is specifically reflected in the text of Schedule 10(e) as quoted above.

With this awareness, the RMP was finalized in 1992 by the IWC SC for the purpose of undertaking "a comprehensive assessment" of the effects of its decision on whale stocks (reflected by the population models underlying the RMP *ISTs*"), and the establishment of non-zero catch limits, as stipulated in paragraph 10(e) (IWC, 1986; 1987; 1988a). The RMP is a risk averse, powerful and important management tool developed by the IWC SC. The full RMP process is composed of three steps: (i) *pre-implementation assessment*, (ii) implementation process including the *Implementation Simulation Trials* (*ISTs*), and iii) application of the *Catch Limit Algorithm* (*CLA*) based on the output from steps (i) and (ii). The implementation process (ii) above takes two years to be completed. Each of the steps requires data identified in the Requirements and Guidelines for Implementations under the Revised Management Procedure (IWC, 2012d).

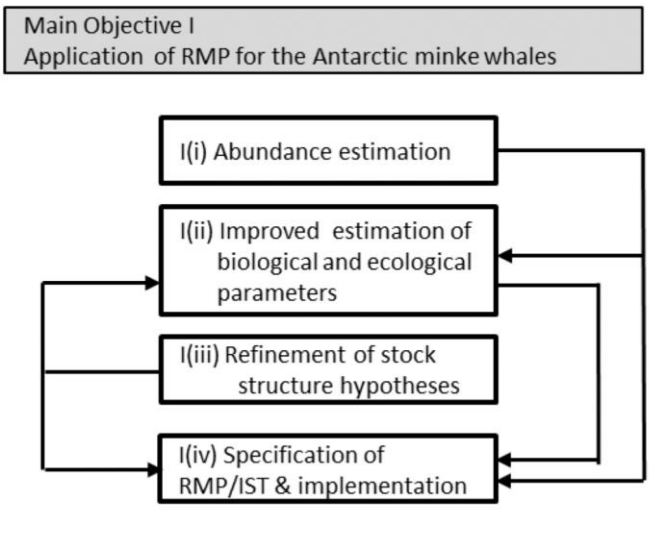
Regarding to (ii) the plan explains the basic concepts behind the RMP as well the data required for its implementation (see detail in section 2.1.2 of the NEWREP-A plan).

The plan notes that under the RMP the most conservative whaling scenarios are selected as a precautionary approach, when there is uncertainty in the biological and ecological information required in the RMP *ISTs* such as stock structure and reproductive parameters (uncertainty is related to the limited amount of data, which in turn implies less precision in the parameters). In other words, further biological and ecological information will contribute to reducing uncertainty, and therefore less conservative whaling scenarios can be used, which usually provide larger catch limits. In this way, additional data to be obtained under this new research program could be used to increase the allowable catch limits of Antarctic minke whales without increasing the depletion risk. This will be in line with one of the IWC's management objectives for commercial whaling under the RMP, which is "making possible the highest possible yield from the stock" (IWC, 1988b, p.36).

IWC Resolution 1997-5 "INSTRUCTS the Scientific Committee not to consider Southern Hemisphere minke whales in the context of implementation of the RMP unless advised to do so by the Commission" (IWC, 1998). However, in this sense, it should be noted that NEWREP-A does not request the IWC SC to conduct the *implementation* of the RMP on Antarctic minke whales. Furthermore, the general RMP issues of improving the SCAA analysis and investigating means to incorporate ecosystem effects into the RMP have been recognized as high priority issues by the IWC SC (see for example Item 13.2 in IWC, 2014c) and results from this new research program are expected to contribute to the IWC SC discussions.

Regarding to (iii) the plan discusses in more details the biological and ecological information that could improve the application of the RMP to the Antarctic minke whales, namely abundance data, biological parameters such as natural mortality and MSYR, and stock structure (see detail in section 2.1.3 of the NEWREP-A plan).

Table 1 of the NEWREP-A plan summarizes the current information on the key data: abundance, biological and ecological parameters, stock structure and specification of *ISTs*. The table also identifies those aspects that potentially can be clarified with past data and new data to be collected under NEWREP-A for each of those items.



The research items correspond to Objectives under Main Objective I:

I (i): Abundance estimates for Antarctic minke whales taking into account of g(0) and additional variance.

I (ii): Improvement of precision of biological and ecological parameters of Antarctic minke whale (part 1: improvement of age data precision, and part 2: refinement of the SCAA model and estimation of biological parameters.

I (iii): Refinement of stock structure hypotheses in Areas III-VI for the implementation of the RMP.

I (iv): Specification of RMP ISTs for Antarctic minke whales

Furthermore each of the Objectives is composed of sub-objectives (see Annex C).

In summary the RMP is a management procedure which guarantees sustainability with safe levels of catch limits over a period of 100 years (IWC, 2012e). While considerable data and information are already available through past research, more refined information over a longer period is necessary for improvement of the RMP *Implementation* (see Table 1 of the NEWREP-A plan).

Therefore, the Main Objective I aims at providing required data for application of the *ISTs* and improving the assessment process under the RMP *Implementation*. Furthermore, the actual catch limits will be derived from the achievement of this research objective. The specific data and samples required in NEWREP-A for the Main Objective I are amplified in section 2.4 of the NEWREP-A plan.

2.1.2 Comments and conclusion by Panel

The Panel **welcomes** the clearer identification of primary objectives and sub-objectives in NEWREP-A compared to previous proposals, partly in response to recommendations of previous expert review workshops (IWC, 2014a; 2015b). In this part of its report the Panel will comment briefly on the importance of the primary objectives and sub-objectives. The questions of proposed methods and feasibility of achieving objectives within the proposed timeframe are dealt with elsewhere in the report.

Primary objective 1 relates to the improvement in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales. As the proponents note, the Commission has instructed the Committee not to work on the implementation of the RMP without being told to do so. The Panel **recognises** that this is an internal IWC matter, but **notes** the value of the RMP approach for examining potential anthropogenic removals including but not limited to commercial whaling i.e. the RMP approach has broad potential for conservation and management. The Committee is undertaking an in-depth assessment of Antarctic minke whales and the Statistical Catch-at-age (SCAA) approach, which has been developed under the guidance of the Committee, has been central to this.

In terms of objectives and sub-objectives, the Panel **agrees** that obtaining good estimates of abundance (and trends) is central to successful conservation and management (Objective 1 (i)) and to the Committee's assessment work. The Panel also **agrees** that good information on stock structure, including information on mixing within the feeding grounds is also especially important for any assessment approach. Whilst the RMP does not require perfect knowledge of stock structure, examination of the results of *Implementations* and *Implementation Reviews* for other species and ocean areas (IWC, 2014c; 2015c) has shown that the performance of the RMP in terms of user objectives is increased with no effect on conservation performance as stock structure uncertainty is reduced. This is also true as the number of abundance estimates accumulate.

With respect to the work related to improved precision of parameters such as mortality, age at sexual maturity, changes in *K* and MSYR, it is the latter two that have been shown to be the most important with respect to RMP performance. However, these are also extremely difficult to estimate, as witnessed by several efforts to consider MSYR made by the Committee (e.g. IWC, 2009; 2010a; 2011b; 2014b). Whilst the NEWREP-A proposal does discuss improvements in some biological parameters, it does not evaluate the level of improvement that might be expected either in the SCAA or in RMP performance by improved precision in biological parameters which is an important component of evaluating the importance of this part of the proposal. The Panel **recommends** that this be done by the proponents using simulation studies. Step one might involve the proponents developing *ISTs* based on existing information (including that developed under JARPA and JARPAII), while step 2 might be to examine how performance might improve with expected reduction of uncertainty in particular parameters. Such work will also enable improved estimation of sample size (see Item 4).

2.2 Primary objective 2 – Ecosystem-related

2.2.1 Presentation by proponents

Explanation and the rationale of the Main ('Primary') Objective II "Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models' are given in section 2.2 of the NEWREP-A plan.

The importance of the investigation of the Antarctic marine ecosystem is highlighted in section 2.2.1 of the NEWREP-A plan. JARPA and JARPA II have found, through their lethal and non-lethal research components, the possibility of ongoing and substantial changes in the Antarctic marine ecosystem as reflected by annual shifts in the distribution and migration of the main species of whales (*e.g.* Antarctic minke, humpback, and fin whales) (Murase *et al.*, 2014) and through changes in the nutritional condition of minke whales (Konishi *et al.*, 2014; Konishi *et al.*, 2008; Konishi and Walløe, 2014). Such findings indicate that whales are crucial species in understanding the changes in the Antarctic marine ecosystem.

One important indicator of shifts in the ecosystem is ASM. In fact, it has been estimated that ASM in the Antarctic minke whales changed from 12 years old to 7 years old between 1946 and 1970 and stabilized subsequently until now (Thomson *et al.*, 1999; Zenitani and Kato, 2006). It has been hypothesized that such changes occurred in response to change in nutritional condition, which improved among Antarctic minke whales after the depletion of large whales, such as blue and humpback whales, which fed on the same prey, the Antarctic krill.

Furthermore in view of potential ecosystem functions in the Antarctic marine ecosystem such as climate control and sustainable provisions of useful natural resources, it is of vital importance to investigate the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models.

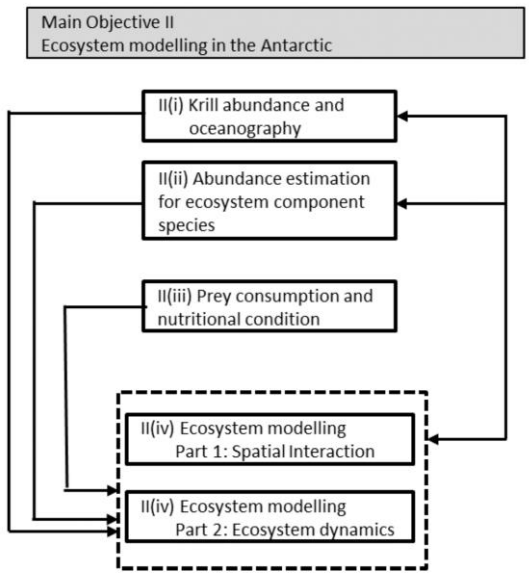
While numerous attempts have been made to build ecosystem models in the Antarctic and other marine areas, it is well recognized that the exercise is not simple and requires substantial investment of time, data, analysis and trials. In section 2.2.2 of the NEWREP-A plan, several approaches for building ecosystem models are discussed and summarized.

NEWREP-A states that in view of examining multi-species competition among whales, it is important to collect relevant information on humpback and fin whales. This is mainly because it has been observed that they have increasing biomass and are in possible competition with other whale species over space and krill for food in the Antarctic marine ecosystem. Data on distribution and abundance for these species will be obtained by the non-lethal component of the program and this program will also seek to utilize proxies derived from existing scientific knowledge accumulated through JARPA and JARPA II on other species of whales in the Antarctic and the same species in other seas at this stage, pending the result of the mid-term review in 6 years.

NEWREP-A therefore attempts to build ecosystem models through analysing data (data required under the Main Objective II is listed under section 2.4 of the NEWREP-A plan) in the Antarctic Ocean; 1) modelling spatial interaction among baleen whales and 2) estimation of multi-production models with consideration of the predator-prey system and allometric reasoning.

Ecosystem modelling was one of the primary objectives in the JARPAII. However, it became evident that the lack of information on krill abundance and its trend caused difficulty in the identification of key parameters in the model. In this new research proposal, the krill survey component is strengthened to obtain that type of information. In addition, observations of the body condition of Antarctic minke whales conducted in JARPA and JARPA II are proposed to continue, and improvement of the indicators of body condition and nutrition level through the collection and use of blubber thickness and stomach contents will be attempted so as to detect an effect on the prey consumption by the Antarctic minke whales. It should also be noted that such an effort will further contribute to the better interpretation of ASM data that is an important indicator, as mentioned above, of the Antarctic marine ecosystem. These data are to be integrated for better ecosystem modeling and estimation.

It is important to reiterate that the Objective II has also scientific significance regarding the elucidation of the Antarctic marine ecosystem as a whole from mid-and long-term perspectives, despite current uncertainties in the models investigated, as recognized among IWC SC scientists (IWC, 2014e).



Within Main Objective II, several Objectives are identified:

II (i): Krill abundance estimation and oceanographic observation.

II (ii): Abundance estimate of some cetacean species as input data for ecosystem modelling.

II (iii): Estimation of prey consumption by Antarctic minke whale and its nutritional condition.

II (iv- part 1): To study the spatial interaction among baleen whales.

II (iv- part 2): Investigation of ecosystem dynamics in the Antarctic Ocean.

Furthermore each of the Objectives is composed of sub-objectives (see Annex C).

The importance of collaboration with CCAMLR under Main Objective II is highlighted in section 2.2.3 of the NEWREP-A plan. On the other hand there are scientific discussions on the need to incorporate factors such as interactions with other whale species into the RMP process and also into the RMP itself. Research outputs from Main Objective II could contribute to this aim (see details in section 2.2.4 of the NEWREP-A plan).

2.2.2 Comments and conclusion by Panel

Primary Objective II relates to building ecosystem and multispecies models to investigate ecosystem dynamics. The Panel **notes** that there is a clear distinction between 'ecosystem' and 'multispecies' models. So-called 'whole-of-ecosystem' models (such as Ecosim with Ecopath) give a broad picture of ecosystem functioning, but have high and often unquantifiable levels of uncertainty arising from the need to parameterise many ecosystem processes in the absence of data. In contrast, multispecies models only consider a portion of the ecosystem, typically several competing predators and a limited number of prey species. This smaller scale represents each species at finer resolution than is possible within whole-of-ecosystem modelling, and the results from multispecies models are typically expected to have higher precision and reliability than those from ecosystem models. However, being constrained to a limited number of species may mean that such models ignore key interactions. Combining the two approaches (as in NEWREP-A) gives the possibility of examining different aspects of ecosystem functioning in the most comprehensive and reliable manner possible.

The Panel **agrees** that main Objective II is an important topic of research. Given that whales are major predators in the region studied, they are a critical component of any ecosystem understanding or modelling work. Such modelling is also a key part of investigating the hypothesis of increasing competition between whale species. Finally, in the context of a global trend towards more ecosystem-based management, producing such ecosystem models would be a precursor for introducing ecosystem topics into management. The IWC Scientific Committee is investigating ways in which ecosystem considerations can be incorporated into the RMP (IWC, 2015c).

In terms of objectives and sub-objectives, Objectives II (i), II (ii) and II (iii) relate to gathering data on the ecosystem, while II (iv) and II (v) relate to constructing ecosystem and multispecies models. In terms of the data gathering objectives, the Panel **agrees** that obtaining good estimates of abundance and distribution (and trends) in the main food supply (Objective II (i)), time series of abundance of different whale species (Objective II (ii)), and prey consumption and nutritional condition (Objective II (iii)) are key inputs to constructing multispecies models, and form an important subset of the data required for whole-of-ecosystem models. The Panel **recommends** that species for which abundance estimates are obtained in II (ii) match with the species to be modelled in Objectives II (iv) and II (v). Objective II (iii) on prey consumption and nutritional condition relates to a number of related but distinct factors (total consumption, diet composition, predator condition, the impact of changing condition on the predators) which are all important to understanding and modelling the ecosystem.

Spatial interaction (Objective II (iv)) is obviously an important part of understanding and modelling competition and interactions between whale species. Constructing ecosystem and multispecies models (Objective II (v)) is important for understanding ecosystem dynamics in several ways. Simply constructing the models (especially the whole-of-ecosystem models) requires making explicit all of the functional links between the components, and gives an overview of the ecosystem function. The Panel **recommends** that once the models are constructed, different model formulations (e.g. with different functional relationships) should be used to examine different hypotheses of ecosystem functioning and to identify knowledge gaps. The Panel **notes** that multispecies, and especially ecosystem modelling, is a field in development, and that it is difficult to specify in advance exactly what the outcomes will be over the course of a 12-year project. However the Panel **agrees** that if the proposed Objectives can be achieved, this would make an important contribution towards understanding the ecosystem of the Southern Ocean. Whilst the NEWREP-A proposal does discuss the background for the ecosystem and multispecies modelling, it is lacking in details of the model structure proposed and the issues associated with the data needed to parameterise the models.

3 METHODS (FIELD, LABORATORY AND ANALYTICAL) TO ADDRESS OBJECTIVES INCLUDING CONSIDERATION OF NON-LETHAL ALTERNATIVES AS APPROPRIATE

3.1 Stock structure

3.1.1 Presentation by proponents of lethal methods proposed (genetics, morphometry)

The proposal for the research on stock structure using DNA and morphometric analyses is presented in Appendix 6 of the NEWREP-A plan.

The most recent results of the research on stock structure of Antarctic minke whales were based on JARPA and JARPAII samples, genetics based on mtDNA control region sequencing and microsatellite DNA, and morphometrics based on ten body measurements. Results were presented and discussed at the JARPAII review workshop, and subsequently at the 2014 IWC SC Meeting (Pastene *et al.*, 2014); (IWC, 2015b; 2015c; Kitakado *et al.*, 2014e). The hypothesis accepted by the IWC SC is the occurrence of at least two stocks in the JARPAII research area (35°E-145°W), with the cores of these stocks distributed in the western (Indian or 'I' stock) and eastern (Pacific or 'P' stock) sectors of the research area (see Figure 1 in Appendix 6). There is a soft boundary between these stocks in Areas IVE and VW with the mixing proportion between stocks in these sectors changing by year and sex (Kitakado *et al.*, 2014e).

Furthermore the JARPAII review workshop noted that 'management procedure considerations on stock structure focus on developing plausible interpretations of available data, not simply the single 'best' interpretation when examining uncertainty' (IWC, 2015b). In this spirit, at the JARPAII review workshop, an alternative hypothesis was proposed: a single stock that exhibits one-dimensional isolation by distance along a longitudinal gradient (IWC, 2015b).

Appendix 6 stated four sub-objectives under the Objective on stock structure of Antarctic minke whale, all of them aimed to refine the current stock structure hypotheses. Plausible hypotheses can then be used to develop *Implementation Simulation Trials* (*ISTs*) during the RMP *Implementation* process, which are aimed to span the uncertainty in different aspects, in this case the uncertainty in stock structure. There are three sub-objectives relevant to this agenda item:

a) *Investigation of the stock structure in Areas IIIW (0-35°E) and VIE (120°-145°W)*

The JARPAII review workshop commented that 'Antarctic minke whales are more-or-less continuously distributed around the Antarctic continent and that in contrast the JARPAII research area represents just under half of the circumpolar area'. They further noted that 'the lack of information provided for areas outside the programme's research area presents some inherent difficulties in fully meeting the objective to elucidate spatial and temporal variation in stock structure, even though the information developed under JARPAII is probably sufficient for the purposes of developing trials to evaluate RMP variants within the area of sampling' (IWC, 2015b). The examination of the stock structure of Antarctic minke whales in the areas immediately contiguous to the JARPAII area, *e.g*. Areas IIIW and VIE is considered useful to refine the current hypothesis on stock structure. This will allow the investigation of the longitudinal expansion of the I and P stocks, to the west and east, respectively. In addition, longitudinally-extended data sets would probably facilitate the analyses of the second hypothesis on isolation by distance proposed by the JARPAII review workshop.

SAMPLES AND DATA

As noted above, the analyses on stock structure have involved genetics and non-genetics (morphometric) methods. Both markers have been informative of the stock structure (Kitakado *et al.*, 2014e). Therefore, NEWREP-A proposes that the lethal sampling planned in each western and eastern parts every two years, be expanded at least in two years to cover Areas IIIW and VIE, respectively. This would allow the collection of genetic samples and detailed body measurements to investigate stock structure in the adjacent sectors.

Some genetic samples are available for those sectors from the time of commercial whaling, which could assist the genetic analysis. The distribution of those samples are restricted to the southern strata (see Figure 2 of Appendix 6). The quality and utility of the historical samples for DNA analysis on stock structure should be investigated at an early stage of the research (see details in Appendix 6).

LABORATORY WORK AND ANALYTICAL PROCEDURE

The routine procedure for mtDNA control region sequencing and genotype with a number of microsatellite loci, will be used. In the case of mtDNA the first 500bp at the 5' end of the control region will be sequenced. In the case of microsatellite DNA a set of 12 loci are used: AC045, AC082, AC087, AC137, CA234, DlrFCB14, EV1, EV104, GT23, GT129, GT195 and GT211. Details of the laboratory procedure for those two markers can be found in (Kanda *et al.*, 2014). Regarding morphometrics, up to 10 body measurements will be used, as in the past studies (e.g. Figure 2 in Kitakado *et al.*, 2014e).

b) Analytical procedures for microsatellite and mtDNA data will be similar to those explained in Pastene *et al*., (2014), which were discussed at the JARPAII review workshop and at the 2014 IWC SC meeting. Also some analytical procedures recommended at the JARPAII review workshop i.e. genetic analyses of isolation-by-distance (Rousset, 2000) will be considered. Phylogenetic analyses will be also conducted using several methods.

c) *Investigation of the spatial and temporal pattern of mixing between the I and P stocks in Areas IVE and VW*

As reported above, modeling work based on genetic and morphometric data showed an area of mixing between the I and P stocks in Areas IVE and VW, with the area of mixing and mixing proportion changing by year and by sex ('soft boundary'). The concept of a 'soft boundary' is a new one within the RMP *Implementation* process. A long-term data series of spatial and temporal pattern of mixing in Areas IVE and VW would be required to capture the uncertainty in stock structure and mixing for use in the *ISTs.*

SAMPLES AND DATA

Research take will be conducted alternatively in Areas IV and V. At least in two years of the total research period sampling will be designed to cover both Area IVE and VW. Morphometric and genetic data obtained from the whales sampled can be examined in conjunction with the relevant data from JARPA (16-year period) and JARPAII (6-year period) to create a long-term data series to examine temporal and spatial pattern of stock mixing in the relevant longitudinal sectors.

ANALYTICAL PROCEDURE

The method developed by Schweder *et al*. (2011), improved following suggestions from the IWC SC (Kitakado *et al.*, 2014e), will be used. Several recommendations provided by the JARPAII review workshop will be taken into consideration in the use of this analytical approach.

Sub-objective d) involves the use of lethal techniques as well.

d) Application of new genetic techniques to assist the analyses and interpretation of results in the sub-objectives above

The IWC SC has welcomed the development of alternative analytical procedures in addition to the standard hypothesis testing approach. For example the paternity analysis presented to the JARPAII review workshop (Kanda *et al.*, 2014) was welcomed by the Panel as such method could contribute not only for the development of genetic-based abundance estimate but in the assistance of the interpretation of stocks structure (IWC, 2015b).

At the 2014 IWC SC meeting, the development of close-kin mark recapture methods for a number of species, including North Atlantic minke whales and Antarctic blue whales, was welcomed. For example Tiedemann *et al*. (2014) reported a method for finding relatives among North Atlantic common minke whales based on microsatellite data. They investigated the relationship between false discovery rate and detection power. This method could be used for investigating relatives among Antarctic minke whales, and this information will be valuable for the interpretation of the hypothesis on stock structure.

These techniques will be applied to assist the analyses and interpretations under the three sub-objectives above, and both JARPA/JARPAII and new samples will be used.

3.1.2 Presentation by proponents of non-lethal alternative/complementary sources of data (e.g. biopsy sampling)

Feasibility experiments on biopsy sampling along the sighting surveys in Areas IIIW and VIE, particularly in offshore areas, is proposed. This has the potential of collecting some genetic samples for DNA analyses that will complement the data obtained by the lethal sampling of NEWREP-A.

Design of the feasibility biopsy experiments in offshore waters will be similar to those conducted under the IDCR/SOWER (Ensor *et al.*, 2004; 2001) and JARPN/JARPA (Nishiwaki, 2000) surveys. Final design will be made when the plan for sighting surveys in the relevant Areas are completed. At least the following factors should be considered during the experiment a) weather, b) sea condition, c) effort, d) school size, e) feasibility of random sampling.

3.1.3 Comments and conclusions by Panel

The proponents note (NEWREP-A, Appendix 6) that all of the sub-objectives under Objective I (iii) are designed to help refine current stock-structure hypotheses of Antarctic minke whales. The Panel **agrees** that this emphasis is appropriate because, as mentioned elsewhere (e.g. Item 2.1.2), refining hypotheses related to stock structure is one of the key elements in improving performance of the RMP.

Genetic and morphometric data for Antarctic minke whales have been interpreted in terms of two discrete stocks (I in the west and P in the east) that reproduce in different breeding areas but mix in feeding Areas IVE and VW. Conceptually, the data can be thought of in terms of the following simple model: samples from areas in the west (Areas III-E and IV-W) have 'blue' genetics, samples from areas in the east (V-E and VI-W) have 'yellow' genetics, and samples from the areas of proposed mixing have genetic characteristics that are various shades of green, depending on the mixture fractions. In 2014, the JARPA II review Panel suggested that the available data might also be consistent with an isolation-by-distance model, in which there are no discrete populations; instead, interbreeding occurs primarily among individuals that are geographically proximate.

The Panel **recognises** that it is difficult to distinguish between these two hypotheses based on samples taken from the extreme east or extreme west, because even under the isolation-by-distance scenarios these areas are different enough that they would produce samples that could be mistaken for discrete populations. However, the two hypotheses lead to different predictions regarding samples from the intermediate region (Areas IV-E and V-W). Under the two-stocks-with-mixing hypothesis, on a coarse scale these areas have intermediate allele frequencies as a consequence of mixing, but a finer scale analysis would indicate that the intermediate allele frequencies arise from a mixture of pure east (yellow) and pure west (blue) individuals. Under the isolation-by-distance hypothesis, individuals in the area of mixing would have intermediate (green) genotypes.

As acknowledged in NEWREP-A, in 2014 the Panel of the JARPAII review (IWC, 2015b) recommended one type of analysis that could potentially distinguish between these two hypotheses using existing data. If two stocks of Antarctic minke whales occur in the study area and mix (but do not interbreed) in the intermediate areas, then samples from the east and west should be in Hardy-Weinberg equilibrium (due to random mating), while samples from the area of mixing should show a deficiency of heterozygotes due to the Wahlund effect. If so, this should be detectable as a longitudinal pattern in the fixation index F_{IS}, which measures agreement with Hardy-Weinberg equilibrium. Under isolation-by-distance, random mating should occur within each subarea, leading to no expected pattern in F_{IS} with longitude.

Several other similar analyses could be employed on the existing data to test these two hypotheses. Examples include:

(a) *Principal components analysis of individuals*. If there are two distinct stocks, that should be apparent as two separate clusters in a PCA plot. Under isolation-by-distance, the expectation is a single, elongated cluster of points, with an association between PCA scores and longitude.

(b) *Pairwise genetic distances among individuals* (e.g., D or F_{ST}). Under the two stocks hypothesis, these distances should be small in the "pure" areas to the east and west, but large in the intermediate areas, where many comparisons would involve blue and yellow individuals from different stocks. Under isolation-by-distance, individuals within each area should be relatively homogeneous genetically, so there should be no change in mean genetic distance with longitude.

(c) *STRUCTURE analysis*. If the program STRUCTURE (or another clustering program) is used under the assumption of k = 2 populations, each individual will be assigned a q value indicating the estimated fraction of its genes that come from populations 1 and 2 ($0 \leq q \leq 1$; $q = 0$ indicating pure population 1 and $q = 1$ indicating pure population 2). Under the two stocks hypothesis, each individual, even in the intermediate longitudes, should be strongly associated with either population 1 or 2 (*q* close to 0 or 1). Some individuals might have ambiguous genotypes, but these should not be correlated with longitude. Under the isolation-by-distance hypothesis, the most divergent genotypes (the blue or yellow individuals at the extreme east or west) should have either very high or very low *q* values, while those in intermediate longitudes should have *q* values closer to 0.5.

The Panel **notes** that each of these analyses can be conducted fairly simply with existing data and **recommends** that this be undertaken as a priority. Given the small genetic differences between the two putative stocks (F_{ST} about 0.001), any one of these tests might not have high power, but collectively they might provide sufficient information to indicate the relative plausibility of the two competing hypotheses. The Panel **notes** that although the above approaches focus on genetic analyses, some methods (such as pairwise distances, perhaps using Mahalanobis distances) could also be used with the morphometric data. This is important as previous analyses (Kitakado *et al.*, 2014d) have suggested that a combination of genetic and morphometric data may be more powerful than genetic data alone.

The Panel **welcomes** the proposal to expand the geographic range of the sampling to inform conclusions about stock structure. An implicit assumption of the current two-stocks-with-mixing hypothesis is that the I and P stocks both have as-yet-undetermined boundaries beyond the current study areas. If that is not the case (if, for example, the two stocks have continuous distributions and another zone of mixing on the other side of Antarctica), then this would be important information for incorporation into the *Implementation Simulation Trials*.

The Panel **notes** that the NEWREP-A proposal lacks a quantitative evaluation of the expected improvements in management-relevant information that can be expected to accrue from the proposed experimental design. A key metric that affects performance of the RMP is the mixing rate among populations and how that varies in space and time. The Panel **recommends** that an evaluation of how additional sampling could be expected to improve precision and/or reduce bias in estimates of mixing rates.

The Panel **welcomes** the proposal to explore close-kin analyses as a potential means of informing evaluations of stock structure, as well as potentially obtaining information on abundance. Some thought is required, however, to determine how the information obtained from such analyses might help distinguish between the two competing hypotheses. In general, one might expect that the two-stocks-with-mixing hypothesis would predict that some close kin might be found at considerable distances apart, while close relatives would be expected to be found closer together under isolation by distance. Whether these methods can provide useful information in populations as large as Antarctic minke whales remains to be determined but could be addressed using simulations of some plausible scenarios.

3.1.3.1 BIOPSY SAMPLING (GENERAL)

The Panel **welcomes** the proposed efforts to evaluate efficacy of biopsy sampling of Antarctic minke whales. In addition to the use of genetic data from biopsy samples for stock structure studies referred to by the proponents above, there are a number of potential studies that can be undertaken using biopsy samples related to ageing, reproduction, feeding ecology etc. The feasibility and strengths and weaknesses of those studies are discussed elsewhere in this report, but in addition to assessing their feasibility as techniques, a key component of assessing their feasibility relates to the practicalities of obtaining sufficient biopsy samples (in absolute numbers as well as quantity of relevant tissue per sample e.g. skin, top layer of blubber, complete blubber layer) from Antarctic minke whales in Antarctic waters, whatever their ultimate use is.

The Panel therefore **recommends** that an experiment to examine the effort required to obtain biopsy samples from Antarctic minke whales be given high priority at the start of any long-term programme. This will provide essential information in terms of evaluating lethal versus non-lethal techniques and thus in determining lethal sample size. The study needs to incorporate sufficient field effort and be able to *inter alia:*

(1) involve people with expertise in successfully biopsy sampling common minke whales in the North Atlantic;

(2) mimic the sampling strategy developed for lethal sampling (e.g. when dealing with schools >2);

(3) record information on time taken, sea state, swell, etc. to enable a plausible measure of effort required to be developed;

(4) consider the amount of tissue and nature of tissue required (for each analysis and in total).

Ideally, to account for the spatial/temporal heterogeneity apparent in the Antarctic minke whale data (de la Mare and McKinlay, 2015), the biopsy sampling design should be representative of the entire area and time period, and ideally involve random sampling techniques resulting in a sufficiently large sample size. This could, for example, be done by following the same type of fixed transects as the previous IDCR or JARPA sighting surveys. Consideration might be given to focus initial training efforts primarily in near-shore areas where animals can more reliably be encountered. Consideration also should be given to standard issues relating to any biopsy programme, such as an upper limit to the number of attempts to be made on an individual, how long a whale will be followed, whether females with calves will be targeted, etc.

3.1.4 Presentation by proponents of proposed methods (telemetry)

This corresponds to sub-objective c) of the Objective on stock structure of Antarctic minke whale.

c) Investigation of the pattern of movement of Antarctic minke whales within the feeding grounds and between feeding grounds and putative breeding grounds

There is an assumption that the I and P stocks are related to breeding areas in the eastern Indian Ocean and western South Pacific, respectively, where high sighting density areas of minke whales have been identified in October (Kasamatsu *et al.*, 1995) (see Fig. 1 in Appendix 6). However there is no direct evidence of this link, and no genetic samples are currently available for Antarctic minke whales in low latitude areas. The IWC SC has recommended on several occasions that research should be conducted to investigate the location of breeding grounds of this species in the Southern Hemisphere, and the collection of genetic samples (IWC, 2008).

Therefore the migratory destination of Antarctic minke whales of the I and P stock in autumn and winter is another important research topic to address. Are minke whales from the I stock migrating in winter to the high density areas in the eastern Indian Ocean? Are minke whales from the P stock migrating in winter to the high density areas in the western South Pacific Ocean?

Further studies on movement of whales within the feeding grounds and movement of whales between high and low latitudes areas can be investigated through satellite tracking. The latter topic should have priority as there is already some information on movement of whales within the feeding grounds.

Some experiments on satellite tagging were conducted on Antarctic minke whales around the pack-ice (Gales *et al.*, 2013). The following kinds of tags were used by those authors: blubber penetrating satellite tags, Wildlife Computers, SPOT 177N; dorsal fin mounted satellite tags, Wildlife Computers, SPOT 240C; dorsal fin mounted satellite, Wildlife Computers, SPLASH 292A. As noted above the priority at this stage should be the searching for breeding areas, and for this particular aim, long-term monitoring tags should be selected.

Satellite tagging should be carried out at the end of the feeding season for the I and P stocks in their 'core areas', IVW and VE, respectively. If biopsy sampling is conducted at the same time of the satellite tagging in the feeding grounds, some genetic information for whales migrating into potential breeding grounds will be obtained.

3.1.5 Comments and conclusion by Panel

The Panel **welcomes** the proposed work on the movements of Antarctic minke whales, which will be of value in terms of stock structure and movements, particularly if breeding areas can be identified. The Panel also **notes** that unless tags transmit for long periods, telemetry will not provide information on when whales arrive in the Antarctic region or movement patterns the animals may follow at the start of the feeding period. The Panel **recommends** that this should be accorded high priority but **notes** the difficulties in the attachment and functioning of long-term satellite tags on minke whales in both hemispheres. The Panel also **recommends** that the proponents undertake this work in collaboration with research groups with experience in such work rather than try to develop techniques on their own. This applies to field methods as well as tag types. Insight can be gained from the works of Gales and colleagues (2013), and that undertaken by several groups in the Northern Hemisphere (e.g. see the studies summarised in the 2014 AWMP/RMP workshop on the stock structure of North Atlantic common minke whales, (IWC, 2015a). This recommendation also applies to work on shorter-term tags for obtaining information on diving behaviour and duration related to correction of abundance estimates and feeding ecology.

3.2 Abundance of cetaceans within the research area

3.2.1 Presentation of methods by proponents

The proposed method for whale abundance estimation corresponding to Objective I (i) 'Abundance estimates for Antarctic minke whales taking into account of g(0) and additional variance' is given in Appendix 3 of the NEWREP-A plan, and that corresponding to Objective II (ii) 'Abundance estimate of some cetacean species as input data for ecosystem modelling' is given in Appendix 9 of the NEWREP-A plan.

In order to address Objective I (i), sighting surveys are planned to be conducted by line transect method following the survey protocols set out in the Requirements and Guidelines for conducting surveys and analyzing data within the Revised Management Scheme (IWC, 2012c) so that sighting surveys are conducted under oversight of the IWC/SC. Sighting protocols are the same as those used in the IDCR/SOWER surveys (Matsuoka *et al.*, 2003). Survey areas are planned to cover one IWC Management Area (one of Areas III, IV, V and VI) in a year. It is planned to survey in Areas III and VI twice and Areas IV and V three times in twelve years. Additionally, ecological surveys and sighting surveys in waters north of 60°S will be conducted in two years. In this way, it is planned to produce abundance estimates in these Management Areas every six years which can be used in application of RMP for the Antarctic minke whale. In case that sighting surveys cannot be conducted due to external violent interference, there would be a possibility that the survey area will be changed from the original plan.

The OK model (Okamura and Kitakado, 2012) is applied to estimate abundance taking *g*(0) estimate into account using sighting data obtained in closing and IO mode. In the OK model, detection probability function can be modeled with covariates such as perpendicular and forward distance, school size and weather conditions, which are available for JARPA/JARPA II data. Applying the model above using data obtained by sighting vessels (SVs) in this survey, *g*(0) can be estimated considering the effect of covariates for each sightings of the Antarctic minke whale. The approach in (Kitakado and Okamura, 2005; 2008; 2009) will be used to estimate yearly variation in abundance levels due to inter-annual change in distribution of the Antarctic minke whale population in the same way that OK model was applied to estimate the Antarctic minke whales abundance based on IWC-IDCR/SOWER.

In order to address Objective II (ii), sighting surveys will be conducted under the same survey protocols in the same survey area as mentioned above. Following the recommendation at the Expert Workshop to review JARPAII (IWC, 2015b), if an initial sighting occurs near to a vessel, effort will be made to identify the ecotype of killer whale. To examine the distribution and abundance of fin whales, a sighting survey will be conducted in one year out of 12 years in the latitudinal band of 55-60°S. The longitudinal area will be decided considering the distribution pattern of the species and logistics.

To attain sub-objective i) under objective II (ii), the Standard methodology of line transect surveys (e.g. Branch and Butterworth, 2001) will be applied to estimate abundance assuming that *g*(0)=1 but an attempt to estimate g(0) will also be made. For abundance estimation, recommendations made at the Expert Workshop to review JARPA II will be considered. Candidates for abundance estimates are humpback, fin, blue, southern right, sperm, southern bottlenose and killer whales. Abundance estimates for species such as sperm and southern bottlenose whales may need to be treated as relative because g(0) was estimated as less than 1 for these species (Kasamatsu and Joyce, 1995). To attain sub-objective ii) under objective II(ii), Density Surface Modeling (DSM) (Miller *et al.*, 2013) will be used, which is one of the packages in the DISTANCE program (Thomas *et al.*, 2010). Furthermore, the utility of using environmental covariates in the spatial modeling for improving the abundance estimates will be investigated.

3.2.2 Comments and conclusion by Panel

The Panel **welcomes** the emphasis on obtaining abundance estimates in the NEWREP-A proposal. The data resulting from the proposed line transect sighting surveys will be used to estimate overall species-specific abundances for the study area (as discussed in this section), develop spatial distribution models (SDM) as discussed in Item 3.10 (spatial interactions amongst baleen whales), and contribute to the ecosystem models as discussed in Item 3.11 (Ecosystem dynamics in the Antarctic Ocean) as well as providing direct input for the SCAA and the RMP. The Panel **welcomes** that the sighting surveys are planned to follow the survey protocols set out in the 'Requirements and Guidelines for conducting surveys and analysing data within the Revised Management Scheme' (IWC, 2012c), as well as the guidelines and recommendations being developed by the Committee for estimation of SDMs and model-based abundance estimates (IWC, 2015a). The Panel **welcomes** the plans to obtain estimates of *g*(0) for Antarctic minke whales by using IO mode, recognising this was a key component in the lengthy process to obtain abundance estimates from the IDCR/SOWER surveys. However, the Panel also **recommends** that every effort be made to estimate *g(0)* for the other whale species, at least to determine rather than assume whether it is significantly different from one. This is important for cetaceans that will be in the SDMs and ecosystem models as it may result in potentially large biases when comparing/contrasting the various species.

Given the many difficulties in analysing the data from the previous IDCR/SOWER and JARPA/JARPA II sighting surveys, the Panel **recommends** the survey design and analysis methods be carefully considered to enable the survey results to have multiple uses (abundance estimates, SDMs and input into ecosystem models). Taking in account these issues and considering recommendations discussed in Matsuoka (2011) and recommendations made during the JARPAII review (IWC, 2015b), the Panel **agrees** that more details of the survey plans are required than appears in the NEWREP-A proposal at present. The Panel **stresses** that an appropriate future survey design, data collection and analysis methods to meet the various objectives, may not be as similar to those used previously as is suggested in the proposal.

The Panel **emphasises** the discussions at the Committee last year (IWC, 2015c) including issues raised in Hedley and Bravington (2014), that indicated that traditional design-based analyses methods (e.g. the OK method) and survey designs may not be the most appropriate for the NEWREP-A study region because of unequal coverage probabilities, gaps in the data (due to the retreat of the ice edge during the survey time period, weather, or sabotage) and the need to account for the spatio-temporal changing patterns in distribution. The Panel **recommends** that the proponents should give serious consideration to using model-based methods to estimate abundance, recognising that the Committee has not yet finalised its advice on such methods for use in the RMP. This consideration should include an examination of the existing survey data to determine spatial and temporal variability, which could then be used to determine the future design of the track lines and possibly achieve an overall lower CV, which is one of the objectives of this proposal.

An important aspect of the input data to SDMs that relate the physical and biological habitat with whale distribution and density and the data needed to measure levels of interactions between species, is that the cetacean, krill and habitat environmental data should be collected as simultaneously as possible. The Panel **welcomes** the proponents' decision to attempt some multi-disciplinary work (see Items 3.7 and 3.8 for a more detailed discussion with respect to krill and oceanography, respectively).

The design and implementation of any multi-disciplinary survey using a dedicated sighting survey vessel requires careful consideration. Implementation of such surveys is complex because the different disciplines can sometimes create competing non-compatible needs of ship resources, personnel and time. The optimal design will depend on the exact question to be addressed and how the data are to be used in the various modelling scenarios envisaged under Primary Objectives 1 and 2.

Consideration needs to be given to using different survey designs, at least in some years, because of the differing objectives of, for example conducting focussed studies of prey swarming behaviour and density in relation to local whale distribution and abundance (e.g. see the SOWER 2000 discussions, Cox *et al.*, 2009; IWC, 2000). This may require focussed fieldwork conducting sighting surveys under different designs for one or more seasons and integrating data from focal follows, telemetry (radio and/or satellite), krill abundance and density estimates and biopsy sampling. The survey design could also include surveying the same track lines multiple times within a season to document the intra-annual spatial and temporal variability.

Finally the Panel **notes** that the proposal does not address the issue of whales in the ice that cannot be surveyed by the current shipboard platforms. As discussed at recent Scientific Committee meetings (IWC, 2010b; 2011a; 2012b; 2013b; 2014d), this may have a large influence on the abundance estimates, SDMs and ecosystem models. Changing ice conditions over time (e.g. increased extent of the marginal ice zone (MIZ)) may change the proportion of Antarctic minke whales in ice-covered and open waters. Thus, to determine changes in whale abundance over time, spatial distribution and interactions between the various cetaceans and between the cetaceans and krill, sighting surveys in open and ice-covered waters should be conducted. These should examine the behaviour of individual whales to determine whether individuals remain within the ice for long periods or move more freely between ice-free and ice-covered waters. The Scientific Committee has discussed several recent attempts to do this (IWC, 2015c item 10.1.1.2), such as Williams *et al.* (2014) who reported a combined ship/helicopter survey that provided abundance estimates in open and ice-covered waters. The Panel **agrees** that NEWREP-A would benefit from inclusion of this type of approach or inclusion of collaborative data collection surveys with other researchers who are attempting this type of approach.

The Panel **welcomes** the attempts to use data loggers on minke whales which might result in area-/species- specific dive patterns. These data could then be used to address availability bias in the abundance estimates, a subject that has not been considered in the past. As recommended under Item 3.1.5, such work should be undertaken in collaboration with researchers experienced in such techniques.

In summary, the Panel **recommends that the proponents:**

(1) carefully consider a number of options for survey design and methods taking into account:

(a) the experience gained from the several years of data analysis before the Scientific Committee adopted abundance estimates from the previous IWC IDCR/SOWER cruises;

(b) the developments in spatial modelling approaches;

(c) the experience of previous multi-disciplinary survey efforts;

(d) the recommendations from the JARPAII review;

(e) the possibility of incorporating more focussed surveys to address specific issues in some years;

(f) consideration of whales within the ice;

(g) updated power analyses of the effects of survey interval and estimation of trend to determine necessary levels of effort and survey design in the future (including consideration of the regions outside the core study area (additional longitudinal range in Areas III, VI, and coverage north of 60°S)).

(2) work closely with the IWC Scientific Committee before finalising their survey approaches;

(3) ensure that future survey plans submitted to the Scientific Committee follow fully the guidelines for such survey plans, including incorporating proposed track lines - since the dedicated sighting survey/echo sounder platform will be separated from the sighting/sampling vessels, sabotage should not be an issue.

3.3 Age determination

3.3.1 *Presentation by proponents of lethal methods (GLG*s and aspartic acid)

'Improvement of precision of biological and ecological parameters - Part 1: Improvement of age data precision' corresponds to an objective of Main Objective I 'Improvement in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales' (see section 2). Explanation of the analytical procedure related to this Objective is given in Appendix 4 of the NEWREP-A plan.

Physical age is one of the life history parameters required for management of large whale stocks (Zenitani and Kato, 2006). During the JARPA and JARPAII programs, the method of counting GLGs was adopted for age estimation of Antarctic minke whales, and the obtained data have been used for statistical catch-at-age (SCAA) analysis (Punt, 2014a). Under this research program, age data will be obtained from counting of GLGs at the bisected surface of the earplug under a stereoscopic microscope, as this is the accepted procedure by the IWC/SC. In addition, new methods for age estimation will be explored to improve precision of the data. Ratio of aspartic acid enantiomers in the lens nucleus, and level of DNA methylation (see next section) will be examined for evaluating their potential use in age estimation of Antarctic minke whales. These chemical methods have high reproducibility compared to age estimated from earplugs. Enantiomers of aspartic acid in lens of whales are measured using high performance liquid chromatography (Yasunaga *et al.*, 2014). The new statistical methods, such as the Delta method (George *et al.*, 1999), are applied to estimate the precision of age estimation with the enantiomers. In addition, theriogenological data, such as number of corpora for both ovaries, is applied to verify the accuracy of the estimated ages (Rosa *et al.*, 2012).

3.3.2 *Presentation by proponents of non-lethal alternative experiment*

This research program will evaluate the feasibility of an age-determining method based on DNA methylation analysis for Antarctic minke whales. This study will examine the correlation between DNA methylation levels and whale ages determined by counting GLGs. As an initial feasibility test, DNA samples from Antarctic minke whales collected from JARPAII surveys will be used. The 'calibration' sample contains aged individuals from one to 55 years old (estimated using the method of counting GLGs). Twenty-five samples for males and twenty-five samples for females will be analyzed. The samples will include animals from different ages in the 'calibration' sample. After the initial test, DNA samples from this research program will be used for age determination. Following Polanowski *et al (2014)*, DNA methylation changes will be identified at the Antarctic minke whale genes homologous to the humpback whale ones. The procedure for identification of age-related DNA methylation site and measurement of methylation level will follow the previous studies (Bocklandt *et al.*, 2011; Maegawa *et al.*, 2010; Polanowski *et al.*, 2014). The accuracy of the relationships between methylation levels and ages determined using counting GLGs will be assessed by statistical methods including multiple linear regression.

3.3.3 *Presentation by observers of methods to age Antarctic minke whales*

Papers SC/F15/SP05 and SC/F15/SP06 were provided to the Panel and are summarized in Annex D (see also Annex F).

3.3.4 *Comments and conclusion by Panel*

Enumerating growth layer groups (GLG) in the wax earplugs of baleen whales to estimate physical age, while imperfect (it has not been possible to validate with known age animals), is the most accepted long-standing method for ageing species such as fin whales, sei whales, Bryde's whales and Antarctic minke whales (e.g. see review in Lockyer *et al.*, 1988) . This method has been the subject of a recent experiment undertaken by the Committee to examine reading errors (Kitakado *et al.*, 2014b). New chemical ageing methods are promising for animals in which readable earplugs were either not obtainable or upon which non-lethal sampling methods were used (e.g. via biopsy).

Aspartic Acid Racemization (AAR) of the eye lens has been shown to be reliable, although CVs tend to be high (Rosa *et al.*, 2013). The use of the AAR age estimation method, adapted for mammals by Bada *et al.* (1980), has recently regained interest for use on cetaceans. The AAR age estimation method is useful for species where standard methods are not applicable (e.g. species lacking teeth or readable earplugs) as well as for comparison with other methods e.g. earplugs. The Panel **agrees** that the AAR methodologies in Rosa *et al.* (2013) are better developed and should replace the earlier techniques in George *et al.* (1999)– particularly for error estimation.

Yasunaga *et al.* (2014) showed progress in some aspects of the use of AAR ageing and the Panel **reiterates** several suggested improvements made during the JARPA II review (IWC, 2015b)

The DNA Methylation (DNA-M) technique as recently applied to known age (from photo-identification studies) humpback whales by Polanowski *et al*. (2014) offers a promising new age estimation approach (also see Wade, 2015b). However, this technique does not provide the chronological age of the individual but rather a physiological age that can be used as a proxy for chronological age. Thus, physiological and metabolic differences between species, means that the method will need to be calibrated for each species. In addition, because the conditions in which individuals grow may also affect their physiological age and metabolism, it is possible that the calibration slopes and variances of the DNA methylation technique may not be interchangeable between populations found in different areas or even between different periods within the same population i.e. the technique may require calibration by species, population and period. Given the novelty of the technique and the fact that it has only been applied to a single population of a single species of cetacean, there is as yet no experience on this regard.

The Panel **agrees** that existing samples are appropriate to further understand and evaluate the use of the DNA-M technique for Antarctic minke whales, for example by investigating the correlation between earplug readings and methylation rates. If the correlation between earplug counts and DNA methylation rates is high, it will offer a significant contribution to cetacean science generally. It will enable ages to be obtained from biopsy samples, to determine age in individuals in which earplugs are/were not readable, and provide a further way to investigating ageing errors between readers. However, if the correlation is low, it will not possible to determine which method is better because the true ages are not known. The Panel **welcomes** the fact that the proponents intend to investigate this new approach during NEWREP-A. The Panel **recommends** that the method be investigated early in the programme, initially using a sub-sample of animals only with clear 'highly readable' earplugs. The samples should also be divided by stock and also by time period (to the extent possible) to examine possible differences in the calibration slopes within different geographical areas and time period (see above). The Panel also **notes** the importance of evaluating interlaboratory reproducibility and **recommends** that this be examined by having independent laboratories running a control set.

Recognising the differences in readers identified by (Kitakado *et al.*, 2014b) the Panel **stresses** the importance of (a) not relying solely on one reader in any long-term programme and (b) calibration of any new readers (and periodically 'old' readers) using the existing standard dataset (Kitakado *et al.*, 2014b).

The value of age data is discussed under Item 3.4.3 and the issue of biopsy sampling is discussed under Item 3.1.3.1.

3.4 Biological parameters in use of refined SCAA approach

3.4.1 Presentation by proponents including use of data collected using lethal methods

'Improvement of precision of biological and ecological parameters – Part 2: Refinement of the SCAA model and estimation of biological parameters' is an objective of the Main Objective I 'Improvement in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales' (see section 2). Explanation of the analytical procedure related to this objective is given in Appendix 5 of the NEWREP-A plan.

The JARPAII review workshop agreed that 'the SCAA model is both the best currently available model for examining stock dynamics for the Antarctic minke whales in the JARPAII area, and that the model performs well in this regard' (IWC, 2015b). SCAA has provided robust estimates of natural mortality by stock and age, and trend in abundance. Such trend provides information on productivity and its changes over time (IWC, 2014). The estimate of MSYR (1+) by the SCAA is sensitive to the model configuration and NEWREP-A will try to narrow the range of estimates with longer series of catch-at-age data and abundance estimates.

The SCAA is the most useful tool to provide tangible trial structures in the RMP Implementation because the information from the SCAA could be used to develop hypotheses related to changes in carrying capacity, natural mortality, and variation in birth rates. Models used in this sub-objective are mostly similar with the current SCAA models developed in Punt (2014b). The basic assumption is same as that in Punt (2014b). This model is described in Appendix 5 the NEWREP-A plan in detail. It is expected that the results of SCAA analyses will provide improvement in the precision of key biological and ecological parameters such as MSYR, natural mortality recruitment rates and growth curves as was the case in the previous programs although the extent of improvement cannot be evaluated given recent time-varying parameters such as carrying capacity and productivity etc. Outcomes based on the new SCAA analyses will contribute to the specification of the Implementation Simulation Trials as noted above.

The data required by the SCAA approach are abundance estimate, catch history, body length, age and maturity status of females. Furthermore, the age at sexual maturity and stock structure for the Antarctic minke whales will be applied for SCAA model in the NEWREP-A.

3.4.2 *Evaluation by the proponents on the need of lethal and non-lethal data*

As noted above the key data used in the SCAA analysis are data on age, sexual maturity of females, body length, information on stock structure and abundance. Data requiring lethal sampling are age (earplug), sexual maturity (ovaries and testis) and body length (but see discussion on biopsy sampling for studies on stock structure in Appendix 6 of the NEWREP-A plan). As explained in the section 3.2.1 of the NEWEP-A plan, age at the annual scale can be obtained only through lethal sampling methods. DNA based techniques have been proposed recently but these need further investigation and refinement to decide whether such techniques can be used for Antarctic minke whale (through biopsy sampling). NEWREP-A proposed a feasibility study of the age determination method based on DNA methylation (see Appendix 4 of the NEWREP-A plan). There is also a technique available to determine pregnant females through measurement of progesterone concentration in blubber (blubber can be obtained through biopsy sampling) (Kellar *et al.*, 2006; Mansour *et al.*, 2002). However the technique cannot distinguish among non-pregnant mature females, immature females, mature males and immature males. Therefore this technique cannot provide information on sexual maturity of females for the SCAA analysis. The precision of body length measures obtained from shipboard techniques are insufficiently accurate (Best, 1984; Dawson *et al.*, 1995; Jaquet, 2006). Therefore at this stage of knowledge data on age, sexual maturity and body length of Antarctic minke whale required for the SCAA analysis can be obtained only through the lethal technique.

3.4.3 *Comments and conclusion by Panel*

3.4.3.1 BIOLOGICAL PARAMETERS

The Panel **agrees** that at present, the techniques commonly used for the determination of the biological parameters used in the SCAA model (see Item 3.3.4) require lethal sampling: i.e. earplugs for age determination (see Item 3.3) and animal length. In addition, the proposed version will require reproductive organs for sexual maturity.

However, the Panel **notes** that there are new techniques available that require validation and calibration that may enable the determination of these biological parameters for Antarctic minke whales in the future using non-lethal techniques. A recommendation regarding the DNA methylation approach for ageing is given under Item 3.3.3. The Panel **recommends** that the proponents also investigate the possibility of obtaining information on sexual maturity through hormones in blubber (IWC, 2014a). The Panel **notes** that the relevant parameter for possible use in the SCAA model is the proportion of mature adult females; as the proportion of pregnant females is high and that of resting mature females low, although this would be expected to change under a hypothesis that density-dependent factors could affect the dynamics of the population, the Panel **recommends** that simulation studies should be used to examine the effect on the SCAA of errors that may result from assuming that resting females are in fact immature females (low hormone levels are common to both). A recommendation related to the issue of obtaining sufficient biopsy samples (number and tissue quantity) is discussed under Item 3.1.3.1.

The issue of examining changes in age at sexual maturity over time is addressed under Item 4.

With respect to animal length, the Panel **agrees** that the available ship-based methods are, at present, probably not effective for estimating lengths of Antarctic minke whales with sufficient accuracy. However, the Panel **notes** that aerial photogrammetric techniques (from aircraft and drones) can be effectively used to estimate whale length (Perryman *et al.*, 2014) and so the Panel **recommends** considering the possibility of using drones.

3.4.3.2 MODIFICATIONS TO THE SCAA

The SCAA will form the basis for the proposed *Implementation Simulation Trials* (NEWREP-A, Section 4.6). Its structure will be largely unchanged from its most recent version (Punt *et al.*, in press), although Appendix 5 of the proposal includes a different density-dependence function. The density-dependence function in Appendix 5 of NEWREP-A has the disadvantage that pregnancy rates can exceed 1 and that the number of calves can be zero if the stock is larger than its current carrying capacity. Equation App.A.C.1 of Punt *et al.* (in press) addresses these problems by treating the calving rate as a parameter constrained to lie between 0 and 1, and by adopting a Ricker-like stock-recruitment relationship. The Panel **recommends** that the proponents adopt this approach.

The major extensions to the SCAA in NEWREP-A include allowing for mixing of populations. The existing SCAA code allows for mixing of stocks by area (Punt and Polacheck, 2006) but to date this variant of the SCAA has not been used as analyses of mixing are currently preliminary (Punt et al., in press). The Panel **agrees** that there is sufficient information from JARPA and JARPA II data to update the SCAA to include mixing and **recommends** that this be done. Furthermore, the Panel **reiterates** the recommendations of the JARPA II review panel in regard to extensions to the analyses already undertaken to estimate mixing rates. The Panel **recommends** that this updated SCAA be used to investigate the effect of the collection of additional data to quantify mixing of stocks.

However, the present SCAA does not allow mixing to depend on age, maturation state or sex, as envisaged in the NEWREP-A proposal. Appendix 5 of NEWREP-A indicates that natural mortality will depend on maturity state (immature and mature) as well as time, and that the mixing rate will depend on maturation state. At present the SCAA does not distinguish mature and immature animals; enabling maturation-specific mixing rates and natural mortality will require that the numbers-at-age matrix be extended to explicitly consider mature and immature animals. The proposal is unclear which data will inform time-variation in natural mortality. Estimation of natural mortality is very difficult, even when the aim is to estimate an average rate of natural mortality. However, estimation of time-varying natural mortality has not been achieved for any whale stock and only for a very small number of fish and invertebrate stocks (e.g. herring in Prince William Sound Alaska, the stock of red king crab in Bristol Bay), owing primarily to lack of data on time-trends in predation mortality or other sources of natural mortality. The Panel **recommends** that the proponents identify more fully the data to be used to inform the time-varying natural mortality and present analyses of previously collected data to determine the feasibility and accuracy of obtaining such estimates.

A key extension to the SCAA is to include time-varying age-at-50%-maturity information. The Panel **recommends** that the proponents develop metrics to evaluate the benefits of including these data in the SCAA. This is because the SCAA already includes 'recruitment deviations' which capture the combined effects of changes in maturation rates, as well as inter-annual variation in fecundity and calf natural mortality. Consequently, it appears unlikely that allowing for time-varying age-at-50%-maturity will enable quantities such as MSYR to be estimated more accurately and precisely. However, other quantities such as recruitment and current abundance may be estimated more precisely if temporal variation in age-50%-maturity were included in the model.

Appendix 5 of NEWREP-A indicates that data on time-varying mixing and age-at-maturity will be included in the SCAA model. The Panel **agrees** that the most appropriate way to achieve this is to include the raw data on mixing and proportion mature in the likelihood function and hence enable the uncertainty regarding estimation of mixing and maturity to be propagated throughout the analyses, and hence into the estimates of trends in carrying capacity and age-specific natural mortality.

3.5 Specification of RMP *IST*s for Antarctic minke whales

3.5.1 Presentation by proponents of methods proposed including use of data from lethal methods

'Specification of RMP *ISTs* for Antarctic minke whales' is an objective of the Main Objective I 'Improvement in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales' (see section 2). Explanation on the analytical procedure related to this objective is given in Appendix 7 of the NEWREP-A plan.

The proponents explained planned specifications of the RMP *Implementation Simulation Trials* (*ISTs*) under the NEWREP-A. This corresponds to one of the objectives under Main Objective I, which aims at providing information for application of the RMP/*ISTs.*

In the process of RMP/*ISTs*, a set of operating models (OMs) has to be conditioned for simulation purpose. These become underlying models for the trial structures. For cetacean species, age-structured models are common for expressing their population dynamics. For the Antarctic minke whales, the IWC SC has been investigating the population dynamics through the Statistical Catch-at Age Analysis (SCAA; Punt, 2014a) which utilize the age-reading outcomes and abundance estimates as the primary data as well as maturity and other bio/ecological information as the scenarios.

The results of SCAA conducted until now have however led to the conclusion that issues such as the improvement of the precision of MSYR estimates still require further relevant information and warrants further investigation on the time-varying parameters such as carrying capacity and productivity (IWC, 2015c). Thus, while considerable data and information are already available through past research, more refined information over a longer period is necessary for improvement of the RMP *Implementation* (see Table 1, NEWREP-A proposal).

Under the NEWREP-A proposal, revised SCAA analyses will be conducted by assuming basically the same models used in the existing SCAA. However, possible changes in the age-at-sexual maturity and refined hypotheses for stock structures will be taken into account. The parameter values estimated and used in the revised SCAA will be provided as sets of plausible ranges of parameters for the trials used in NEWREP-A (see Appendix 5, NEWREP-A proposal). Information from other sub-objectives under Main Objective I (see Appendices 3, 4 and 6), will also contribute to the specification. The proponents noted that *Small Areas* will be defined based on the updated information on stock structure (see Appendix 6) and possible whaling operations. The kind of parameter/structure in the model and potential contribution from the new research is shown in the table below.

Parameter/Structure in the model	Source of information
$MSYR_{1+}$	Existing range/outcomes from NEWREP-A
$MSYL_{1+}$	0.6 (given)
Stock structure	Existing hypotheses/outcomes from NEWREP-A
Mixing pattern	Outcomes from NEWREP-A
Mortality rate	Outcomes from NEWREP-A
Max pregnancy rate	Outcomes from NEWREP-A
K_{1+}	Outcomes from NEWREP-A
Time varying K	Outcomes from NEWREP-A

Parameter/Structure in the model	Source of information
Additional variance (inter-annual distributional change)	Existing range/outcomes from NEWREP-A
Small Areas and Management Variants	Several variants will be proposed with consideration of stock stucture hypotheses and possible whaling operations

The proponents further noted that some implication or results from Main Objective II (investigation of ecosystem in the Antarctic Ocean) will also be taken into account for specifying the trial structures.

3.5.2 Evaluation by the proponents on the need of lethal and non-lethal data
See proponents view in section 3.4.2.

3.5.3 Comments and conclusion by Panel
The process of developing and implementing *Implementation Simulation Trials* involves following the steps outlined by IWC (2012d). In particular, there is a need to (a) select a set of plausible hypotheses, (b) define a set of trials based on these hypotheses, (c) fit the operating model to the available data, (d) assign plausibility ranks to each trial, (e) identify a range of RMP variants based on the selection of *Small Areas* and whether catch cascading or catch capping is to be applied, and (f) conduct projections for each combination of trial and RMP variant. The results of *Implementation Simulation Trials* have been found to be most sensitive to assumptions regarding productivity (usually quantified via the MSY rate), stock structure (number of stocks and how they mix), and abundance.

The *Implementation Simulation Trials* for the Southern Hemisphere minke whales, including the Antarctic minke whale (IWC, 1993b) reflect the broad range of uncertainties regarding stock structure and productivity that was consistent with the available information in the early 1990s. No *Implementation Reviews* have been conducted for Southern Hemisphere minke whales. Moreover, the trials used to select the 1992 implementation were not developed using the protocol that has been used when conducting the *Implementations* for the Western North Pacific minke whales and the North Atlantic fin whales (IWC, 2012a). The information from NEWREP-A, along with previous information from JARPA and JARPA II should enable the hypotheses regarding stock structure and population dynamics on which the current trials are based, to be refined. In addition, the new survey estimates of abundance should reduce the uncertainty regarding current stock size.

These trials could be conducted using existing information, although additional information is proposed to be collected during NEWREP-A on stock structure, abundance, and potential trends in biological parameters, including MSYR. Revised *Implementation Simulation Trials* could therefore be developed irrespective of whether the field component of NEWREP-A is undertaken. Any further information from NEWREP-A to refine hypotheses depends on the outcomes from other components of the project, as noted in Item 3.6.1. The data to be used for developing *Implementation Simulation Trials* are proposed to come from both lethal and non-lethal methods (see Items 3.1 – 3.5 for discussion of these data).

NEWREP-A intends to base the *Implementation Simulation Trials* on the SCAA (and extensions to this model, Item 3.5). The Panel **agrees** that this is an appropriate basis for an operating model. However, extending the SCAA to enable projections to be undertaken, as well as quantifying parameter uncertainty, will be a substantial undertaking, given the complexity of the associated software. For example, the projections of the model will require that future trends in carrying capacity be specified. Ideally, such trends should be informed by the results of, inter alia, ecosystem models.

3.6 Abundance estimation of krill
3.6.1 Presentation of methods by proponents
'Krill abundance estimation and oceanographic observation' is an objective of the Main Objective II 'Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models' (see section 2). Explanation on the analytical procedure related to this objective is given in Appendix 8 of the NEWREP-A plan.

The Antarctic Ocean can be considered as a wasp-waist ecosystem featuring many species at the bottom and top, and a few dominant species at mid-level. Unlike other was-waist ecosystems where small pelagic, planktivorous fish such as sardine and anchovy are dominant at mid-level, a plankton species, Antarctic krill *(Euphasia superba*), is dominant at this level in the Antarctic Ocean (Atkinson *et al.*, 2014; Bakun, 2006). The mid-level species are also called as forage species which a play pivotal role in marine ecosystem and economics by sustaining many predators and fisheries directly and indirectly (Pikitch *et al.*, 2014). Abundance of Antarctic krill is fundamental information to understand the Antarctic Ocean ecosystem. Two types of surveys will be conducted. One survey would be conducted under of NEWREP-A while the other survey would be conducted as a CCAMLR standard type krill survey. The main objective of this research is to estimate abundance of Antarctic krill acoustically in the survey area. The estimates would be used as an important input parameter of ecosystem models.

Abundance estimation of other krill species (e.g. ice krill; *E. crystallorophias*) as well as other planktons (e.g. copepods) will also be attempted. The echosounder data recorded in previous JARPA and JARPAII will be reanalysed so that they can be compared with the results of the new data.

3.6.1.1 SURVEY FROM NEWREP-A SIGHTINGS VESSEL

A quantitative echosounder onboard a cetacean sighting survey vessel will be used to record acoustic data. At least 3 frequencies (38, 120 and 200 kHz) will be used. Abundance of krill will be estimated in accordance with the method agreed by CCAMLR (IWC and CCAMLR, 2010). A small ring net (e.g. 80 cm in diameter) will be hauled vertically from the vessel. A high intensity white LED will be attached to the net with an expectation that sampling efficiency of krill will be increased (e.g. Wiebe *et al.*, 2004). Biological samples obtained by the net will be used as qualitative information to analyse the acoustic data. Biological samples obtained from stomach contents of Antarctic minke whales as well as from the CCAMLR standard type krill survey will also be considered in the analysis. The survey will be conducted every year from the 2015/16 season. As the acoustic and cetacean sighting data will be recorded simultaneously, these data will be one of the main sources to investigate their relationship in a temporal and spatial context (see also Item 3.11.2).

Echosounder data will be recorded simultaneously with behavioural data of cetaceans once data loggers are successfully deployed. These data will be used to study feeding ecology of cetaceans (see also Item 3.9.3).

3.6.1.2 BROAD SCALE KRILL SURVEY FOLLOWING CCAMLR GUIDELINES

A trawler type fisheries research vessel which fulfils the noise standard recommended by ICES (Mitson, 1995) will be used. The survey will be conducted for at least one austral summer season in every six years. An echosounder with at least 3 frequencies (38, 120 and 200 kHz) will be used. Abundance of krill will be estimated in accordance with the method agreed by CCAMLR (CCAMLR 2010).

Survey design standards similar to those developed and implemented for CCAMR 2000 (Trathan *et al.*, 2001), BROKE (Nicol *et al.*, 2000) and BROKE-West (Nicol, 2010) will be applied to this survey. Area IV and Area V will be surveyed once in every six years. Area IV is overlapped with the CCAMLR management areas 58.4.1 and 58.4.2. Area V is overlapped with the CCAMLR management areas 58.4.1, 88.1 and 88.2. The survey area and design which was used in BROKE and BROKE-West will be applied when the survey is conducted in Area IV.

A frame type trawl net would be towed at either predetermined or targeted stations. Targeted tows will be conducted to identify the species and size compositions of biological backscattering detected by the quantitative echosounder. The purpose of the predetermined tows will be to estimate the abundance and distribution of planktons independently from the echosounder. The nets will be run down to 1,000 m or near the sea bottom at the predetermined stations. Either the rectangular midwater trawl (RMT) with nominal mouth areas of 8 and 1 m^2 (1 + 8) and mesh sizes of 4.5 and 0.33 mm (Baker *et al.*, 1973), Isaacs-Kidd Midwater Trawl (IKMT) or Matsuda-Oozeki-Hu-Trawl (MOHT) (Oozeki *et al.*, 2004; 2012) will be used. Field studies suggested that euphausiids were effectively sampled in North Pacific (Pakhomov and Yamamura, 2010). As the main objective of this excise is estimation of Antarctic krill using the echosounder, priority will be given to targeted tows. Length frequency data of Antarctic krill obtained by the net sampling is required to estimate abundance of Antarctic krill by using the echosounder. Species compositions of net samples will be analysed.

Detailed survey plans will be presented to the SC-CAMLR in advance of the survey to receive their comments. Preliminary results of the analysis will be reported to the CCAMLR-EMM within 2 years after the completion of each survey. The analysis will be completed within 4 years after the completion of each survey and submitted to peer review journals.

3.6.2 Comments and conclusion by Panel

The Panel **welcomes** the fact that the proponents are proposing to obtain information on krill as part of NEWREP-A as had been recommended during the JARPAII review. The information on krill is proposed to be used in two ways: (1) to assist in the development of Antarctic minke whale spatial models as an explanatory variable with respect to cetacean abundance (see Item 3.2.2) and (2) to provide input into ecosystem and multispecies models. The Panel **notes** that the detailed plans for the work to be undertaken are lacking (e.g. equipment has not been finalised for either the annual or large-scale surveys, large-scale survey tracks are not yet developed, ability to detect changes has not been estimated etc.). Thus, the Panel has been unable to provide a detailed review of the proposed krill work and below provides only initial comments. The Panel **welcomes** the proponents' intention to consult CCAMLR with respect to the plans for the two large-scale surveys.

3.6.2.1 SURVEY SCALE

The Panel **notes** that the proposed surveys will provide some indication of regional–scale abundance and distribution, but may not reveal much information on the small-scale interactions between whales and krill. This is in part due to the different windows-of-observation provided by a downward looking echosounder (typically sampling a 7° cone directly beneath the ship) and the broad strip that is sampled (and analysed in a distance framework) visually for whales. Previous studies have found reasonable correlations between krill and whales at the 100 km scale, but increasingly poor correlation at smaller (10s of km to sub km) scales (e.g. Reid *et al.*, 2000). The Panel **notes** that the degree of overlap between visual and acoustic sampling can be improved by use of multibeam sonars that sample a swath (up to *ca* 100m either side of the ship depending on frequency and hardware) either side of the ship. Cox *et al*. (2009) for example revealed a much greater match between krill distribution and distribution of air-breathing predators through use of multibeam data than downward-looking echosounder data . Multibeam technology is increasingly affordable (for example WAASP which now records water column data, c $50K). The Panel **recommends** that the proponents consider adoption of this technology in their surveys.

3.6.2.2 ECHOSOUNDER EQUIPMENT

The issue of multibeam technology is considered under Item 3.6.2.1. The Panel **notes** the importance of calibration of echosounders before each survey (annual and large-scale). Echosounders capable of operating at least three frequencies, with high ping-rates, over depth-ranges of at least 250m should be used. The EK500 likely to be used for the large-scale surveys is capable of this, but it has been superseded by more modern instruments and so obtaining spares is becoming problematic. Echosounders with adequate spares should be installed to avoid loss of sampling in the event of failure in the remove Antarctic locations.

3.6.2.3 NOISE

As the proponents note, the sighting survey vessel will not meet the ICES noise specification. This raises two issues. One is that the effective acoustic sampling range (depth beneath the vessel) is likely to be more limited than from a quiet vessel, so the effective sampling depth will be more limited (possibly to just 50 m at 200 kHz). The other is that the noise emanating from the vessel may disturb krill, such that krill may move off the survey line or change their angle of orientation (for example because they may dive downwards) or both: both of these effects will serve to reduce the apparent quantity of krill detected, biasing the abundance estimate.

To address the effect of the ship's noise, the Panel **recommends** that the ship and echosounder system(s) be trialled well before going to the Antarctic to determine the likely effective acoustic sampling range (signal-to-noise by depth characterisation) and potential for detecting krill. Such trials should be conducted with both the vessel(s) to be used in the proposed annual surveys and the vessel to be used in the broad-scale survey conducted every 6 years using the standard CCAMLR protocols.

3.6.2.4 KRILL SAMPLING: ACOUSTIC ISSUES

Echoes arising from krill are discriminated from echoes from other organisms on the basis of a size-dependent multi-frequency echo-intensity signature. The Panel **notes** that the small ring-net proposed for use with the annual surveys will probably fail to capture larger krill (which may avoid the net) and thus the size of krill in the survey area will be underestimated, leading to the use of a potentially-erroneous multifrequency krill-discrimination window. Furthermore, a biased view of krill size will lead to bias in the target strength (TS) estimation (TS is used to scale echo intensity to krill abundance) and thus abundance. The proponents recognise this and consider that the annual survey estimates provide a relative index only (and see Item 3.6.2.5).

3.6.2.5 BETWEEN-VESSEL COMPARISON

In the years (two out of 12) when it is proposed that both NEWREP-A and CCAMLR-type surveys are conducted, the Panel **recommends** that surveys of the same transects by both vessels are conducted in as close to a synchronous manner as possible to enable some cross-calibration between vessels, enabling perhaps the relative estimates to be anchored to a more absolute framework. However, since survey transect designs have not been presented, it is not yet possible to determine the degree of overlap or consequently the extent to which the between-vessel comparison could be achieved. Any such anchoring would have to take into account the fact that the annual surveys would – for reasons of noise outlined above – perhaps only provide abundance estimates in the top 50m or so of the water column.

3.6.2.6 STATISTICAL POWER

The proponents recognise that the annual surveys will provide an index of relative abundance rather than absolute abundance, whilst the large-scale survey is expected to yield estimates of absolute abundance. The proponents suggest that variance from the former may range from 10-37% whilst that from the latter will be of the order of around 20%. However, they do not define the effect size that they wish to be able to detect for either type of survey, where this is appropriate (e.g. related to possible changes in the ecosystem). For example, in an ecosystem context, what scale of interannual variability do the proponents wish to detect, and how large a change in krill abundance will need to be detected to inform feeding models? In the absence of this, the Panel is unable to evaluate whether either survey type will deliver the required data. The Panel therefore **recommends** that the proponents conduct an analysis of statistical power. The Panel **notes** that the CVs reported above relate only to transect-to-transect variability, and do not include any uncertainty due to issues related to, for example, bias in krill size-distribution estimation. The power analysis should consider all such influences. CCAMLR's WG-EMM has considered factors contributory to uncertainty in surveys of krill (https://www.ccamlr.org/en/wg-emm-95/72) and the Panel **recommends** that the proponents interact with this community.

3.6.2.7 KRILL SAMPLING: FEEDING ECOLOGY ISSUES

The proponents suggested that krill caught in large horizontally-towed frame nets will be used for comparison with stomach contents. Since the vessel proposed to be the dedicated sighting vessel cannot tow such a net, the

Panel assumes that stomach-to-net comparisons will only be possible in two of the planned 12 years i.e. when the large-scale CCAMLR-type surveys are envisioned. Although it is not possible without having the cruise tracks to compare, it seems unlikely that the dedicated sighting vessel and the CCAMLR-type large-scale krill survey will be in the same position at the same time to enable robust spatio-temporal comparisons between net samples and stomach samples to be conducted. The Panel **recommends** that further more detailed plans be developed to consider how and if such comparisons are to be made.

3.7 Demography of krill

3.7.1 Presentation of methods by proponents

This topic is included within 'Krill abundance estimation and oceanographic observation', which is an objective of the Main Objective II 'Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models' (see section 2). Explanation of the analytical procedure related to this objective is given in Appendix 8 of the NEWREP-A plan.

Demography of Antarctic krill in the survey area will be studied to understand its ecology. Length frequency distribution and maturity stage of Antarctic krill will be constructed using samples from stomachs of Antarctic minke whales in the JARPA and JARPAII periods) (e.g. Ichii *et al.*, 1998) in addition to samples (both from stomachs and net haul) obtained in the upcoming surveys. Regional and temporal differences of demography will be investigated. Comparison between samples from stomach and net will also be attempted. Though several demographic studies on Antarctic krill in the survey area have been reported (Kawaguchi *et al.*, 2010; Nicol *et al.*, 2000; Pakhomov, 2000; Sala *et al.*, 2002; Taki *et al.*, 2008) the information is scarce in comparison of the Antarctic Peninsula region. The obtained data will contribute to the understanding of the ecology of Antarctic krill in the survey area.

Construction of population dynamics modelling will be considered using the above mentioned demography data. Modelling approaches similar to the past studies (Murphy and Reid, 2001; Reid *et al.*, 2006; 2002; 1999; 2010) will be applied with modifications whenever these are appropriate. This study will potentially provide information on population dynamics of Antarctic krill in the survey area where no population dynamics studies on Antarctic krill have been carried out.

Stock structure of Antarctic krill will be examined at the circumpolar scale including samples obtained by this research. Stock structure of Antarctic krill within Areas IV and V will also be examined using samples obtained by this research. The results of combination of this study and other studies outside of the program will potentially provide new information on stock structure of Antarctic krill in the survey area, which is important for interpreting demographic results.

3.7.2 Comments and conclusion by Panel

The proponents explained that krill would be sampled in three ways: using a ring net as part of the annual acoustic surveys proposed to be undertaken from the sightings vessel; using a large frame-net in CCAMLR-type acoustic surveys; and from whale stomachs.

Sampling of krill from whale stomachs is discussed elsewhere (Item 3.9.3) so is not considered in detail here. Suffice to say that depending upon the time between feeding and dissection, krill in the stomachs may have suffered digestive degradation, although some allowance for this can be considered e.g. Lindstrøm *et al*.(1998).

Sampling with a small, vertically-hauled ring net will under-sample larger krill, so will deliver a biased view of size distribution (see Item 3.6.2).

Sampling using the large frame net proposed under the large-scale CCAMLR-type surveys is the most likely to deliver krill representative of local size structure. The Panel **notes** that size structure may well not be uniform throughout the proposed survey areas and **recommends** that sufficient time should be allocated to the survey schedule for adequate net sampling. To determine this time requirement, the Panel **recommends** that the proponents carry out an analysis of previous net sampling data; consideration of BROKE/BROKE West data will inform the amount of net sampling effort that would be required to adequately-characterise the expected variability in krill size structure required for demographic studies and informing (from a TS perspective) analysis of the acoustic surveys.

3.8 Oceanography

3.8.1 Presentation of methods by proponents

This topic is included within 'Krill abundance estimation and oceanographic observation', which is an objective of the Main Objective II 'Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models' (see section 2). Explanation of the analytical procedures related to this objective are given in Appendix 8 of the NEWREP-A plan.

Monitoring of oceanographic conditions in the Antarctic Ocean is important as decadal scale change in oceanographic properties have been reported around the Antarctic (Jacobs and Giulivi, 2010; Meredith *et al.*, 2014; van Wijk and Rintoul, 2014). The main objective is to collect oceanographic data to test whether oceanographic conditions in the Antarctic Ocean are changing. Oceanographic data will provide us information on current status of oceanography in the survey area. The data will be sent to an appropriate data repository for further analysis integrating data obtained by other surveys. Information on water temperature and salinity is also required to correct echosounder data.

3.8.1.1 ANNUAL SURVEYS

Oceanographic data will be obtained by a memory type conductivity-temperature-depth profilers (CTD) and expendable CTD (XCTD). Observation depth for the first and second instruments will be 500 and 1000 m respectively.

3.8.1.2 CCAMLR STANDARD LARGE-SCALE KRILL SURVEYS

The CTD/Rosette Multi-bottle Samplers (CTD/RMS) will be used as the primary oceanographic observation instrument. The XCTD will also be used as a supplementary instrument. The CTD will be deployed down to 3,500 m or near the sea bottom while water samples will be collected by the RMS for the purpose of study on physical, chemical and biological oceanography. The XCTD will be cast on an opportunistic basis.

3.8.2 Comments and conclusion by Panel

Oceanographic data are required for several reasons including: (a) determining sound velocity and attenuation parameters for interpretation of acoustic survey data; (b) considering the distribution of populations of krill within potentially discrete water masses; (c) considering environmental change; and (d) potentially providing information for spatial modelling and explanatory variables when estimating abundance. The spatial scales over which data are required for different objectives may be different, and the proposal does not provide sufficient detail for the Panel to evaluate this component of the programme. The Panel **recommends** that careful consideration be given to these scales in design of the oceanographic sampling programme. Observations at just a single station per day, for example, are probably insufficient to characterise the potentially variable physical environment in a manner adequate for quantitative treatment of acoustic survey data. XCTD deployments could be made more frequently than once per day during the acoustic surveys. Furthermore, there may be gains to be made by considering data available from, for example, other sources such as Argo floats. The importance of considering data from outside the direct programme is considered further under Item 3.10.2.

The Panel **recommends** that due consideration should be given to the spatial distribution of oceanographic sampling, and a regular geographic sampling design might be preferable. Benefit could arise from occupation of the same CTD stations as occupied during BROKE and BROKE West.

Finally, in order for oceanographic data to be useful in the context of other international observations, the Panel **stresses** that it will be necessary to ensure that CTD instruments are calibrated to international (e.g. WOCE) standards.

3.9 Feeding ecology (prey consumption and nutritional condition)

3.9.1 Presentation by proponents of lethal methods (stomach contents and nutritional condition)

'Feeding ecology of Antarctic minke whales (prey consumption and nutritional condition)' is the Objective II (iii) of the Main Objective II 'Estimation of prey consumption by Antarctic minke whale and its nutritional condition' (see section 2). Explanation on the analytical procedure related to three sub-objectives is given in Appendix 10 of the NEWREP-A plan.

The prey consumption by Antarctic minke whale can be an important input parameter for the ecosystem model. The quantitative stomach contents data is needed for calculation of the daily prey consumption.

In the 2014 JARPA II review meeting (IWC, 2015b), the panel pointed out the uncertainties in the various estimates of consumption and recommended that further analysis be developed and allocated high priority. The uncertainty issues on prey consumption for Antarctic minke whales were:

(1) *r* (the ratio of low/high feeding intake) and the length of the feeding season

(2) the extent of night feeding

Based on the recommendation above, tagging studies and night time sampling will be conducted under the NEWREP-A as feasibility studies. Daily prey consumption of Antarctic minke whales will be calculated by the diurnal change of stomach content weights and basal metabolism (ex. body weight) using Monte-Carlo simulations to account for the uncertainties.

NIGHT SAMPLING FOR THE STUDY OF PREY CONSUMPTION

Data during night have not been obtained due to logistical difficulties during JARPA and JARPA II. However, to clarify the existence of night feeding, attempts will be made to obtain the Antarctic minke whales by lethal sampling from 21:00 to 02:00. As the first step, sampling during white night in high latitude area will be tried. Based on additional new data obtained during night, attempts to calculate the daily prey consumption of Antarctic minke whales will be made considering the uncertainty.

ASSESSMENT OF NUTRITIONAL CONDITION

The blubber thickness is significantly correlated with lipid contents in blubber (IWC, 2015b). The results of direct evidence of nutritional condition have been agreed in the Scientific Committee (IWC, 2015c) and the continuation of data collection will contribute the monitoring Antarctic ecosystem and validation of ecosystem modelling. In the 2014 JARPA II review meeting

(IWC, 2015b), the Panel recommended that further studies should incorporate blubber lipid content analyses, and that the collection of current measurements also continues to ensure comparability with past and future

In NEWREP-A, for assessment of nutritional condition, the measurements of body condition (blubber thickness, girth, total fat weight) and weighing of stomach contents will be conducted by lethal method. For the evaluation of body condition by chemical analyses, blubber and internal fat are sampled from the entire body of the whales and the lipid content % of samples will be analysed to calculate total lipid contents per individual. This total lipid contents will be compared to the indicators.

3.9.2 Presentation by proponents of non-lethal alternative experiment (tagging and biopsy sampling)

Recent tagging techniques can give useful information to increase precision in the calculation of daily consumption by the Antarctic minke whale and this will contribute to account for the uncertainties in the calculation. The tagging and satellite tracking that records the position of whales for a long period will be conducted for the Antarctic minke whale to examine the migration patterns and duration of stay in the Antarctic waters and successful results would provide more precise daily food consumption and arrival and leaving time to calculate seasonal consumption. For the feeding ecology study, the feasibility study of stable isotope ratios (δ13C and δ15N) will be examined to determine whether they can be provide enough information for the purpose of the program. These samples will be obtained by both biopsy sampling (non-lethal methods) and lethal sampling. The samples from lethal sampling will be compared to the stomach contents from the same animals. An initial feasibility test will be planed.

The new research will assess the body condition indicators to examine the whales' biological condition by comparing to the amount of total fat storage. Additionally other chemical body condition markers will be tested to examine their usability. Some of these include samples possibly obtained by biopsy sampling. An initial feasibility test will be planed. As an initial feasibility test, at least 50 Antarctic minke whales for each sex and area collected from this program will be used. In the assessment, data consistency comparing ordinal method from the JARPA and JARPA II period that were collected such as blubber and girth measurement and chemical indicator from biopsy seems appropriate for monitoring of body condition.

3.9.3 Comments and conclusion by Panel

One (although not the only) use of feeding ecology data is as inputs into the ecosystem and multispecies modelling described under Item 3.11. The key feeding ecology data that are required in order to support such modelling are the total consumption, the composition (by species and size) of the diet, and how the food availability impacts on the predators (e.g. growth, reproductive success).

3.9.3.1 ESTIMATES OF PREY CONSUMPTION

Research on feeding ecology can provide insights into how Antarctic minke whales are able to meet their basic energy requirements as well as providing inputs into the ecosystem modelling. The data required to estimate the composition of the diet are rather different to those required to estimate total consumption over the course of the feeding season. For estimating diet composition, data are required on 'recent' feeding, whereas estimates of total consumption require knowledge on the consumption integrated over the year. The proponents have proposed that stomach content information will be collected along with morphological information including total length, body mass, blubber thickness, blubber lipid content and total fat weight. The Panel **agrees** that stomach content data do provide insights into diet composition (prey species) as well as the size and composition of prey that are consumed, with the comments and provisos given below.

Under one hypothesis i.e. that competition increases between minke whales and other species of baleen whales, as the latter recover, it is important to determine whether changes occur in species composition as well as size composition in the Antarctic minke whale diet. For example, under JARPA II, some overlap was observed between fin whales and minke whales in diet composition, although the sample size for fin whales was small (Murase *et al.*, 2014). The proponents suggest a feasibility study to determine whether stable isotope ratios (δ13C and δ15N) may provide information on this regard. However, the Panel **notes** that this is already a standard technique routinely used to investigate overlap in diet between species; it has already been successfully applied to mysticetes on a number of occasions (Ryan *et al.*, 2013). Such a study can be conducted with skin samples and thus the Panel **recommends** its implementation without the need for a feasibility study. The Panel **recommends** concurrent analyses of krill samples to ensure the correct determination of stable isotope baselines, which may vary geographically and temporally, particularly considering the probable shift in trophic level of krill through the season.

NEWREP-A proposes that stomach content information is needed to determine total food intake. For this to be the case, the Panel **agrees** that information is also needed on digestive rates and passage rates, as well as the number of times that Antarctic minke whales fill their stomachs during a specified period of time. However, whilst the Panel **agrees** that modelling digestion rates and passage times in Antarctic minke whales is a valid scientific objective, it is unlikely to reduce uncertainties related to energy intake (food consumption) by Antarctic minke whales; such shortcomings have been highlighted before (e.g. IWC, 2007; Leaper and Roel, 2015)

However, with regard to further elucidation of feeding ecology and energetics, the Panel **notes** the value of quantitative work on digestive efficiency. Such data have application to feeding ecology and energetic extraction from krill. For example, the Panel **refers** to the approach applied to common minke whales in the North Atlantic (e.g. Nordoy, 1995; Nordoy *et al.*, 1993) which could be applied in the Antarctic. Proximate composition analysis provides a quantitative assessment of macronutrients and is most commonly used to evaluate forage quality. Applied to samples obtained at intervals through the digestive tract, digestibility and uptake of macronutrients and overall digestive efficiency of prey can be estimated.

The Panel notes that stomach content data can provide some information on diet composition (species and size classes of prey consumed) and time of feeding. However, the Panel **recommends** that a more powerful approach to estimating energy intake (requirements) is to develop a bioenergetics model that estimates basic energy requirements using standard allometric relationships and previously collected data. Such a model would need to take into account age and maturity status of the animals. Costs of growth and the build-up in stored energy reserves could be estimated using the change in body mass, as well as changes in energy density of collected animals (e.g. changes in lipid content in blubber, fat storage in core), growth and energy density of the foetus and placenta. These could be evaluated as within-season changes in growth and energy storage, to determine total energy requirements. Such data can be used for inter-annual comparisons in growth and energy reserves – these might be expected if density-dependent factors are affecting the dynamics of the population. Such effects may result from changes in Antarctic minke whale abundance, competition or changes in environmental carrying capacity. They would be expected to impact on minke whale growth rates, energy storage (lipid content of blubber, energy density of the core), foetal development or growth of calves and would be reflected as changes in body mass, lipid content of the blubber, energy density in the core or slower growth at age. An illustrative example for some of this is found in Lindstrøm *et al.* (2009)

The NEWREP-A proposal intends to deploy satellite transmitters and data loggers on Antarctic minke whales to obtain information on migration timing and routes, the duration of stay in Antarctic waters and in diving behaviour which would provide insights into potential foraging activity. The Panel **agrees** that this component of the research direction is important for a number of reasons including improved understanding of feeding ecology, information on temporal and spatial distribution for inclusion in ecosystem models, stock structure and to correct abundance estimates (see Item 3.1.5). However, few telemetry deployments on Antarctic or common minke whales aimed at long-term tracking have lasted more than 100 days. At this point, further development work is required to improve tag attachments to achieve useful attachment durations for management purposes. In addition, work is needed to determine appropriate sample sizes that can provide useful insights into migration and seasonal residency at the level of the population. The Panel **commends** the proposed experimental work on telemetry in the programme (see **recommendation** under Item 3.1.5).

However, the Panel also **notes** that satellite transmitters and data loggers will, of course, only be able to provide information from the moment they are deployed; under the proposed programme this will occur some time after the arrival of the whales on the feeding grounds. Unless tags remain attached for almost a complete year, they will only provide a date of departure from the feeding grounds, not the date of arrival, thus preventing determination of the complete feeding period. The Panel **notes** that sequential analysis of stable isotope signals along the edge of baleen plates may provide an insight into such duration (e.g. Aguilar *et al.*, 2014; Best and Schell, 1996; Lee *et al.*, 2005) and **recommends** that this be investigated from existing samples, if they exist.

3.9.3.2 ASSESSMENT OF NUTRITIONAL CONDITION

Nutritional condition is an important consideration, both as a direct indicator of the health of the population, and as an indicator of energy consumption for input into the multispecies models. The NEWREP-A programme proposes investigating the effectiveness of retinol as a chemical marker for body condition by examining tissue samples that can be obtained by biopsy samples such as blubber tissues. The Panel **questions** the validity of this approach. Although retinol levels in liver or blubber do reflect the quality of the food ingested, this only refers to the retinol content of that food, not its energetic content, which is what determines body condition. As in other mammals, in cetaceans retinol levels are homeostatically controlled and therefore do not show a relation with energy intake except in situations of extreme starvation or disease (e.g. Borrell *et al.*, 2004). Furthermore, tissue retinol levels are affected by the consumption of different sources of food, irrespective of body fat condition (Borrell *et al.*, 2004). For example, Vitamin A (retinol) levels in liver and blubber were very different between freshwater and marine ringed seals without this being associated to difference in body condition (Käkëla *et al.*, 1997). Thus the Panel considers that retinol is unlikely to be a reliable indicator of body condition. The Panel **reiterates** that body mass-at-length, blubber mass, percent lipid (in blubber) and other metrics are likely to be more robust than retinol.

3.9.3.3 LETHAL VERSUS NONLETHAL SAMPLING IN FEEDING ECOLOGY

Two important inputs to multispecies modelling can potentially be obtained from lethal sampling; total consumption and prey preference. A third factor related to feeding ecology is a condition index, which unlike total consumption is a relative value. The Panel **referred** to the discussions in the expert review of the Icelandic programme (IWC, 2014a) that showed that many, if not all of the feeding ecology-related 'non-lethal' techniques could also be employed using tissue from dead animals (the possible exceptions relate to longitudinal studies on the same animals). That review also noted that these methods often produced additional inferences for feeding ecology (e.g. with respect to timeframes, see below) and thus employment of these techniques can improve the results from any lethal sampling.

CONDITION INDEX

Although a condition index is not direct input for modelling studies, it does have relevance as a direct measure of population health and contributes to the assessment of temporal trends associated to ecosystem changes.

Using lethal sampling, many of the same measurements that can go into estimating total consumption can also be used to compute a condition index. For example, a condition index can be obtained by combining blubber lipid with blubber mass corrected for total body mass or body length. This was not done during the JARPA or JARPA II programmes and the Panel **recommends** that the proponents explore the development of such a condition index using the data from those programmes. Age at attainment of sexual maturity (ASM) is also an indirect condition index, as discussed in the NEWREP-A project. The strengths and weaknesses of such an approach have been discussed on a number of occasions within the IWC Scientific Committee (IWC, 2013c; 2014e). At present, non-lethal methods provide few alternatives. The first and most immediate would be blubber lipid content but biopsies only include the most superficial and external layer of the blubber, which is less indicative of body condition (e.g. Aguilar and Borrell, 1990). Whilst other proxies may be developed (e.g. leptin levels), none have yet been shown to be applicable for cetaceans. The Panel **recommends** that such non-lethal alternatives be evaluated.

TOTAL CONSUMPTION.

Total food consumption per predator is a key input to multispecies/ecosystem modelling in Objective II and it is thus important to obtain the best available estimates (and quantify uncertainty). As discussed above, although it is theoretically feasible to calculate consumption from stomach contents, bioenergetic modelling is likely to be a better approach; such models require data on the amount of energy used on metabolism, movement and other physiological functions and thus will require careful estimation of uncertainty. Lethal sampling provides information on body mass, age, growth, energy storage and reproductive status that can be used as inputs for bioenergetic modelling (e.g. Lindstrom *et al.*, 2009; Smout and Lindstrøm, 2007)

Whilst there are no well-developed non-lethal alternatives at present, data from Antarctic minke whales from JARPA II as well as from common minke whales in the Northern Hemisphere may already provide material for building the basic models, which could be tuned to consider inter-annual changes with new data. The Panel **recommends** that this be considered by the proponents. In principle, other methods such as photogrammetry and satellite telemetry may provide insights into changes in condition and buoyancy, and in the case of telemetry would provide information on movements and activity, but considerable development is still required.

PREY COMPOSITION

Prey composition is another key input into the ecosystem and multispecies models required for Objective II. At present Antarctic minke whale consumption is predominantly krill. If this remains the same then there is no need to collect further data. However, it is possible that prey composition may change under the hypothesis that minke whale abundance and condition may be being negatively impacted by competition with other whale species. It is therefore important that some ongoing monitoring is conducted to ensure that any change in prey composition is detected. The Panel **notes** that consideration needs to be given to the sample sizes and spatial/temporal sampling schemes necessary to detect changes of importance to modelling, whatever methods are used.

Lethal sampling will permit stomach content analyses that provide a high quality direct measure of the composition of the food just ingested. However, stomach content analysis does not provide information on the composition of previous (long- or short-term) feeding. Stable isotope analyses conducted on different tissues provide different windows of temporal information; for example, blood would inform about prey consumed in the last days or few weeks, skin about the prey consumed in the last few months (typically about 2 months) and bone would integrate the prey consumed during a period of several years (IWC, 2014a). In addition, since baleen plates are composed of inert tissue with no isotopic turnover, and have continuous growth, along their longitudinal axis they preserve a continuous record that can be used to investigate long-term variation in diet composition (Aguilar *et al.*, 2014; Hobson and Schell, 1998). In the common minke whale, the baleen plate may preserve information spanning approximately the 2 years previous to death (Mitani *et al.*, 2006). Lipid content of the blubber can contribute to estimates of energy stores, while fatty acid analysis can also provide insights into diet composition. However, both fatty acids and stable isotopes will require the development of prey libraries that may need to be updated in if prey signatures change spatially or temporally. This will be particularly important if diet becomes more complex, in which case stable isotopes may only provide information on trophic level of feeding.

Non-lethal alternatives are few in number because of the limitation to access to organs and tissues. Stable isotope values in skin can be used to infer prey composition in the previous two months, approximately. Skin and blubber biopsies could provide some diet information, but the inner blubber layer needs to be sampled to provide information on dietary fatty acids. Faecal analysis can also be used to obtain direct information on prey composition. The Panel **recommends** that such alternatives be evaluated, especially in the context of a biopsy survey.

3.10 Spatial interaction amongst baleen whales

3.10.1 Presentation of methods by proponents

'To study the spatial interaction among baleen whales (Ecosystem Modeling Part 1)' is an Objective of Main Objective II 'Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models' (see section 2). Explanation on the analytical procedure related to this objective is given in Appendix 11 of the NEWREP-A plan.

Spatial distribution of cetaceans have been studied using empirical (statistical) models in recent years such as generalized additive models (GAMs) (Beekmans *et al.*, 2010; Friedlaender *et al.*, 2006; Hedley *et al.*, 1999; Murase *et al.*, 2013; Williams *et al.*, 2006) maximum entropy models (MaxEnts) (Ainley *et al.*, 2012; Ballard *et al.*, 2012; Bombosch *et al.*, 2014; Friedlaender *et al.*, 2011) and Getis–Ord G statistics and spatial regression models (Santora and Reiss, 2011). These empirical models are commonly termed as species distribution models (SDMs). However, it was recognized that SDMs could be complex and often difficult to formulate, and development of guidelines and recommendations for modelling steps for cetaceans are now being considered in the IWC/SC (IWC, 2015c). Furthermore, interaction among cetaceans and krill in spatial context has not been studies extensively in the Antarctic with few exceptions (Friedlaender *et al.*, 2011; Murase *et al.*, 2014).

The objectives of this research are (1) constructing appropriate SDMs of cetaceans as well as krill based on the guidelines developed by the IWC/SC and (2) developing appropriate methods to measure interaction among cetaceans and krill in spatial context using output form SDMs.

Various types of SDMs such as a generalized linear model (GLM), GAM, Ecological Niche Factor Analysis (ENFA), Random Forest (RF), Boosted regression tree (BRT) and MaxEnt will be tested using data obtained by upcoming surveys. Data of the IDCR/SOWER, JARPA and JARPAII will also be used in the analysis. Appropriate methods to formulate and compare results among models will be considered throughout the exercise. The results will also be compared with the results obtained by model based abundance estimation methods which currently underdeveloped in the IWC/SC (IWC, 2015c)

Development of appropriate methods to measure interactions among cetaceans and krill in a spatial context will be considered using the results of SDMs. Both estimated abundance and presence/absence of cetaceans will be considered in the research. Magnitude of interactions among cetaceans and krill will then be measured using the results.

The research will contribute to the development of guidelines for SDMs and model based abundance estimation methods which are actively considered in the IWC/SC. The results of SDMs will contribute to understanding temporal changes of spatial distributions of cetaceans in the survey area. SDMs will contribute to development of more advanced spatial explicit ecosystem models as the output of former models will be used as input of latter models.

3.10.2 Comments and conclusion by Panel

Much of the new data proposed to be used in the SDMs will be collected during the proposed sighting surveys. Panel discussions of survey design, data collection methods and analyse of these data as they relate to the SDMs can be found under Item 3.2.2.

The Panel **notes** that there was insufficient detail provided in Appendix 11 of the NEWREP-A proposal about the methods proposed to be used to develop SDMs and measure interactions. The Panel was thus unable to review fully the adequacy of the proposed methods and determine if the suggested changes from the work already conducted under JARPA II are sufficient to achieve the objectives of the NEWREP-A proposal. The JARPA II review was critical of these types of analyses in that programme and the Panel **reiterates** the discussions and recommendations found therein (IWC, 2015b).

However, in general the Panel **recommends** that the SDMs explore many types of potential habitat environmental explanatory variables where the choice of explanatory variables should reflect the environment that probably describes the distribution of each species. This includes variables such as sea-ice, primary production and oceanography. Some of these variables are available from broader datasets than those expected to be collected during the NEWREP-A sighting surveys, e.g. remote sensing resources, bathymetry databases (GEBCO or others) and related indices and the Panel **recommends** that these be acknowledged and incorporated into any revised proposal.

The Panel **concurs** with the proponents' view that developing SDMs is complex and there are several analytical methods that may be used. Thus, the Panel **recommends** that in the near future the proponents use previously collected data to further explore and compare the various methods. This exploration may result in suggested improvements to the future data collection survey design; for example to identify areas with high CVs which could be reduced by modifying future survey effort and design.

The Panel also **recommends** that in the near future the proponents use existing samples to compare prey in minke whales' stomach contents in areas where several cetacean species overlap in distribution, and in areas where they segregate, including investigation of whether whale species and krill length-maturity classes exhibit distinct spatial segregation in their distribution patterns.

3.11 Ecosystem dynamics in the Antarctic Ocean

3.11.1 Presentation by proponents of methods proposed including use of data from lethal methods

'Investigation of ecosystem dynamics in the Antarctic Ocean (Ecosystem Modeling Part 2)' is an Objective of Main Objective II 'Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models' (see section 2). Explanation on the analytical procedure related to this objective is given in Appendix 12 of the NEWREP-A plan.

The proponents explained two types of planned approaches for ecosystem modelling; 1) multi-species ecosystem modelling and 2) Ecopath-with-Ecosim-Ecospace models. These correspond to the fourth objective under Main Objective II, which aims at building ecosystem models in the Antarctic Ocean.

The first modelling above was intended to refine the earlier approach by Mori and Butterworth (2006) and Kitakado *et al.* (2014c), but some twists were added into their basic system of equations for multiple predators (some baleen whales and seals) and single prey species (krill). Although the multi-species production model is simpler than the approach of whole-of-ecosystem modelling, it still has many unknown parameters. To reduce the number of parameters to be estimated, some bioenergetic and allometric reasoning by Yodzis and Innes (1992) were incorporated for the predator species. The maximum consumption is linked to the body weight of the predators. This sort of model has the potential to estimate the extent of competition between the baleen whales. For example, since the population sizes of other larger baleen whales such as blue, fin and humpback whales declined through commercial harvesting, there may have been a state of krill surplus in the Antarctic. This surplus could be utilized by the Antarctic minke whales, and since that time the minke whales may be still above their pre-exploitation level.

The works on the first modelling would also contribute to development of management objective and procedures. Although any species interaction is not explicitly taken into account in the existing RMP implementation, multispecies adjustment would contribute to improvement of operating models and development of harvest controls to make more effective use of this resource. The multi-species production model, which development is undergoing now in the Antarctic Ocean, must be a good tool to precede such process. For example, the model could give some information on changes in carrying capacity and provide a scenario for running "RMP" simulation to see if the current single species CLA may or may not work under the changes in carrying capacity. This was a reason for our further development of multi-species production models. In this regard, it might be possible to extend our research objective toward work for linking ecosystem modelling with management with consideration of species interaction etc. Therefore, in the first modelling approach, the following ancillary research items are handled:

(a) Elucidation of history of the ecosystems in the Antarctic using multi-species production models

(b) Future projection of ecosystem using multi-species production models

(c) Contribution to the RMP trial specification using ecosystem models

(d) Examination of performance of the current RMP under ecosystem interactions

In the second modelling approach, construction of a spatially explicit ecosystem model using Ecospace module of EwE will be attempted as an initial EwE model was constructed in Area IV (Kitakado *et al.*, 2014c). The output of species density models (SDMs) will be considered as input data of the ecosystem models. Construction of other spatially explicit ecosystem models will be considered once modelling of Ecospace module of EwE is completed. The results of the spatially explicit ecosystem models will be compared with the results of multi-species-production ecosystem models. Initially, the proponents will start to design EwE-Ecospace models in Area IV and V using available data mainly obtained from the literature. The models will be updated once data from the ecological research are available. Environmental factors such as global warming and ocean acidification which potentially affect the Antarctic marine ecosystem (Constable *et al.*, 2014) will be considered in the updated models as external forces as in the case of Ainsworth *et al.* (2011). Coupling EwE-Ecospace and lower trophic models such as NEMURO (Kearney *et al.*, 2012) will be considered as an ambitious attempt.

The proponents consider that the perspective of ecosystem modelling constitutes an important bridge between the two Main Objectives. More specifically, in the existing RMP Implementation, species interactions are not taken into account explicitly neither in the trials nor for the catch limit. However, some adjustment to reflect this multispecies aspect would contribute to improvement of operating models and harvest controls. For example, the ecosystem model could give some information on changes in carrying capacity and provide a scenario for running "RMP" simulation to see if the current single species CLA may or may not "work" (*e.g.* may fail to allow harvests levels that are perfectly possible without putting a population at risk) under the changes in estimated carrying capacity. In this regard, this research objective could contribute to the future improvement of the RMP in terms of species interactions.

3.11.2 Comments and conclusion by Panel

The Panel **agrees** that the ecosystem and multispecies modelling in the proposal seems generally to be a valid approach to the main Objective II of investigating the ecosystem through modelling studies. However, the Panel

agrees that there is currently insufficient information in the proposal to conduct a full technical review. For example, the example multispecies model provided to the Panel did not fit the data adequately and the approach used to estimate the values for the parameters appeared to perform poorly. The main text of the proposal provides a reasonable justification and background for the ecosystem and multispecies modelling, but is lacking in details of the model structure proposed and the issues associated with the data needed to parameterise the models. In particular, the success or failure of the modelling is likely to depend more on the quality of the data to parameterise the models than on the precise modelling tools chosen.

Combining an ecosystem model with a multispecies modelling approach, as proposed here, provides a broad perspective of the ecosystem and the impact of changes in numbers of whales of ecosystem components. So-called 'whole-of-ecosystem' models (such as Ecosim with Ecopath) give a broad picture of ecosystem functioning, but have high and often unquantifiable levels of uncertainty arising from the need to parameterise many ecosystem processes. This requirement to parameterise an Ecopath model has the advantage that knowledge gaps can be identified. Furthermore, such models can help identify the relative importance of the linkages among functional group.

In contrast, multispecies models only consider a portion of the ecosystem, but represent each species at finer resolution than is possible within whole-of-ecosystem models. In general, the results from multispecies models would be expected to have higher precision and reliability than those from ecosystem models. It is important to compare multiple formations of multispecies models (e.g. different functional relationships) to enable for comparisons of hypotheses on possible ecosystem structures. Specifically, there is need to consider alternative functional forms, some of which include competition among baleen whale species and other which do not given the desire to understand the potential for competition among baleen whale species.

Developing ecosystem and multispecies models is a long term process, and the structure of the models will almost certainly evolve over a 12-year project. Consequently, the Panel **agrees** that it is not necessary to be too prescriptive on the model structure at the start of the project. However, the Panel **recommends** that any revised proposal should include an outline of the proposed model structures in the Appendix 12 of the NEWREP-A proposal. In particular, the species proposed for inclusion in the multispecies and whole-of-ecosystem models should be specified, together with the linkages among these species. For each species, a brief description of the underlying data and data quality should also be given, together with an explanation of how the information will be acquired. For example, the data related to the diet of the non-sampled whale species can be expected to be of a lower quality than those for the sampled Antarctic minke whales. It is not necessary to give the details of the modelling tool in the proposal, the focus at this stage should be on outlining the ecosystem structure to be modelled and how the difficulties in parameterising the models will be addressed.

The multispecies modelling would require knowledge, preferably based on time series of data, on the following for each predator species. For each input the relevant section of this report is given in brackets

(1) Number/biomass of each species (3.2)
(2) Total consumption by each species (3.9)
(3) Relative consumption of different prey by each predator species (3.9)
(4) Predator response to changed food availability (3.9)
(5) Link between food consumption and biological outcomes e.g. condition, growth, breeding success (3.9)
(6) Total available food (3.6)

The Panel **recommends** that the project proposal include more emphasis on describing how each of these data needs will be achieved and a 'gap analysis' should be conducted early in the timeframe. This would use the model structure to identify the relative importance and quality of the data underlying the various sections of the model. There are no lethal techniques involved in the modelling itself, although there may be in obtaining the data needed to parameterise the models. The issue of lethal versus non-lethal sampling is dealt with in the sections describing the data (listed above).

The Panel also **notes** that since the ecosystem and multispecies model structure may be expected to evolve during the project, the data needs can also be expected to evolve. Consequently, analytic calculations of ideal sample size may not be possible in advance. Rather, the aim of the project should be to collect a robust dataset which can be used for a variety of purposes (not all of which may be foreseeable during the proposal stage).

4 SAMPLE SIZE ESTIMATION

4.1 Presentation by proponents including consideration of use of non-lethal alternatives

Explanation of the calculation of sample size of Antarctic minke whale is given in section 3.3 and Appendix 13 of the NEWREP-A plan.

The first step for calculating a sample size under NEWREP-A was to identify all necessary data and information items to achieve the two Main Objectives. Some of them can be obtained through non-lethal research methods while others can be collected only through lethal methods. Extensive review of the discussions at the IWC SC as well as available scientific literature has been conducted to determine what data and information can be obtained only through lethal means given the present state of science. Several data items have been identified under this category, e.g. age, sexual maturity, body and nutritional conditions, and others. For all these items, statistical calculations and simulations have been conducted as described below. Eventually, age at sexual maturity was identified as a basis to calculate the sample size.

The key data that requires lethal methods is the age. The age will be measured from counting GLGs accumulated in the earplug. The age data themselves are then used as main data in SCAA analysis for the estimation of biological parameters including the natural mortality, MSYR and parameters in recruitment relationship and also ecological parameters like the time-varying carrying capacity. In addition, an indicator derived from a combination of age and maturity status, ASM, is of great importance not only for contributing information on the proportion of matured animals in the SCAA but also as an important indicator to know the change in the nutritional condition of whale populations. The ASM is affected by the mid- or long-term nutritional condition in the population. This does neither change rapidly nor fluctuate greatly. In this sense, it might be possible to detect a future change in the ASM if it happens. In addition, the ASM can be observed with relatively less uncertainty and also has an advantage that it can be observed directly. The ASM is influential to the number of mature animals (especially female), and hence a possible future increase in the ASM affects the productivity and of course population dynamics of the Antarctic minke whales. These factors demonstrate that the ASM makes considerable contribution to achieving Main Objective I. This leads to the better assessment and management of the Antarctic minke whales. It therefore constitutes the sole scientific ground for the sample size calculation under this proposed plan.

Given that the ASM has an accessible feature to set a target sample size, a single indicator, the age-at-50% sexual maturity (ASM50), is used to set an annual sample size in this plan. For this purpose, a conditioning was conducted to infer some effect sizes using maturity data taken from past JARPA and JARPA II samples. Secondly based on conditioned values for the changes in the ASM50 and consideration of the changes in the mean ASM based on transition phase over the last couple of decades, simulation studies are performed to examine sample sizes to detect possible changes. A necessary level of annual sample size is finally determined by the statistical testing and estimation performance. Specifically, the annual sample size is calculated to assure a reasonable degree of statistical power for detecting the change (i.e. the statistical power is greater than 90% for detecting ASM50's annual increase of 0.1 per year, and is close to 80% for the extent of increase 0.075 per year) with 5% significance level (i.e. the level of accuracy) over the whole research period (i.e. 12 years) and to improve estimation precision of the estimate of the extent of change.

The sample size for lethal method is calculated based on the required amount of both earplugs and reproductive organs for collecting age and maturity data respectively. This is directly related to Main Objective I, which includes performing the SCAA and to provide better specifications for the *IST*s. The annual sample size for Antarctic minke whales is set at 333 (for more details, see Appendix 13 of the NEWREP-A proposal).

It should be noted that, in the initial stage of developing of this proposed plan, simulation studies were conducted to determine whether required parameters for Main Objective II needs lethal methods. For determination of the sample size with a simulation framework, the first thing to do is to derive some conditioned models as in the case above. One of the ecosystem models which will be employed in the current plan is a set of multiple production models for prey (krill) and predators (mainly baleen whales) with some links between them (see Section 2.2 of the NEWREP-A proposal). It may be possible to set some conditioned values for the models. However, parameters in the models such as abundance estimate might have their own large uncertainty in addition to the inevitable uncertainty of the models themselves, and therefore it was not feasible to fix a set of reliable simulation scenarios at this stage. In addition, the models assume to use both the time series of abundance estimates for component species and that of a nutrition index for the Antarctic minke whales (*e.g.* stomach fullness or its proxy value), but the latter index from one krill predator, the Antarctic minke whales, is not so influential in the model simulations. Therefore it is not achievable at this stage to assess its contribution to the estimation of ecosystem models. In other words, it is not possible to evaluate the influence of sample size for Antarctic minke whales on models' performance. For this reason, the sample size determination based on the data items to be used for the Main Objective II is not scientifically feasible at this time.

As the program progresses, the calculation of sample size of Antarctic minke whales could be retried and the plan could be accordingly modified.

The proponents noted that this proposed sample size is the best estimation at the present level of scientific knowledge in relation to ASM. However, the sample sizes should be calculated based on the existing knowledge or estimates at the time and it is hard to deny that the assumptions used above could turn out to be inappropriate in light of updated information generated during this research plan. In this regard, the calculated sample sizes should be re-visited at the time of mid-term review (see Section 3.1 of the NEWREP-A proposal). This research program allows for possible modification of the future sample size by taking advantage of the latest available knowledge.

4.2 Presentation by observer on random effects in sample size calculation of age of sexual maturity

Papers SC/F15/SP02 and SC/F15/SP03 were provided to the Panel and are summarized in Annex E (see also Annex G).

4.3 Comments and conclusion by Panel

4.3.1 General issues

The data collected from lethal sampling have been proposed to be used for a variety of purposes. In addition to inputs into the SCAA and the estimation of trends in the ASM, the sampled data will form an important input into the ecosystem and multispecies modelling. As noted under Item 3.11, the final structure of the multispecies and ecosystem models has not yet been finalised. This is partly because the model development during the project should respond to the data gathered, but also because such modelling is a field in development, and it is reasonable to expect that there will be advances in modelling techniques during the course of the project. Consequently, the Panel **agrees** that analytic calculations of the required sample size for all of the different purposes may not be possible in advance, however desirable that may be in principle. The discussion below therefore focusses on ASM.

4.3.2 Calculating the sample size for ASM

A standard approach for determining sample sizes involves:

(a) identifying a quantity (e.g. trend in ASM) and an effect size which is to be detected (e.g. 0.1);
(b) specifying over how many years data collection is to occur;
(c) specifying the intended power of the experiment (and the associated alpha-value for rejecting the null hypothesis that the quality equals a null value);
(d) generating data sets based on the intended experimental design (e.g. that sampling of each half of the study area occurs every second year);
(e) applying the intended method of analyses and a hypothesis test to test whether the quantity is statistically different from the null value to each of the many generated data sets; and
(f) selecting the sample size so that the probability of rejecting the null hypothesis when the quantity equals the target effect size equals the desired power.

This is the approach adopted in Appendix 13 of NEWREP-A. However, the reliability of the resulting sample size given steps (a), (b) and (c) depends on the extent to which steps (d) and (e) adequately represent the situation being sampled, the experimental design and the method of analysis. In this context, the analyses of Appendix 13 of NEWREP-A make a number of assumptions (such as the lack of overdispersion or that ASM does not differ among cohorts after accounting for the time-trend) which means that the estimated sample size needed to satisfy the specifications at steps (a), (b), and (c) may be underestimated (e.g. see de la Mare and McKinlay, 2015)

The proponents state that ASM is an important source of information for estimating the population dynamics of Antarctic minke whales, including changes in carrying capacity. They also state that ASM is an important indicator of changes (or shifts) in the Antarctic ecosystem. The choice of effect size of 0.1 was selected because it is half of the change estimated for cohorts born from 1955 to 1970, recognising that the abundance of the stock of the Antarctic minke whales changed substantially over this period based upon the SCAA analyses (Punt *et al.*, in press). However, the Panel **notes** the NEWREP-A proposal does not provides a quantitative link between the effective size in change of ASM and the ability to conserve and manage minke whales (see Item 8 for additional information). Thus, the Panel **recommends** the proponents outline more explicitly how improvements in estimating ASM will lead to improvements in management and conservation.

The Panel **recommends** that the proponents conduct a power analyses for ASM using simulation by postulating a fairly complex and realistic process model, fitting it to available data, and then simplifying it by eliminating factors that are not supported by the data. In relation to step (d) above, the following process model should capture most of the features of how the data for estimating ASM will be collected:

(1) Generate the cohort sizes for all cohorts that will be subject to sampling during NEWREP-A. This can be achieved given the estimates of the cohort sizes from the SCAA [note that some of the cohorts to be sampled during NEWREP-A already exist and the analysis could condition on those]
(2) Select the ASM for each cohort. A model which is likely sufficient would entail an underlying time-trend, and cohort-specific variation about that trend that is temporally correlated.
(3) Select the width of the maturity ogive, likely a constant, but perhaps with temporally-correlated cohort-specific deviations.
(4) Project each cohort forward given natural and NEWREP-A related mortality, taking account of the selectivity of NEWREP-A.
(5) For each year generate a year-specific random effect to account for the effect of spatial and temporal variation in sampling effect.
(6) Generate the expected numbers of females by age and maturity state (mature, immature) for each survey year
(7) Sample from the expected numbers given the intended sample numbers
(8) Add ageing error to true ages based, for example, on the analyses of Kitakado *et al.* (2014a). This would necessarily account for the possibility of ageing bias as well as random ageing error.

(9) Restrict the data set to ages 4-13 if the analysis method is to be based on this range of ages.

The analysis in Appendix 13, a special case of the above, does not directly account for: inter-annual variation in cohort size; possible random effects on ASM and the width of the maturity ogive; annual deviations on the proportions of mature animals due to how the survey is implemented; or ageing error. Whether such simplifications are appropriate or not should be evaluated by fitting a model similar to the above process model and applying model selection methods to select a process model which is supported by the data.

If desired, an alternative approach, which might be computationally easier, would be to fit the process model within the Bayesian context (e.g. using JAGS) and hence obtain posterior distributions for the key parameters of the model, such as the random effects structure for the ASM and the width of the maturity ogive. Carrying the uncertainty reflected in the posteriors forward into process error when generating data sets would provide a more rigorous basis for evaluating sample size. Note that the above process model is not the most exhaustive possible. For example, it ignores the possibility that the expected change in ASM over time is linear and that the maturity ogive is logistic.

Ideally, the selected process model should be subject to diagnostic analyses, such that (a) the simulated number of cohorts that would be rejected based on the criteria applied in Appendix 13 of NEWREP-A is consistent with the observed numbers, and (b) the proportion of females of ages 4-13 falls within the observed range.

The method of analysis should mimic as closely as possible the one that would be applied in practice. For example, if data for some cohorts are to be ignored, this should be part of how the data are analysed within the simulations. Note that uncertainty related to step (5) could be reduced depending on how closely the intended track lines are followed.

4.3.3 Other analyses to determine sample size

The approach outlined above for determining sample size for lethal sampling was only applied to the problem of estimating trends in the ASM. This is a useful illustration of the approach and a good first step. However, by itself it does not provide information on the sample sizes required to produce a specified improvement in the amount of management-relevant information. The Panel **notes** that a similar approach could have been applied to several other quantities such as:

(1) *Outputs from the SCAA*. The SCAA is intended as a core analysis method for NEWREP-A and the quantities from the SCAA are intended to parameterize the ISTs. Simulation could have been used to assess how different levels of lethal (and potential non-lethal) sampling could inform (a) age-specific natural mortality and its temporal variation, (b) changes over time in carrying capacity and growth, and (c) MSYR.

(2) *Mixing rates* based on genetic and morphological information.

In common with the approach used to select sample sizes for ASM, it is necessary to justify effect sizes for each quantity to determine sample sizes. For some quantities (e.g. MSYR and temporal variation in natural mortality), it might be shown that the length of the programme is insufficient to meaningfully improve current estimates irrespective of sample size, in which case the effect size is irrelevant. Ideally, development of ISTs conditioned to existing data would provide effect sizes for most of the inputs to the ISTs. For example, effect sizes could be computed along the lines of the following management-related lines:

> *'The efficiency of the RMP (as expressed as catch, given satisfaction of a conservation threshold') will be substantially larger if process / quantity X > Y%. What is the required sample size to reject the null hypothesis that quantity ≤ Y%) using the results of ISTs?*

5 EFFECT OF PROPOSED CATCHES UPON THE STOCK(S)

5.1 Presentation of methods by proponents

Evaluation of the effect of the annual catch of 333 Antarctic minke whales on the stocks is presented in section 5 of the NEWREP-A plan.

To evaluate effect of proposed annual catches of 333 upon the stocks, two methods, simple catch limit algorithm (CLA) application and Hitter-Fitter program were conducted based on the latest information on stock structure, abundance estimates and biological parameters. For this examination it is assumed that future catches are made to the west of 130°E in the first year, and to the east of that longitude in the second year. Subsequently future catches are conducted in each of the sectors every two years alternately (therefore figures obtained by the CLA should be compared with sample size n= 333/2).

STOCK STRUCTURE

Based on information from JARPA and JARPAII two stock scenarios were examined: i) a base-case where two stocks occur in the research area, one distributed west of 130°E (I stock) and the other east of that longitude (P stock), and ii) a sensitivity test where two stocks occur in the research area (I and P stocks) which mix to each other in Area VW with a proportion of the I stock of 55% (Pastene and Kanda, 2005). Because the stock structure in Areas IIIW and VIE is unknown, it is assumed that there is one stock other than I stock in Area IIIW and that there is one stock other than P stock in Area VIE, for the most conservative scenario.

ABUNDANCE ESTIMATION

Abundance estimates for Areas IIIW, IIIE, IVW, IVE, VW, VE, VIW and VIE are 69,267, 11,782, 23,668, 23,096, 105,951, 154, 658, 20,438 and 29,928 in CPII and 33,375, 34,659, 29,745, 26,127, 43,640, 136,457, 48,206 and 25,683 in CPIII. Those for I and P stocks are 58,545 and 281,047 in CP II and 90,532 and 228,303 in CPIII in the base case and 116,818 and 222,774 in CPII and 114,534 and 204,301 in CPIII for sensitivity case. These estimates are based on the estimates derived from OK model with adjustment factors agreed by IWC SC (IWC, 2013a).

In the Fitter runs, some biological parameters were used: MSY level of 0.6, ASM 7.5 (50%) and 10 (95%). 50% ASM of 7.5 is assumed because 50% ASM for recent cohort ranges 7-8 years in both stocks (Bando *et al.*, 2014). It is assumed natural mortality for the I stock for ages <=3, 10-20 and >=40 are 0.077yr-1, 0.048yr-1, and 0.107respectively and the corresponding values for the P stock are 0.074yr-1, 0.046yr-1, and 0.103 yr-1 respectively and that natural mortality is assumed to vary linearly with age between ages 3 and 10, and between ages 20 and 40 (Punt, 2014b). Using a fixed MSYR (1+) option of the Hitter-Fitter program, runs were conducted for MSYR (1+)=1% and 4% and for agreed abundance estimates and historical catches.

Catch limit derived from CLA for I and P stocks are 739 and 3,153 respectively in base case and 1,260 and 2,857, respectively in sensitivity case. Those in Areas IIIW, IIIE, IVW, IVE, VW, VE, VIW and VIE were 182, 202, 186, 183, 614, 2,142, 413 and 259, respectively. These catch limits are larger than half of the annual catch proposed. Fitter runs estimated population trajectory for the I and P stocks, respectively, for MSYR (1+)=1% and 4%. The trajectory for I stock shows an increasing trend after the 2015/16 for all scenarios examined. In the case of the P stock, trajectory remains constant around the pre-exploitation level. Fitter run estimated population trajectory for the stock in Area IIIW and that in Area VIE. In both cases the trajectories are stable or show an increase over time.

In conclusion both approaches used, CLA and Hitter-Fitter, suggest no negative effect on the stocks of the proposed annual sample size of the new research program.

5.2 Comments and conclusion by Panel

The proponents provided results based on one application of the *CLA* and by using the program Fitter to conclude that catches of the order of 333 every 2nd year will not harm the stocks. Whilst the Panel **agrees** that this conclusion is very likely robust to the analytical method applied, it provides the following comments on the analyses and **recommendations** for additional analyses:

(1) The application of the *CLA* is not based on the RMP variant that had been recommended by the Scientific Committee in 1992 (IWC, 1993a, p.62). In particular, the *Small Areas* were set to half Management Areas whereas the Committee recommended that the *Small Areas* should be 10^0 longitudinal sectors. While a future *Implementation Review* may conclude that half Management Area *Small Areas* are appropriate for application of the RMP, the Scientific Committee has not undertaken an *Implementation Review* upon instruction by the Commission. In addition, the *CLA* used by the proponents was based on the 0.6 tuning of the *CLA* rather than Commission-agreed 0.72 tuning (IWC, 1992). Results should also be provided that apply the currently-adopted version of the RMP for the Antarctic minke whales.

(2) The use of Fitter is normally appropriate to explore the implications of catches on stocks. However, the SCAA would seem a stronger basis for conducting such projections as it is based on fitting to more data than Fitter and the results have been reviewed by the Scientific Committee. Moreover, the historical trends in abundance from the SCAA differ markedly from those inferred from the Fitter analysis (contrast Fig 3 of Punt *et al.* (in press) with Fig. 4 and 5 of the NEWREP-A proposal). Ideally, the use of a population model to evaluate the impact of catches should also account for areas of mixing of stocks.

6 BACK-UP PLAN FOR CONTINGENCIES

6.1 Presentation by Proponents on Backup Plan for Contingencies

Back-up plan for contingencies is presented in section 7 of the NEWREP-A plan.

The proponent will establish a backup plan, in the case where a contingency disrupts the research, in order to respond to the contingency and secure the scientific value of data collected for the purpose of achieving the established scientific objectives. Such backup plan will address three aspects; (i) adjustments of research protocols at the scene of disruption, (ii) adjustment of research plans including research period, sample size, and research areas after the year of disruption, and (iii) consideration of analysis methods to compensate for the effects of disruptions.

The considerations of these aspects also responds to the recommendation made at the Expert Workshop to Review the Japanese JARPA II Special Permit Research Programme, held in Tokyo on 24-28 February 2014 (IWC, 2015b).

6.2 Comments and conclusion by Panel

The Panel **welcomes** the recognition in the proposal of the importance of planning for unexpected disturbances. The Panel **notes** that the presentation by the proponents included more information than in the proposal on the immediate action to be taken i.e. that catching would be suspended. However, whilst noting the need to develop them, the proposal does not provide information on how research plans might be modified in the years after the disruption or what analytical tools may be used to compensate. Whilst the Panel **recognises** that these will depend upon the precise circumstances of the disruption, the Panel **reiterates** the view of the JARPAII review that analyses could be undertaken based on the disruption that occurred to assist in the planning for the future.

7 PROVISIONS FOR COOPERATIVE RESEARCH

7.1 Presentation by proponents on collaboration with other researchers/organisations

This is explained in section 8 of the NEWREP-A plan.

Research collaborations will be sought with relevant scientists and research institutions (national and international), in consideration of the respective objectives of the research. Collaboration will be made with scientists of the IWC SC that have been heavily involved with this type of research, international research institutions involved in the research of the Antarctic ecosystem, such as CCAMLR-SC and national research institutions such as the Tokyo University of Marine Science and Technology, National Research Institute of Far Seas Fisheries, National Research Institute of Fisheries Science among others.

In addition, participation of foreign scientists in the field surveys as well as the analyses of data derived from the research will be welcomed, and for the purpose of the latter, databases will be created after each survey, which will specify the kind of samples and data collected during the research activities.

Consideration of the above responds to the recommendation made at the Expert Workshop to Review the Japanese JARPA II Special Permit Research Programme, held in Tokyo on 24-28 February 2014 (IWC, 2015b).

7.2 Comments and conclusion by Panel

Whilst welcoming the intention of the proponents for outside collaboration, the Panel **agrees** that at this stage, there is insufficient information available for it to comment on the extent and the scope of collaborations with national and international scientific bodies. The Panel was informed that given the early stages of proposal preparation, contacts with potential partners had just started and thus final arrangements were not yet formalised.

Specific comments with respect to CCAMLR are included in a separate section (Item 7.2.1). The Panel also recommended previously in this report a number of *ad hoc* collaborations for specific aspects of the NEWREP-A proposal that require the participation of highly skilled personnel (e.g. biopsy sampling and tagging, see Items 4.1.3 and 4.1.5, respectively). The Panel **notes** that this may involve costs to the programme but comments that such costs are necessary.

The proposal notes that participation of foreign scientists (at their own cost) in the field surveys as well as the analyses of data derived from the research will be welcomed. However, the application approach is not specified so the Panel **recommends** the proponents develop a formal protocol for expression of interest by foreign scientists. The Panel also **recommends** that they consider developing a strategy to promote incorporation of external Japanese and/or foreign scientists into the research. Potential instruments could include a call offering a limited number of post-doctoral posts, identifying subjects for conducting PhD research to be offered to collaborating universities, and discussing mechanisms for advancing international collaborations, including fellowships and partnerships with the Japanese Society for the Promotion of Science or other similar governmental organisations.

The Panel **notes** that one of the provisions (1(e)) of Resolution 2014-5 instructs the Scientific Committee to provide advice on ‘the degree to which the programme coordinates its activities with related research projects’. There is little detail of this in the proposal but the Panel **notes** that the NEWREP-A programme could potentially provide new information relevant to the work of the Scientific Committee, in addition to those related to in-depth assessments, RMP and ecosystem modelling. For example, the SWG on Environmental Concerns discusses cetacean disease, habitat degradation, marine debris and chemical pollution. With regard to these, specific studies on Antarctic minke whales might include: characterisation of internal parasite loads, morbidity, presence of biotoxins and ingestion of marine debris. Similarly, the incidence of injuries related to ship strikes and entanglement in fishing gear could be examined and reported to the working group on human-induced mortality other than hunting.

7.2.1 Collaboration with CCAMLR

As noted under Items 3.7 and 3.8, the proponents are intending to undertake two large-scale krill surveys during the 12-year period following CCAMLR guidelines as well as annual surveys from the sightings vessel. In the regions covered by NEWREP-A, single ship surveys were undertaken by Australia in 1996 covering 80-150°E (BROKE) and in 2005 covering 30-80°E (BROKE-West). These surveys form the basis for the existing precautionary catch limits for krill in the CCAMLR divisions 58.4.1 and 58.4.2 that came into being as Conservation Measures (CM 51-02 and CM 51-03) in 2008. The Panel **notes** that there has not been an active krill fishery in the CCAMLR areas covered by this proposal since 1992 (Area 88 -fishery from 1977-1987, 1990-1992) or 1995 (Area 58 – fishery from 1975-1988, 1990, 1991 and 1993-1995)[1] and that this region is not a high priority for CCAMLR.

The Panel was informed that the results from a previous acoustic survey for krill by Japan in the Ross Sea were presented to CCAMLR in 2008 (WG-EMM-08/31 and WG-EMM-08/35). The Panel **welcomes** the stated intention of the proponents to submit plans to the appropriate forums in CCAMLR (e.g. ASAM) and **recommends** that this be done at the earliest opportunity in the context of the field and analytical methods can be designed and implemented in accordance with CCAMLR protocols.

8 CONCLUSIONS & RECOMMENDATIONS BASED ON ANNEX P AND RESOLUTION 2014-5

The Panel recognised the considerable work that had been undertaken by the proponents in developing the NEWREP-A proposal. However, as summarised below and detailed in the body of the report, the present proposal contains insufficient information for the Panel complete a full review. The Panel has made a number of important **recommendations** for additional work that the Panel believes are **essential to be completed** before a full review of the programme under the Annex P and Resolution guidelines can be completed. The recommended analyses can be conducted with existing samples/data and new non-lethal sampling efforts.

In terms of timelines, the Panel recognises the value in maintaining long-term datasets. However, the Panel **agrees** that if there is a short (e.g. 2-3 year) gap in the existing series to enable the recommended analyses to be completed related to fully quantifying and prioritising sub-objectives and determining appropriate techniques (lethal or non-lethal), this will not have serious consequences for monitoring change. The Panel therefore **agrees** that the recommendations in Table 1 should be completed and the results evaluated before there is a final conclusion on lethal techniques and sample sizes. This consideration does not affect the non-lethal components of the proposal, which can be undertaken without discontinuation of the current research. The Panel’s view on the need for new samples and/or data feasibility, relevance, and contributions to the RMP, scientific research and conservation and management for aspects of Primary Objective I and II are summarised in Tables 2 and 3, respectively.

In summary, with the information presented in the proposal, the Panel was not able to determine whether lethal sampling is necessary to achieve the two major objectives; therefore, the current proposal does not demonstrate the need for lethal sampling to achieve those objectives.

[1] In the South Atlantic/Scotia Sea region the last large-scale synoptic survey (CCAMLR-2000) was undertaken by Japan, Russia, UK and USA in January-February 2000. This is currently the area where all the krill fishing is undertaken and is the major focus for much of CCAMLR in understanding the krill-based ecosystem and how the fishery can be managed.

Table 1

Summary table of recommendations (see full agenda item for details of the recommendations).

Key for 'Purpose'

A: To evaluate contribution of a particular objective or sub-objective of the programme to meet conservation and management needs

B: To evaluate feasibility of particular techniques (whether lethal or non-lethal)

C: Relevant to a full evaluation of whether any new lethal sampling is required

D: Relevant to issues related to sample size (irrespective of method used to obtain data)

E: Relevant to improve existing components of the proposed programme

Note that under 'Timeframe to complete' this is a rough estimate and will depend on the amount of time and effort available. A considerable number of the recommendations require analytical work (this includes simulation modelling). Achieving all of these within the timeframe estimated for each individual item will require considerable resources. Those that relate to purposes A, B, C and D are higher priority for completion.

Agenda Item	Summary	Purpose	Timeframe to complete	Needs new lethal or non-lethal samples/data? Effort type required
2.1.2	Evaluate the level of improvement that might be expected either in the SCAA or in RMP performance by improved precision in biological parameters using simulation studies including updated *Implementation Simulation Trials*	A, C, D	Within 6 months	No, analytical
3.1.3	Analyses to distinguish between 2-stocks with mixing versus isolation by distance	A, D	Within 3 months	No, analytical
3.1.3	Simulation study to examine how additional sampling could be expected to improve precision and/or reduce bias in estimates of mixing rates	A, D	Within 3 months	No, analytical
3.1.3.1	Comprehensive biopsy sampling feasibility study	B, C, D,E	1-2 field seasons	Yes, field effort
3.1.5	Comprehensive telemetry feasibility study	B, E	2-3 field seasons	Yes, field effort
3.2.2	Estimate *g(0)*for all species	E	Throughout	Yes, field effort then analytical
3.2.2	(1) review survey design and methods taking into account: (a) analysis of IWC IDCR/SOWER cruises; (b) spatial modelling developments; (c) experience of previous multi-disciplinary surveys; (d) JARPAII review recommendations; (e) the possibility of focussed surveys on specific issues in some years; (f) whales within the ice; (g) updated power analyses of the effects of survey interval and estimation of trend (2) work closely with the IWC Scientific Committee before finalising survey approaches; (3) ensure that future survey plans submitted to the Scientific Committee follow fully the guidelines for such survey plans, including incorporating proposed track lines	E	Within 6 months then throughout	Yes, analytical then field effort then analytical
3.3.3	Examine feasibility of using DNA methylation ageing technique with Antarctic minke whales using good quality earplugs, testing against geographical areas and different time periods and using several laboratories	B, C, D	Within 1 year	No, laboratory then analytical – also link to biopsy feasibility study (Item 3.1.3.1)
3.4.3.1	Examine use of hormones in blubber to detect sexual maturity	B, C, D	Within 2 years	No, laboratory - link to biopsy feasibility study (Item 3.1.3.1)
3.4.3.1	Evaluate the effect on SCAA of assuming 'resting' females are immature females	A, C, D	Within 6 months	No. analytical
3.4.3.2	Update SCAA with respect to density-dependence following Punt *et al.*, in press, and stock mixing based on existing data	A, C, D	Within 3 months	No. analytical

Agenda Item	Summary	Purpose	Timeframe to complete	Needs new lethal or non-lethal samples/data? Effort type required
3.4.3.2	Identify more fully the data to be used to inform the time-varying natural mortality in the SCAA and analyse existing data to determine the feasibility and accuracy of obtaining such estimates.	A, C, D	Within 6 months	No, analytical
3.4.3.2	Develop metrics to evaluate the benefits of including time varying ASM data in the SCAA	A, C, D	Within 3 months	No, analytical
3.6.2.1	Consider the adoption of this multibeam sonar in krill surveys.	E	Within 6 months	No, logistical
3.6.2.3	Trial the ship and echosounder system(s) in Japan well before going to the Antarctic to determine the likely effective acoustic sampling range and potential for detecting krill for multiple frequencies over the required survey depth. Conduct for both annual and broad-scale survey vessels.	B, E	Within 1 year for annual surveys	Yes, logistical, field effort, analytical
3.6.2.5	In the years (two out of 12) when both NEWREP-A and CCAMLR-type surveys are conducted, try to survey the same transects by both vessels in near synchrony	E	Within programme	No, logistical
3.6.2.6	Conduct full analysis of statistical power to detect changes in krill abundance from proposed techniques	A, E	Within 6 months	No, analytical
3.6.2.7	Develop more detailed plans to consider whether comparisons between stomach contents and proposed krill survey data are feasible and if so, how they can be done	A, B, C	Within 3 months	No, logistical
3.7.2	Ensure that sufficient time is allocated for adequate net sampling, based an analysis of previous net sampling data (e.g. BROKE/BROKE West data).	E	Within programme	No, logistical, analytical
3.8.2	Give careful consideration to scale and design of oceanographic sampling, taking into account BROKE/BROKE West data	E	Within programme	No, logistical, analytical
3.9.3.1	Compare overlap in diet amongst fin and Antarctic minke whales using stable isotopes in skin, with concurrent analyses of krill samples to obtain stable isotope baselines,	E	Throughout programme	Yes, field effort, analytical
3.9.3.1	Develop a more powerful approach to estimating energy intake (requirements) using a bioenergetics model; evaluate non-lethal methods for obtaining a time series of tuning data for such models	A, B, D	Within 6 months	No, analytical
3.9.3.1	Investigate stable isotopes along edge of baleen plates to see if this provides insights into duration of time on feeding grounds.	B	Within 6 months	No (if existing samples), laboratory
3.9.3.3	Use 'non-lethal' techniques on all animals; develop 'condition indices'; work to develop non-lethal techniques for total consumption	E	Within programme	To be determined after relevant analyses related to purposes A-D are completed
3.11.2	Provide an improved outline of the proposed ecosystem and multispecies model structures and provide a data gap analysis	E	Within 3 months	No, analytical
4.2.1	Provide a thorough power analysis of sample sizes required to detect change in ASM and follow the other recommendations in this Item	D	Within 3 months	No, analytical
5.2	Provide additional analyses on effect of catches upon the stocks for comparison with those presented	E	Within 3 months	No, analytical
7.2	Improve mechanisms for co-operative research	E	Within 3 months	No, logistical
8.2	Provide information on programme management, personnel and logistic resources	E	Throughout programme	No, logistical

Table 2

Summary of Panel's views on aspects of Objective I: (H=high; L=low; Y=yes; N=no; TBD= to be determined after further analysis)

Summary of objective	Need for new samples/data	Feasibility	Relevance	Likelihood for RMP improvement
I. Improved precision of biological and ecological information for the application of the RMP[1]				
1. Abundance estimates for Antarctic minke				
• Estimate *g*(0) based on sighting data collected during the survey	H	H	H	H
• Estimate abundance during JARPA/JARPA II considering *g*(0) estimates	No	H	H	H
• Estimate inter-annual variation (additional variance)	H	H	H	H
• Interpret/understand abundance time series [2]				
2. Improvement of age data precision				
• Use ratio of aspartic acid enantiomers in the lens nucleus	H	H	Y	H
• Feasibility study of the age determination method based on DNA methylation	H	H	Y	H
3. Refinement of the SCAA model and estimation of biological parameters				
• Apply longer time-series of newly available abundance estimates with g(0) correction	H	H	Y	H
• Consider a possible change in the age-at-sexual maturity in the model	TBD	H	Y	Analysis
• Consider any new age-reader's bias and variance in age-reading error matrices	L	H	Y	Analysis
• To extend the existing SCAA models to incorporate updated assumptions of population structures (time-varying stock boundary and mixing pattern)	M	H	Y	H
4. Refinement of stock structure hypotheses in Areas III-VI				
• Investigation of the stock structure in Areas IIIW and VIE	TBD	H	H	H
• Investigation of the spatial and temporal pattern of mixing between the I and P stocks in Areas IVE and VW	H	H	H	H
• Investigation of the pattern of movement within the feeding grounds and between feeding and putative breeding grounds	H	M	H	H
• Application of new genetic techniques to assist the analyses and interpretation	L	L	H	H
5. Develop *Implementation Simulation Trials* with lower uncertainty	H	H	H	H

Table 3

Summary of Panel's views on aspects of Objective I: (H=high; L=low; Y=yes; N=no; TBD= to be determined after further analysis)

Research objective	Need for new samples/data	Feasibility	Contribution to scientific research	Contribution to conservation & management
I. Objective II: Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models				
6. Krill abundance estimation and oceanographic observation				
• To produce annual krill indices of abundance in association with sightings	Y	M	M	M
• To produce two absolute estimates of krill abundance for large areas	Y	H	H	H
• To study the demography/ecology of krill from stomach contents from whales sampled in JARPA/JARPAII	N – Y[4]	L	L	L
• To study the demography/ecology of krill from existing stomach contents with additional samples from NEWREP-A from net sampling and whale stomachs				
• To study the oceanography of the research area to test whether oceanographic conditions in the Southern Ocean are changing	Y	L	H	M
7. Abundance estimate of whales species as input data for ecosystem modelling				
• Produce abundance estimates as input data for ecosystem models	Y	H	H	H
• Produce abundance estimates using the spatial modeling approach to investigation of cetacean interactions in a spatial context (Objective II(iv))	Y	M	H	H
8. Estimate prey consumption by Antarctic minke whale and nutritional condition				
• Increase the precision of estimates of prey consumption	N	M	H	H
• Monitor trends in body condition and stomach fullness as an indication of possible ecosystem changes, and to verify the results of ecosystem models	Y	H	H	M
• Investigation of chemical body condition markers	N	Y	M	M
9. To study spatial interaction among baleen whales (Ecosystem Modeling Part 1)				
• To construct appropriate SDMs (Species Distribution Models) of cetaceans and krill	Y	M	H	M
• To develop methods to measure interactions among cetacean and krill in a spatial context using output from SDMs	N	L	M	L
• To construct spatially explicit ecosystem models with a focus on cetaceans	N	M	H	H
10. Investigate ecosystem dynamics in the Antarctic (Ecosystem modeling Part 2)				
• Elucidation of history of the ecosystem in the Antarctic using multi-species production models[3]	N	M	M	L
• Predict future projection of ecosystem using multi-species production models	N	M	M	L
• To contribute to the RMP trial specification using ecosystem models	N	M	-	H
• To examine the performance of the current RMP under ecosystem interactions	N	M	H	H
11. Ancillary research objectives				
• Photo-ID and biopsy of blue, fin, humpback, southern right and killer whales to investigate stock structure, mixing and movements	Y	H	H	H
• Observation and examination of minke whale tissues for monitoring pathology	Y	H	H	H

8.1 Consideration of objectives (see Items 2.1.2 and 2.2.2 for details)

The Panel **welcomes** the fuller expression of objectives and sub-objectives in NEWRPEP-A compared to JARPA II which is accord with Annex P and recommendations from previous review panels.

With respect to Primary Objective I (Improvement in the precision of biological and ecological information for the application of the Revised Management Procedure (RMP) to the Antarctic minke whales), the Panel **agrees** that this objective and its component sub-objectives are important for conservation and management. However, although the NEWREP-A proposal discusses 'improvements' in some biological parameters as a sub-objective, it does not evaluate the level of improvement that might be expected either in the SCAA or in RMP performance by improved precision; this is an essential component of evaluating the importance of that sub-objective and the Panel **recommends** that this be done by the proponents using the simulation studies as described under Item 2.1.2 (and see Item 8.2 below) *based upon existing data* and included in any revised proposal. Without this it is **not possible** for the Panel to properly evaluate either the feasibility of meeting the objectives or appropriate sample sizes (either using lethal and/or non-lethal methods) for Primary Objective I.

With respect to Primary Objective II (Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models), the Panel **agrees** that this is an important area of research worldwide and that whales are an important component of such work. The Panel also **agrees** that an approach that combines a 'whole ecosystem' model with a 'multispecies' model is appropriate. The Panel also **notes** that the Scientific Committee is investigating ways of incorporating such considerations into the RMP. However, the Panel **notes** that this objective relates to a field in development which makes specifying the overall outcomes in a 12-year programme more difficult than for Primary Objective I. Whilst recognising these difficulties, the Panel **recommends** that in any revised proposal the proponents give priority to highlighting the important knowledge gaps *based on existing data* in the light of proposed initial modelling efforts. This will allow a more full analysis of what are higher priority parameters and thus a better evaluation of the feasibility of meeting the objectives or appropriate sample sizes (either using lethal and/or non-lethal methods) for Primary Objective II.

8.2 Programme management, resources, timelines and feasibility

The Panel **welcomes** the greater detail provided concerning timelines that was not present in the original proposal but that was presented by the proponents during the meeting. However, the Panel **recommends** that the revised proposal should provide considerably more information on programme management, personnel and logistic resources than it does at present. This is an essential component of any programme, and without this information it is **not possible** for the Panel to address adequately issues of feasibility.

The expert panels reviewing the previous JARPN II and JARPA II programmes both commented on the need for sufficient resources (expertise and time) to be made available; although past programmes have been strong in terms of field and laboratory work, *the same was not true with respect to analysis and modelling*. The Panel **reiterates those concerns** here. For example, several Panel recommendations (see above) relate to additional modelling to enable the Panel to properly evaluate the proposal in terms of feasibility of meeting objectives within the timeframe, appropriate sample sizes etc. The Panel **underlines** that it is **essential** that these are undertaken and provided in a revised proposal and that they are integrated into a revised timeline. The Panel **stresses** that these considerations are applicable irrespective of whether lethal or non-lethal methods are used. The question of lethal and non-lethal methods is discussed under Item 8.3.

8.3 Consideration of non-lethal methods

The Panel considered the guidance regarding evaluation of non-lethal alternatives to lethal take in the context of Annex P and IWC Resolution 2014-5. Collectively, this guidance indicates that the Panel should consider the relative effectiveness of lethal and non-lethal methods to (a) achieving the two primary objectives outlined by the proponents and (b) achieving the ultimate goal of providing information to improve the conservation and management of whale stocks and the ecosystems on which they and other marine species depend.

In this regard, the Panel was pleased to see that the Proponents' Main Objective I directly relates to a specific management/conservation outcome. However, although some components of the proponents' analyses of experimental design involve quantitative assessments, the comparisons of lethal and non-lethal methods provided were broadly qualitative in nature (as were the suggestions in Wade, 2015a).

Management under the RMP of the IWC is inherently precautionary, thus high levels of uncertainty reduce RMP catch limits. Therefore, improvements in methodology or experimental design and additional data that reduce uncertainty (e.g. by reducing the bias or variance of a key parameters such as MSYR, increasing the number of estimates of abundance, or eliminating stock structure hypotheses) can be expected to increase allowed catches whilst still meeting the conservation objectives of the Commission. Using this framework, the Panel **suggests** that a quantitative comparison of lethal and non-lethal methods in terms of management outcomes could be conducted as follows (and see Item 2.1.2):

(a) using *Implementation Simulation Trials*, calculate the expected increase in catch consistent with the conservation thresholds in IWC (2012) that would be expected by reducing uncertainty in model inputs and hypotheses, using a mix of tested lethal and non-lethal methods as described in the current proposal;

(b) do the same for a programme that could be developed that uses only tested non-lethal methods in the future (existing data from lethal studies or commercial catches may be used).

The Panel **agrees** that it is also important that any comparison of methods (and see Waples and Plummer, 2009) should also evaluate the feasibility of different techniques to meet objectives within a particular timeframe, including costs (field time, personnel, laboratory and analytical time, finances, etc.). The concept of 'tested' is incorporated for situations where particular methods may turn out to be feasible but the necessary validation has not yet been undertaken (e.g. see the discussion of biopsy sampling under Item 3.1.3 and Item 3.9.3).

The Panel **recognises** that such analyses are complex and **notes** that it is not clear who should be responsible for carrying them out. However, the Panel **stresses** that using this framework will allow a rigorous comparison of the relative merits of lethal and non-lethal sampling methods, in a currency that relates directly to the overarching objective of improving conservation/management of cetaceans. Furthermore, without such a quantitative comparison it is difficult to conclude whether lethal methods are required or not to achieve the stated objectives.

The proponents' Main Objective II ('Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models') is more difficult to relate directly to quantifiable management/conservation outcomes. In the context of building ecosystem models, almost all data obtained are likely to contribute in some way but the extent is difficult to quantify given the developmental nature of the work. In addition, ecosystem research is a complex and relatively new discipline, and the iterative nature of model building rather than the fixed and agreed RMP process precludes a full quantification of the issues in the same way as suggested above. Nevertheless, a similar conceptual framework could be developed to evaluate the relative merits of lethal and non-lethal methods *vis a vis* Main Objective II. The Panel **stresses** that key metric is not how much the methods can tell us about any one factor (e.g. stomach contents), but how useful this information is in understanding how the ecosystem works and how this relates to conservation and management of that ecosystem.

An essential component of evaluating the practicality of several non-lethal alternatives is the ability to obtain the necessary biopsy samples[2]. The Panel therefore **recommends** that an experiment to examine the effort required to obtain biopsy samples from Antarctic minke whales be given high priority. This will provide essential information in terms of evaluating the field practicalities of lethal versus non-lethal techniques and thus in determining the sample sizes (lethal and non-lethal) necessary to achieve overall objectives. The Panel **underlines** that this study must incorporate sufficient field effort and be able to *inter alia:*

(1) involve people with expertise in successfully biopsy sampling common minke whales in the North Atlantic;

(2) mimic the sampling strategy developed for lethal sampling (e.g. when dealing with schools >2);

(3) record information on time taken, sea state, swell, etc. to allow a plausible measure of effort required to obtain the sample size required for the studies;

(4) consider the amount of tissue and nature of tissue required (for each non-lethal analysis separately and in total).

In order to account for the spatial/temporal heterogeneity apparent in the data (c.f. de la Mare and McKinlay, 2015), biopsy sampling should follow the same fixed transects as the sighting surveys. However, consideration should be given to focus initial training efforts primarily in near-shore areas where animals can more reliably be encountered in good conditions.

8.4 Sample size (see Item 4)

8.4.1 General issues

The data collected from lethal sampling have been proposed to be used for a variety of purposes. In addition to inputs into the SCAA and the estimation of trends in the ASM (age at attainment of sexual maturity) which formed the basis of the proponents' estimation of sample size, the sampled data will provide input into the ecosystem and multispecies modelling. As noted under Item 3.11, such modelling is at an early stage, should respond to the data gathered and it is reasonable to expect that there will be advances in modelling techniques during the course of

[2] As shown in Table 1, in addition to the need to determine whether it is feasible to collect sufficient biopsy samples, there are also a number of calibration and other issues that need to be examined for a full comparison of lethal and non-lethal techniques.

the project. Consequently, the Panel **agrees** that analytical calculations of the required sample size for each different purpose, with an overall integration of this information to determine the appropriate sample size for the complete programme, although desirable in principle, may not be possible in advance. Furthermore the Panel **notes** that any evaluation of a lethal sample size must consider the utility of supplementary non-lethal data as means of reducing the sample size.

Discussion below therefore follows on the approach used by the proponents for estimating the sample size required to estimate a change in ASM. However, the Panel **notes** that the present proposal provides no direct link between change in ASM and the ability to conserve and manage Antarctic minke whales, although in principle analyses based on the SCAA or from conducting simulation trials of RMP variants could do so. The Panel **recommends** that this link should be explicitly incorporated into any revised proposal.

The Panel **welcomes** the efforts of the proponents to consider a more quantitative approach to examining sample size than in JARPA II. Whilst the broad approach taken with respect to ASM is not unreasonable, the Panel **notes** that certain assumptions made in that analysis mean that the estimated sample size may be underestimated, perhaps considerably. Therefore, the Panel **recommends** that the proponents conduct a power analyses for ASM using simulation by postulating a fairly complex and realistic process model, fit it to available data, and then simplify it by eliminating factors that are not supported by the data. Details of this approach (with a Bayesian alternative) are provided under Item 4. The Panel **emphasises** that such an analysis must be undertaken and provided in a revised proposal before it is possible to evaluate this component of sample size (i.e. estimating a trend in ASM should it occur).

The Panel also **recommends** that the simulation approach be then used to provide information on the sample sizes required to produce a specified improvement in the amount of management-relevant information with respect to other quantities including age-specific natural mortality, changes in carrying capacity, growth etc. as also described under Item 4. The Panel **notes** that sample size considerations should be undertaken for all aspects of the proposal (irrespective of whether lethal or non-lethal methods are used) and an overall view taken of appropriate sample sizes for the programme as a whole.

8.5 Effect of catches upon the stocks (see Item 5)

The proponents provided results based on one application of the *CLA* and by using program Fitter (de la Mare 1989) to conclude that catches of the order of 333 every second year in the two study areas will not harm the stocks. Given the estimated abundances of the stocks involved, the precautionary nature of the RMP and the nature of the sampling regime proposed following transect lines, the Panel **agrees** that this conclusion is very likely robust to whichever analytical method is applied. However, the Panel **recommends** that the revised proposal provides for comparison:

(1) results for the 1992 variant developed by the Scientific Committee (including using the 0.72 tuning and the 10° sectors); and

(2) the use of the SCAA including accounting for mixing of stocks.

8.6 Back-up plan for contingencies

The Panel **welcomes** the recognition in the proposal of the importance of planning for unexpected disturbances. The Panel **notes** that the presentation by the proponents included more information on the immediate action to be taken, i.e. that catching would be suspended. However, whilst noting the need to develop research alternatives, the proposal does not provide information on how research plans might be modified in the years after the disruption or what analytical tools may be used to compensate. Whilst the Panel **recognises** that these will depend upon the precise circumstances of the disruption, the Panel **reiterates** the view of the JARPA II review panel that analyses could be undertaken based on the disruption that occurred in the past to assist in the planning for the future.

8.7 Provision for co-operation

Whilst welcoming the intention of the proponents for outside collaboration, the Panel **notes** that at this stage, there is insufficient information available to comment on the potential extent and the scope of collaborations with national and international scientific bodies. The Panel made a number of recommendations throughout its report on; (1) *ad hoc* collaborations on specific issues; (2) the development of a formal protocol for outside scientists to express interest; (3) the development of a strategy to promote incorporation of external Japanese and/or foreign scientists into the research. With respect to krill research, the Panel **welcomes** the stated intention of the proponents to submit plans to the appropriate forums in CCAMLR (e.g. ASAM) for advice and **recommends** that this be done at the earliest opportunity in the context of the field and analytical methods and on the ability to detect potential trends in krill abundance.

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ANNEX A

List of Participants

Panel

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Andrew Brierley	University of St. Andrews, Scotland
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John Craig George	North Slope Borough, USA
Michael Hammill	Canadian Department of Fisheries and Oceans
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ANNEX B

List of Documents

NEWREP-A. Government of Japan. Proposed research plan for New Scientific Whale Research Program in the Antarctic Ocean (NEWREP-A).

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ANNEX C

General Overview of the NEWREP-A proposal presented by the proponents

Brief background

The research plan for the New Scientific Whale Research Program in the Antarctic Ocean (NEWREP-A) was submitted by the Government of Japan to the Secretary to the International Whaling Commission (IWC) and the Chair of its Scientific Committee (SC) in November 2014 in conformity with paragraph 30 of the Schedule to the ICRW and Annex P (IWC, 2013d). NEWREP-A follows two previous research programs under special permits in the Antarctic, the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) (1987/88-2004/05) and its second phase (JARPAII) (2005/06-2013/14). These are the only long-term whale research surveys in the Antarctic involving the combined use of lethal and non-lethal techniques.

Continuous monitoring programmes form the backbone of all scientific research programmes which have the aim of providing scientific advice on sustainable levels of catch for marine or terrestrial living resources. The reason is that population dynamics, and hence the size of the sustainable yield, can change in a manner that may not be predictable without collecting and analysing biological data on a continuous basis. Factors indexing these dynamics must therefore be monitored so that changes can be detected and important scientific information can be provided to the IWC as the basis for their conservation and management decisions. This is particularly important for the Antarctic Ocean where recent changes in the ecosystem have been reported. This principle guided the research under JARPA and JARPAII and will guide the research under the NEWREP-A.

Some of the key research outputs from JARPA and JARPAII were the following:

Two biological stocks of Antarctic minke whales distribute in the Antarctic between 35°E and 145°W. These two stocks mix in a transition area between 100°E and 165°E. The area of mixing and the mixing proportion changes by year and by sex (Pastene *et al*., 2014; Kitakado *et al*., 2014).

Hypotheses on stock structure of humpback, fin, and southern right whales in the feeding ground were proposed (Pastene *et al*., 2013; Goto *et al*., 2014; Kanda *et al*., 2014).

Several biological parameters related to growth were estimated by biological stock for the Antarctic minke whale (IWC, 2008 pp. 426).

Abundance of Antarctic minke whale remained broadly stable while those of the humpback and fin whales increased appreciably (and statistically significantly) during the JARPA period (Hakamada *et al.*, 2013; Matsuoka *et al.*, 2011).

SCAA provided robust estimates of natural mortality by stock and age, and trend in abundance of the Antarctic minke whale. Such trend provided information on productivity and its change over time (Punt *et al*., in press.).

Recent changes in the ecosystem e.g. changes in whale composition and distribution, and biological changes in krill predators such as the Antarctic minke whale, were confirmed. In particular indices on body condition such as blubber thickness, girth and fat weight has declined significantly in the JARPA period for the Antarctic minke whale (Konishi *et al*., 2008). Also a decline in the stomach content weight of Antarctic minke whale was reported for the JARPA and early JARPAII period (Konishi *et al*., 2014).

Trends in demographic parameters of Antarctic minke whale in 1940s-1970s were consistent with the pattern expected under the krill surplus hypothesis (Pastene *et al*., 2014).

NEWREP-A objectives

The main (primary) Objectives of this proposed research plan are twofold.

Main Objective I: Improvement in the precision of biological and ecological information for the application of the Revised Management Procedure (RMP) to the Antarctic minke whales.

This is aimed at contributing to the consideration and work of the IWC SC in improving the IWC's RMP that is the single-species management procedure adopted by consensus of its members in 1994 to calculate a catch limits of baleen whales for commercial whaling. The IWC SC continues to work on several issues on how the RMP could be improved and how it could be implemented. The program under this proposed research plan will collect data and estimate the parameters required to improve the application of the RMP to the Antarctic minke whale. It will also contribute to the improvement of the RMP itself.

Main Objective II: Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models.

Previous research programs have found that distributions and abundances of Antarctic minke, humpback, and fin whales, which are important parts of the Antarctic marine ecosystem, have been changing appreciably and that there could be competitive relations among those whale species in terms of food (Matsuoka *et al*., 2011; Matsuoka and Hakamada, 2014; Hakamada *et al*.,2013; Murase *et al*., 2014). It can be hypothesized that this phenomenon was caused by increased pressure on Antarctic minke whales from the recovering populations of humpback and fin whales that had been overexploited up to the 1960s, and resultant stagnation/decrease of the Antarctic minke whale populations that had experienced a drastic increase supported by improved food availability as a result of the overexploitation of larger whales. They may also be caused by fluctuations in the abundance of krill populations that are the common food resource for the three species of whales or possibly as a result of changes in the ocean environment associated with climate change. Investigation of the causes and current dynamics is essential for the future conservation and management of the whale resources as well as for the understanding of the Antarctic marine ecosystem.

Achieving a sustainable balance between the maintenance of the unique marine ecosystem and the utilization of its abundant resources is, as is common for all seas and oceans, an important challenge for the Antarctic Ocean. This is also consistent with the objectives of the ICRW stipulated in its preamble; "to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry".

The Main Objectives are sub-divided into specific Objectives and Sub-objectives (Secondary) as follows:

Objective I-(i) (see Appendix 3 of the NEWREP-A plan)

Abundance estimates for Antarctic minke whales taking into account of g(0) and additional variance.

Sub-objectives

Estimate g(0) based on sighting data collected during the surveys.

Estimate abundance during JARPA/JARPA II considering the g(0) estimates.

Estimate inter-annual variation (additional variance).

Interpret and understand time series of abundance estimates for Antarctic minke whales.

Objective I (ii) (see Appendix 4 of the NEWREP-A plan)

Improvement of precision of biological and ecological parameters of Antarctic minke whale. Part 1: Improvement of age data precision.

Sub-objectives

To improve the age estimation system based on ratio of aspartic acid enantiomers in the lens nucleus.

To conduct a feasibility study of the age determination method based on DNA methylation.

Objective I (ii) (see Appendix 5 of the NEWREP-A plan)

Improvement of precision of biological and ecological parameters of Antarctic minke whale. Part 2: Refinement of the SCAA model and estimation of biological parameters.

Sub-objectives

To apply longer time-series of newly available abundance estimates with g(0) correction.

To consider a possible change in the age-at-sexual maturity in the model.

To consider any new age-reader's bias and variance in age-reading error matrices.

To extend the existing SCAA models to incorporate updated assumptions of population structures (time-varying stock boundary and mixing pattern).

Objective I (iii) (see Appendix 6 of the NEWREP-A plan)

Refinement of stock structure hypotheses in Areas III-VI for the implementation of the RMP.

Sub-objectives

Investigation of the stock structure in Areas IIIW and VIE.

Investigation of the spatial and temporal pattern of mixing between the I and P stocks in Areas IVE and VW.

Investigation of the pattern of movement within the feeding grounds and between feeding and putative breeding grounds.

Application of new genetic techniques to assist the analyses and interpretations of results

in the sub-objectives a), b) and c).

Objective I (iv) (see Appendix 7 of the NEWREP-A plan)

Specification of RMP *ISTs* for Antarctic minke whales (no sub-objectives).

Objective II (i) (see Appendix 8 of the NEWREP-A plan)

Krill abundance estimation and oceanographic observation.

Sub-objectives

To produce annual krill abundance estimate by using echo-sounder and net installed in research vessels participating in the NEWREP-A surveys (Krill survey under NEWREP-A).

To produce krill abundance estimate in previously-surveyed CCAMLR areas by using echo-sounder and frame-type trawl net installed in a more specialized research vessel (CCAMLR standard type krill survey).

To study the demography of krill to understand its ecology by using samples from stomach contents of whales sampled in JARPA/JARPAII, and additional samples obtained by NEWREP-A from net sampling and whale's stomachs.

To study the oceanography of the research area to test whether oceanographic conditions in the Southern Ocean are changing.

Objective II (ii) (see Appendix 9 of the NEWREP-A plan)

Abundance estimate of some cetacean species as input data for ecosystem modeling.

Sub-objectives

Produce abundance estimates of some cetacean species as input data for ecosystem models.

Produce abundance estimates using the spatial modeling approach based on the updated IWC/SC guidelines, for investigation of cetacean interactions in a spatial context (Objective II(iv)).

Objective II (iii) (see Appendix 10 of the NEWREP-A plan)

Estimation of prey consumption by Antarctic minke whale and its nutritional condition.

Sub-objectives

Increase the precision of estimates of prey consumption.

Monitoring any trend of body condition and stomach fullness as an indication of possible ecosystem changes, and to verify the results of ecosystem models.

Investigation of chemical body condition markers.

Objective II (iv) (see Appendix 11 of the NEWREP-A plan)

To study the spatial interaction among baleen whales (Ecosystem Modeling Part 1).

Sub-objectives

To construct appropriate SDMs (Species Distribution Models) of cetacean as well as krill, based on the guidelines developed by the IWC SC.

To develop appropriate methods to measure interactions among cetacean and krill in a spatial context using output from SDMs.

To construct spatially explicit ecosystem models which mainly focus on cetaceans.

Objective II (iv) (see Appendix 12 of the NEWREP-A plan)

Investigation of ecosystem dynamics in the Antarctic Ocean (Ecosystem modeling Part 2).

Sub-objectives

Elucidation of history of the ecosystem in the Antarctic using multi-species production models.

Predict future projection of ecosystem using multi-species production models

To contribute to the RMP trial specification using ecosystem models

To examine the performance of the current RMP under ecosystem interactions

NEWREP-A has some ancillary research objectives:

A (i): Photo-ID and biopsy of blue, fin, humpback, southern right and killer whales to investigate stock structure, mixing and movements.

A (ii): Observation and examination of Antarctic minke whale tissues for monitoring pathology.

Regarding the NEWREP-A objectives, the following points are highlighted:

They come within the research categories identified by the IWC SC in its Annex P.

In the development of these objectives, scientific issues that have been actively discussed at the IWC SC (*e.g*. *Implementations* and *Implementation Reviews* of the RMP, in-depth assessments of Antarctic minke and other whales, investigation of marine ecosystems through ecosystem models) as well as the previous four research objectives of JARPAII have been taken into account (see Appendix 2 of the NEWREP-A plan). Under the framework of the ICRW, the IWC SC has established its guidelines for reviewing scientific research to be conducted under Article VIII, and the current guideline is Annex P adopted in 2008 and most recently revised in 2013(IWC, 2013). Annex P lists these broad categories of objectives for such research: (1) to "improve the conservation and management of whale stocks"; (2) to "improve the conservation and management of other living marine resources or the ecosystem of which the whale stocks are an integral part"; and (3) to "test hypotheses not directly related to the management of living marine resources".

Both of Main Objectives I and II of this program, namely, (i) *Improvements in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales* and (ii) *Investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models* are clearly within the research categories identified by the IWC SC in Annex P mentioned above, as were the cases of the JARPAII research objectives (see Appendix 2 in the NEWREP-A plan).

They reflect research need amply recognized by international organizations in charge of conservation and management of marine living resources.

In particular the objectives reflect the research needs of the IWC and CCAMLR. Regarding research on whales, the Objectives and Sub-objectives of NEWREP-A reflect topics of interest for the work of the IWC SC, and on which the IWC SC has made scientific recommendations.

One example on the relevance of Objective II (iii) (Estimation of prey consumption by Antarctic minke whale and its nutritional condition) of NEWREP-A for the work of the IWC SC is the following. The Working Group on Ecosystem Modelling in 2011considered that 'indices of body condition are potentially of importance to ecosystem modelling because they can enable detection of changes over a shorter period of time period than changes in abundance. Studies of body condition in others species such as gray whales have revealed apparent correlation with reproductive rates…Particularly in the context of the models of minke whale population dynamics being discussed in the IA sub-committee, blubber thickness is a possible additional source of information that might indicate consistency or otherwise with the population and recruitment changes estimated by these models' (IWC, 2012). Furthermore in the same year the IWC SC 'noted the potential importance of body condition indices to its work' (IWC, 2012). Blubber thickness, fat weight and girth are data to be collected under Objective II (iii) in NEWREP-A. There are of course other examples of discussions and recommendation of the IWC SC on topics related to the other Objectives of NEWREP-A.

The NEWREP-A plan integrates the previous JARPAII objectives into its main objectives, in a coherent and more sensible way.

Paragraph 127 of the ICJ judgment stated the following. 'The Court observes that the JARPAII Research Plan describes areas of inquiry that correspond to four research objectives and presents a programme of activities that involves the systematic collection and analysis of data by scientific personnel. The research objectives come within the research categories identified by the Scientific Committee in Annexes Y and P (see paragraph 58 above). Based on the information before it, the Court thus finds that the JARPA II activities involving the lethal sampling of whales can broadly be characterized as "scientific research".' This paragraph confirmed that JARPAII objectives are reasonable, they remain relevant and therefore they have been taken into account in the development of NEWREP-A in a coherent way.

For example the stock structure of Antarctic minke whale stood as a separate research objective in JARPAII. In the NEWREP-A plan it became a specific Objective under Main Objective I, which makes more sense since the stock structure research of this species is conducted for- and is essential information of- the RMP *Implementation*.

Outline of some methodological aspects of NEWREP-A

Research area

Determination of the research area and period is a crucial component of the proposed project. The Management Areas from III to VI as defined by the IWC SC, including Areas IIIW and VIE that were not covered under JARPAII but were a part of the recommendation of the JARPA II review workshop in 2014 for further research (IWC, 2014), are proposed to be the primary research areas for the Main Objective I. This is because of the existing level of scientific knowledge about the Antarctic minke whale stocks in those areas and the resultant high potential for the application of the RMP to them. These four areas are also relevant to Main Objective II and data obtained there will be used for the purpose of building ecosystem models. It should be noted in particular that the Management Areas IV and V provide useful information in this regard as the recent observed shifts of the species composition of whales in those areas that might be related to changes in the Antarctic ecosystem (Pastene *et al.*, 2014).

Research period

The research period under this proposed program is planned to be 12 years with a midterm review after the first 6 years in order to achieve research objectives. Main Objectives I and II requires intensive research over a certain period of time. This is because the data sought under these objectives includes long-term trends of changing rates of various biological and ecological parameters. It is therefore considered that certain scientific achievements could be made after about 12 years of analytical work that is to be conducted based on data obtained through this program (See Section 6 of the NEWREP-A plan). In addition, in designing the time frame of this program, practical considerations need to be taken into account, including the natural environment in the Antarctic Ocean including sea and ice conditions where research can be conducted only during a limited period time, required time for verifications and analyses of collected data and information, the capacity of the research such as the number of available vessels, researchers and personnel, and financial constraints. In view of the prospect of scientific work as well as practical considerations, this plan sets 12 years as the timeframe for its research.

Under his plan, a midterm review will be conducted 6 years after its launch, at the halfway point of the entire research period. The detailed timeline of research activities in this program is presented in the Section 6 of the NEWREP-A plan.

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

After the 12-year research period, with an additional research period if necessary under contingency backup plans (see Section 7 of the NEWREP-A plan), this research will be completed and reviewed in accordance with Annex P.

Sample size for the lethal component of the research program

The first step for calculating a sample size under NEWREP-A was to identify all necessary data and information items to achieve the two Main Objectives. Some of these can be obtained through non-lethal research methods while others can be collected only through lethal methods. Extensive review of the discussions at the IWC SC as well as available scientific literatures have been conducted to determine what data and information can be obtained only through lethal means given the present state of science. Several data items have been identified under this category, e.g. age, sexual maturity, body and nutritional conditions, and others. For all these items, statistical calculations and simulations have been conducted as described below. Eventually, age at sexual maturity was identified as the basis to calculate the sample size.

In the NEWREP-A effort was made to calculate sample sizes of Antarctic minke whale for the two Main Objectives of the research plan. The age-at-50% sexual maturity (ASM50), is used to set an annual sample size for Antarctic minke whale in this plan. For this purpose, a conditioning was conducted to infer some effect sizes using maturity data taken from past JARPA and JARPA II samples. Secondly based on conditioned values for the changes in the ASM50 and consideration of the changes in the mean ASM based on transition phase over the last couple of decades, simulation studies are performed to examine sample sizes to detect possible changes. A necessary level of annual sample size is finally determined by the statistical testing and estimation performance. Specifically, the annual sample size is calculated to assure a reasonable degree of statistical power for detecting the change (i.e. the statistical power is greater than 90% for detecting ASM50's annual increase of 0.1 per year, and is close to 80% for the extent of increase 0.075 per year) with 5% significance level (i.e. the level of accuracy) over the whole research period (i.e. 12 years) and to improve estimation precision of the estimate of the extent of change (for more details, see Appendix 13 of the NEWREP-A plan). The annual sample size for Antarctic minke whales is thus set at 333.

The sample size for lethal method is calculated based on the required amount of both earplugs and reproductive organs for collecting age and maturity data respectively. This is directly related to Main Objective I, which includes performing the SCAA and providing better specifications for the *IST*s. Age and sexual maturity data require lethal sampling (see item 3.2.1 in the NEWREP-A plan).

It should be noted that, in the initial stage of developing of this proposed plan, simulation studies were conducted to determine whether the required sample size for Main Objective II could be calculated. For determination of the sample size with a simulation framework, the first thing to do is to derive some conditioned models as in the case above. One of the ecosystem models which will be employed in the current plan is a set of multiple production models for prey (krill) and predators (mainly baleen whales) with some links between them. It may be possible to set some conditioned values for the models. However, parameters in the models such as abundance estimate might have their own large uncertainty in addition to the inevitable uncertainty of the models themselves, and therefore it was not feasible to fix a set of reliable simulation scenarios at this stage. In addition, the models assume to use both the time series of abundance estimates for component species and that of a nutrition index for the Antarctic minke whales (*e.g.* stomach fullness or its proxy value), but the latter index from one krill predator, the Antarctic minke whales, is not so influential in the model simulations. Therefore it is not achievable at this stage to assess its contribution to the estimation of ecosystem models. In other words, it is not possible to evaluate the influence of sample size for Antarctic minke whales on models' performance. For this reason, the sample size determination based on the data items to be used for the Main Objective II is not scientifically feasible at this time. As the program progresses, the calculation of sample size of Antarctic minke whales could be retried and the plan could be accordingly modified.

Even though the calculation of a sample size under the Main Objective II is not feasible at this stage, tissue and other biological samples and data to be obtained from their analysis under the sample size calculated based on the ASM as described above will be fully utilized for achieving the Main Objective II in combination with information from non-lethal research methods and other research and studies. With such effort, there will be certain progress in achieving the Main Objective II, while it is not possible to foresee the level of expected achievement by using statistical methods at present time.

This proposed sample size is the best estimation at the present level of scientific knowledge in relation to ASM. However, the sample sizes should be calculated based on the existing knowledge or estimates at the time and it is hard to deny that the assumptions used above could turn out to be inappropriate in light of updated information generated during this research plan. In this regard, the calculated sample sizes should be re-visited at the time of mid-term review. This research program allows for possible modification of the future sample size by taking advantage of the latest available knowledge.

Necessity of new samples and importance of the long time-series data set

Past data on age, body length and sexual maturity from past data commercial whaling as well from JARPA/JARPAII are available for part of the NEWREP-A research area. However the analyses of those data alone are not sufficient for the objectives of the NEWREP-A.

The rational for this is explained in the NEWREP-A plan as follows: 'this research program's objectives require to ascertain ongoing changes occurring in whale resources and Antarctic ecosystem through collection of relevant data on a yearly basis. This inevitably needs new samples under this program.

The data to be obtained from the new samples, being combined with the past data derived from JARPA and JARPA II as well as from commercial whaling operations, will form an integral part of the long time-series data set, while there is a one-year gap in between (2014/15). Such a data set would be the foundation for the better understanding of the long-term transition of the Antarctic ecosystem including whales and for the conservation and management of whale resources'.

Then the new data will form an integral part of the long time-series data and the new data collected by NEWREP-A will be analyzed in conjunction with past data (see detail in section 3.3.3 of the NEWREP-A plan).

Trial, evaluation and development of new non-lethal techniques

There are established non-lethal research methods, however their usefulness is in dispute, and newly emerging non-lethal methods are at very preliminary development stages. In this research plan, all those non-lethal methods will be employed and tested as described below.

JARPA and JARPAII employed a series of established non-lethal research methods. Those non-lethal methods which will continue to be used in this research program are sighting surveys for whale abundance estimates, oceanographic surveys, echo-sound surveys for krill biomass estimates, photo-id experiments for studies on stock structure, movement and distribution of large whales and biopsy sampling experiments for studies on stock structure in large whales.

Taking account of the 31 March 2014 ICJ Judgment, specifically its statement that "the JARPA II Research Plan should have included some analysis of the feasibility of non-lethal methods as a means of reducing the planned scale of lethal sampling in the new programme" (paragraph 137) the new research proposal includes the examination of non-lethal techniques (see Figure 3 of section 4 of the NEWREP-A plan), which could potentially complement or replace lethal techniques used in the context of achieving the research objectives. The proposed lethal sample size of Antarctic minke whale (333) represents the best estimation at the present time taking account of the available and established non-lethal research methods. However, it should be noted that these methods could be further improved in the future depending on the progress of the feasibility experiments on non-lethal techniques.

The aim is to investigate the potential of these techniques for achieving the objectives of the program. In the investigation it is necessary to consider the following four major tests in assessing the feasibility of non-lethal methods: i) whether the same data sought (*e.g*. age) can be obtained by a non-lethal method; ii) whether it is of sufficient quality for analysis (*e.g*. accuracy); iii) whether the cost to obtain the data is realistic and reasonable; and iv) whether enough data can be obtained for statistical analysis. These tests are often inter-related and not exhaustive. Depending on the results of the investigations, as well as the results of the feasibility study of non-lethal methods under JARPN II, this research plan could be revised in relation to the lethal sample size.

It should be noted that the number of samples to be obtained by non-lethal methods is not necessarily the number to be reduced from the lethal sample size. For example, even if the age-data can be obtained from a non-lethal method in the same quality and accuracy as from the lethal method, when the cost of obtaining the data by the non-lethal method is prohibitive, a sample size trade-off cannot be established in a simple manner.

Timeline of research activities

NEWREP-A specifies the timeline for producing results under the Objectives and Sub-objectives of the research plan. Results of some sub-objectives will be completed and evaluated after six years and of others at the end of the research i.e. after 12 years (see details in section 6 of the NEWREP-A plan).

Effect on the stocks

NEWREP-A includes an evaluation of the effects on the stocks of the planned catch of 333 Antarctic minke whales, taking into consideration the latest information on stock structure and abundance of this species in the research area. Results of simulations under different scenarios suggested no negative impact on the stocks (see details in section 5 of the NEWREP-A plan).

Backup plan for contingencies

As research activities could be disrupted by both natural and human factors including dangerous sabotage activities by an extreme anti-whaling NGO, NEWREP-A establishes a backup plan in order to respond to the contingency and secure the scientific value of data to be collected by this research for the purpose of achieving the established scientific objectives.

The backup plan would address three aspects; (i) adjustments of research protocols at the scene of disruption, (ii) adjustment of research plans including research period, sample size, and research areas after the year of disruption, and (iii) consideration of analysis methods to compensate for the effects of disruptions. Possible issues arising from a disrupted research plan could be reduced sample size, unsurveyed research areas, sampling bias and missed research periods. They could mean reduced accuracies, reduced randomness, and other increased biases. The considerations of these aspects also responds to the recommendation made at the JARPAII review workshop (IWC, 2014) (see details in section 7 of the NEWREP-A plan)

Provision for co-operative research

Under NEWREP-A participation of foreign scientists in the field surveys will be welcomed, so long they meet the qualifications established by the Government of Japan. Also research collaboration will be sought with relevant scientists and research institutions (national and international), in consideration of the relevant analyses under the objectives and sub-objectives of NEWREP-A (see details in section 8 of the NEWREP-A plan).

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ANNEX D

Summaries of SC/F15/SP05 (What is the best way to age Antarctic minke whales?) and SC/F16/SP06 (Brief review of whether lethal methods are required for NEWREP-A)

P.R. Wade

Estimation of the age of Antarctic minke whales from which data are collected is essential to many of the objectives of the NEWREP-A proposal. Wade presented SC/F13/SP05, which compares different methods for aging Antarctic minke whales to determine which is best. The traditional method is based on counting layers in ear plugs, and a recent paper (Kitakado et al. 2013) investigated reading errors of Antarctic minke whale ear plugs through analysis of a multi-reader experiment. A new method based on DNA methylation (Polanowski et al. 2014) was found to accurately estimate the age of humpback whales, so SC/F13/SP05 discussed whether this would be a better method for Antarctic minke whales than using ear plugs. The NEWREP-A proposal states that alternative methods of aging such as DNA methylation are not precise enough to be used in models such as the Statistical-Catch-At-Age analysis, and they conclude that age estimation must be conducted using ear plugs. However, SC/F13/SP05 showed that the precision of the DNA methylation technique (SE=2.2) is similar or better than the precision of ear plug estimates (SE=~1-7 depending upon the reader and the age of the whale). Additionally, the precision of DNA methylation remains the same across any age whale, whereas the precision of reading ear plug layers becomes much worse with older whales. With regards to bias, SC/F13/SP05 noted the calibration of the 4 readers who analyzed commercial, JARPA, and JARPAII samples to a control reader was not guaranteed to correctly account for bias – this would only be the case if the control reader themselves was less biased, but this is an (as yet) untestable assumption. SC/F13/SP05 also noted there was an issue of consistency and repeatability for the ear plug age estimates. The control reader was only willing to assign a valid age to 228 out of 250 ear plugs (91.2%) in the first reading, whereas one week later, they were only able to age 216 out of the 250 same ear plugs (86.4%). In other words, the age of 12 of the 250 (4.8%) ear plugs could be determined in one reading, but could not be determined during a second reading only one week later, by the same reader. This is not intended to be a criticism of the control reader's ability; it is clear that the reading of baleen whale ear plugs is an extremely difficult task, and the nature of the task makes it an exercise that it is not fully repeatable. In contrast, the 4 readers of the full Japanese data set assigned a valid age to ~100% of the samples, indicating different readers do not agree on criteria for when a valid age can be assigned. The lack of repeatability of age estimates from ear plugs would likely not be an issue with the DNA methylation method. Polanowski et al. (2014) did not report any samples that they failed to be able to age. In fact, they note that cytosine methylation is reasonably stable and has been successfully purified from ancient DNA as old as 60,000 years. Importantly, Kitakado et al. (2013) noted that a 'drift' of age-reading methods could lead population models to estimate spurious trends in recruitment for the Antarctic minke whale, which was the reason for calibrating the 4 readers to a control reader, but there is no guarantee a control reader will not experience drift in their own reading over long periods of time. In contrast, no drift in age estimation would occur in DNA methylation techniques. Finally, Wade pointed out one substantial advantage of DNA methylation techniques, which is that with repeated biopsy sampling of the same individual across years it will be possible to calibrate the age estimate to true age by comparing the known elapsed time to the estimated elapsed time between the two samples. There is, as yet, no conceivable method for calibrating ear plug age estimates in Antarctic minke whales to true age; this is currently true for any whale species which cannot be photo-identified as a calf. Wade concluded that DNA methylation aging, compared to ear plug aging, had similar precision and similar biases, and would be preferred because it was a more consistent and repeatable technique to use for aging baleen whales, and because it could eventually be calibrated to true.

Annex P, which describes the process by which new proposals for Special Permits are reviewed, specifies that one of the five terms of reference for the Specialist Workshop is to *"(2) provide advice and suggestions on components of the programme that might be achieved using non-lethal methods, including, where appropriate, power analyses and time frames.*" Wade presented SC/F13/SP06, which provided an initial brief review of components of the NEWREP-A programme that might be achieved using non-lethal methods. After reviewing the proposal, SC/F13/SP06 described that there were five types of data the proponents asserted could only be collected using lethal methods. The first type of data was the age of sampled whales, which is required under objective I(ii), which the proponents argue can only be accomplished through examination of ear plugs. However, SC/F13/SP05 argues that age estimates can likely now be made using a DNA methylation technique, which means that whales can be aged from biopsy samples. Moreover, there are paired samples of DNA and ear plug age estimates in hand from JARPA/JARPAII, so confirming that DNA methylation will work on Antarctic minke whales can be accomplished immediately, without the need for further lethal sampling of whales. Similarly, pregnancy of cetaceans, including minke whales, can be determined from blubber progesterone samples (Perez et al. 2011, Mansour et al. 2002). Second, in objective I(iii), the proponents argue that additional morphometric data are essential for determining mixing rates in areas of overlap between stock boundaries. However, genetic data from biopsy samples can be used to estimate mixing rates, and it has not been demonstrated that additional morphometric samples will have much power to clarify relatively subtle issues of mixing proportions in areas of stock overlap. Third, under objective I(iv), the proponents argue that parameter inputs for the RMP Implementation Simulation Trials (such as estimates of MSYR) can only be improved by fitting models to Catch-At-Age data. However, there is no difference in information content between a sample of ages from the standing age distribution collected by lethal means or collected by DNA methylation aging of biopsy samples, so this claim can be refuted on first principles. Fourth, under objective II(iii), the proponents argue that it is necessary to collect stomach samples to estimate prey consumption rates by minke whales. However, SC/65b/O03 concluded it has still not been demonstrated that the analysis of stomach contents can contribute to a better quantitative understanding of minke whale consumption rates than the current broad range of estimates. Fifth, also under objective II(iii), the proponents argue that it is necessary to measure blubber thickness to monitor the body condition of Antarctic minke whales. However, Wotherspoon et al. (SC/F14/O05) and de la

Mare et al. (SC/F14/O06) documented that changes in sampling design during JARPA and JARPAII, particularly because of confounding between latitude and date, make it impossible to reliably examine trends in body condition indices such as blubber thickness using those data, and the NEWREP-A proposal relies on JARPA/JARPAII samples in order to estimate a trend. Finally, de la Mare (SC/F14/O07) further demonstrated that the data as currently collected will require many decades of sampling before reliable conclusions can be reached. Wade concluded the proponents had not made a strong case for the necessity of lethal sampling for any of these five types of data.

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ANNEX E

Summaries of SC/F15/SP02 (Random-effects invalidate NEWREP-A statistical power analyses) and SC/F15/SP03 (Observers' statement to the NEWREP-A Special Permit expert panel review workshop)

W.K. de la Mare, J. McKinlay and N. Gales

SC-F15-SP02 examines issues arising in the power analysis conducted in NEWREP-A for determining a lethal-take sample size to detect a 0.1/year change in the female age at sexual maturity (ASM50), over a 12 year period, with a 90% chance of detecting the change if it in fact occurred. The authors demonstrate alternative analyses that incorporate additional sampling variability known to be present in data arising from JARPA/JARPA II. This extra variability is due primarily to a confounding of spatial and within-season effects that arise from the sampling design employed. The consequence of including this extra variability is that calculated sample sizes need to be substantially higher – by up to an order of magnitude – to be able to detect the stated effect size over the period in question. At high levels of extra variability the stated statistical objective is unobtainable. The authors conclude that power analyses should include random effects to accommodate the known spatial and temporal heterogeneity in data arising from sampling designs based on JARPA / JARPA II methodologies. In response to SC/F15/SP09 that suggested that when poorly estimated cohorts were omitted that the level of extra variability was negligible, the authors noted that if some cohorts were not reliably estimated in the past, there would be similar occurrences in the future and consequently such cohorts should also be omitted during the power analysis simulations. They reported some additional trials that examined the effects omitting some cohorts based on them being poorly estimated. It was shown that the proposed sample size was too small when such cohorts were omitted even when there was no extra variability. They also showed that if the only cause of poorly estimated cohorts was due to pure sampling variability there would be a very low probability of omitting the number of cohorts that had occurred in setting up the analyses in Appendix 13 of NEWREP-A. Consequently the authors did not consider that the propositions in SC/F15/09 negated their view that the NEWREP-A power calculations were invalid due to extra variability not accounted for in the NEWREP-A simulations.

Paper SC-F15-SP03 presents the Australian Observers' Statement to the review workshop, and begins by stressing the importance of applying methods similar to management strategy evaluation to demonstrate the merit of Special Permit research proposals. Quantitative evaluation by simulation is often employed in SC investigations, and can be used to demonstrate the necessity and amount of sampling required in order to meet program objectives. Serious concerns are expressed about the adequacy of the only quantitative evaluation undertaken in NEWREP-A (Appendix 13 power analysis), and observed that the intrinsic random variability in age at sexual maturity is estimated to be sufficiently large that the statistical requirements (as defined in NEWREP-A) cannot be met with even very large sample sizes. Furthermore, the authors note that the proponents of NEWREP-A provide no convincing scientific rationale as to why the specifics of the power analysis (effect size, power, sampling period) are important or necessary to the work of the SC and can lead to the attainment of the NEWREP-A objectives. They also note that no substantive detail is provided on the proposed sampling design, in spite of limitations and deficiencies with JARPA / JARPA II sampling discussed at the JARPA II Review Workshop. Several specific issues were raised in relation to objectives in NEWREP-A that are stated as being importantly dependant on data from lethal samples, but which are not used to evaluate necessary lethal-take sample sizes. Concerning sections in NEWREP-A that describe ecosystem models, the authors note that it is not clear how, and to what extent, data from lethal sampling can inform these models, particularly as the recent joint CCAMLR/IWC workshop on ecosystem modelling did not identify lethal data as useful for model inputs. In relation to use of lethal data to support development of the statistical-catch-at-age (SCAA) model, the authors note that the current SCAA does not incorporate density-dependant demography such as fertility, mortality or maturity. While the SCAA model may in the future be extended to include demographic information directly, it remains unclear what utility would be provided by lethal sampling compared with non-lethal methods, particularly in light of recent developments in genetic aging from biopsy samples. Here, the authors again stress the importance of simulation testing of existing or preliminary models to demonstrate the requirement for lethal samples. The authors conclude by expressing their view that NEWREP-A gives the appearance of having been developed to continue an existing lethal sampling program, rather than having been developed "from the ground up" in order to address the concerns raised by the ICJ and the JARPA II Review Workshop.

ANNEX F

Summary of SC/F15/SP10 (Response to Document SC/F15/SP05 'What is the best way to age Antarctic minke whales?' by Paul R. Wade.)

G. Yasunaga, T. Bando, T. Hakamada, M. Goto and T. Kitakado

Use of reliable and consistent age data is crucial in the Statistical Catch-at-Age Analysis (SCAA). Age determination of Antarctic minke whale has been conducted by counting Growth Layer Groups (GLGs) in the earplug, and the information has been accumulated since 1970's. SC/F15/SP05 state that standard error (SD) of ageing by GLGs are not substantially smaller than the 2.99 reported by Polanowski *et al*. (2014), and there is the possibility of 'drift' in the GLGs counting within a single control reader over time in the age-reading error experiment conducted by Kitakado *et al*. (2013). However, we state that the SD of GLGs tends to be substantially smaller than that reported for humpback whales in Polanowski *et al*. (2014) at least up to age 30, the age range examined by that paper. Note that the SD in Polanowski *et al*. (2014) is derived under the assumption of a constant SD for all ages, but this seems an unreasonable assumption. For the possibility of 'drift' in control reader, effect of drift would not be substantial, because the control reader read 250 samples collected from 1974/75 to 2005/06 within half a month (Lockyer, 2010). Furthermore, in the NEWREP-A program, age reading will be conducted by the person who read JARPA II samples (T. Bando) and no additional inter-reader problem will be expected. "Improvement of age data precision" is one of the Objectives of the NEWREP-A program under Main Objective I, and new methods for age estimation will be explored to improve precision of the data. Ratio of aspartic acid enantiomers in the lens nucleus, and level of DNA-M will be examined for evaluating their potential use in age estimation of Antarctic minke whales.

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Summary of relevant part of SC/F15/SP07 "Correspondence of NEWREP-A with the guidelines for new research proposals in Annex P" (A response to SC/F14/SP06 by Paul R. Wade)

L. A. Pastene and T. Kitakado

The objectives requiring lethal sampling in NEWREP-A are Objectives I (ii), I (iii), I (iv), II (iii) and II (iv). Key data for Objective I (ii) are the age, sexual maturity and body length. The NEWREP-A critically reviewed whether age data is indeed unobtainable by methods other than lethal sampling. It was concluded that age data at the annual scale can be obtained only through lethal sampling (earplug reading). NEWREP-A noted that a DNA methylation approach was recently developed and applied to humpback whales. However the IWC SC noted in 2014, that *de novo* calibration of methylation pattern is required to develop this method to different species as inter-species methylation pattern and accumulation rates are not consistent (IWC, 2014). Progesterone level in blubber can provide information on pregnancy only. It cannot distinguish among non-pregnant mature female and immature females (Mansour *et al*., 2002; Kellar *et al*., 2006). Accurate measurement of the whale body length can be taken only through lethal sampling. After the review of relevant literature (Best, 1984; Dawson *et al.*, 1995; Jaquet, 2006) it is concluded that the precision of measurements obtained from shipboard techniques are insufficiently accurate. The key data for Objective I (iii) are genetics and morphometry. While DNA can be extracted from biopsy samples, there is a dispute on whether sufficient number of biopsy samples can be obtained from Antarctic minke whales, especially in offshore areas. Morphometric analyses on stock structure are conducted based on up to 10 body measurements, which is not possible using non-lethal techniques. Both genetic and morphometric analyses have been informative on the stock structure of the Antarctic minke whale. The JARPAII review workshop noted that this was in accord with the IWC SC's view that stock structure can best be addressed using a suite of techniques and data types (IWC, 2014). Key data for Objective I (iv) are those requiring lethal techniques under Objectives I (ii) and I (iii) above including MSYR under I (ii). Key data for Objective II (iii) and II (iv) are stomach content and body conditions, which require lethal sampling. There are some non-lethal approaches suggested to assess diet and food habit such as molecular analysis of faeces and analysis of carbon and nitrogen isotope ratios. However none of them provides quantitative information on stomach contents, which is important for evaluating the impact of whale's prey consumption on the ecosystem. The JARPNII review workshop noted that 'the primary rationale for stomach sampling, which requires killing the animal, is the qualitative and quantitative information on prey consumption (e.g. species, age) functional relationships between marine mammals and their prey…The Panel recognized that at present, certain data, primarily stomach content data, are only available via lethal sampling' (IWC, 2010). Body condition index such as blubber thickness, fat weight and girth can be obtained only by lethal sampling.

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ANNEX G

Summary of SC/F15/SP09 ('A response to "SC/F15/SP02')

T. Kitakado

SC/F15/SP09 was prepared in response to Paper SC/F15/SP02, which stated that the random-effects invalidate NEWREP-A statistical power analyses. A question was posed in SP02 if the age composition is assumed as fixed or randomized vectors in the simulation. The answer is that the age composition in each year in each simulation replica is independently and identically generated by random sampling with replacement from the fixed age composition observed in cohorts of 1980-2000. So, the scenario assumed in NEWREP-A is essentially same as "Model 2" in SP02. Table 1 in SP02 provided their replicated simulation results. Unfortunately Table 2 in SP02 is not an appropriate comparison because it is an extraction of results from Model 1 in SP02. However, even when looking at the power values for Model 2 in SP02, there are slight differences. One possible reason for this is that SP02 tried to read the age frequencies from the Figure 6 in Appendix 13 in NEWREP-A plan, which might have provided exactly the same numbers as the original values. Note that the pattern of difference in the power between Model 1 and 2 in SP02 are not consistent over the values of effect size. The author further note that (and this has not been disputed) the power analysis in the NEWREP-A guarantees a significant result (both at the 5% and 1% levels). Regarding the effect of random-effect argued in SP02, the author agree that observation from wildlife tend to have a certain level of over-dispersion attributed to heterogeneity and correlation. This must be the case when the volume of stomach content is observed because the food availability might differ in a spatial manner and that pattern could change over years. However, it seems unreasonable to assume randomness in ASM50 with the great extent of variance used in SP02, particularly as this reflects the accumulation of the effects of feeding conditions over a number of years, rather than from one year only. For example, SP02 drew values of standard deviation (SD) of residuals in the linear regression. The value mentioned in SP02 is 0.822 (correctly 0.816), which is unfortunately calculated from the results in Mode1 with data of all the years. Using this value, the authors of SP02 estimated the extent of random effect SD as 0.69. But this is an overly-stated value. As mentioned in Appendix 13, in some cohorts, there is not enough information to estimate ASM50, and that is why data in some years are deleted in the linear regression. In "Model 2 (some years deleted)", which it is recommended to use, the SD is calculated as 0.395, and if the same formula to estimate the random effect SD is used, it would be almost zero. So, the random effect for the ASM50 is negligible. It is also worth noting that the time series for the age-at-transition (related to the age at sexual maturity) shown in Figure 5 of Appendix 13, shows little inter-annual variability, and is quite inconsistent with an argued random effect with a SD of 0.69. In addition, when quickly using a quasi-likelihood estimating equation, the estimated dispersion is dramatically less than 1 (0.377). This value seems too under-dispersed, which might be due to ignoring the difference in sample size among years (beta-binomial assumption is more suitable), but this result is again evidence that the over-dispersion in the generalized linear model is negligible. In conclusion given the statistical reasons above, and also given the ecological reason that the ASM does not change randomly but it should a case of directional change (decrease, stable, or increase), the author consider that the GLMM with a random effect for cohort is not appropriate model for the maturity analyses for the Antarctic minke whales, and therefore the statement by the authors of SP02 that the analysis in the NEWREP-A is invalid, is not correct.

Summary of SC/F15/SP11 (A response to SC/F15/SP03)

L.A. Pastene, T. Tamura, T. Hakamada and T. Uoya

SC/F15/SP11 responds to the Australian Observers' Statement in SC/F15/SP03 as follows. **i)** *little change in substance in NEWREP-A objectives*: The NEWREP-A integrates the JARPAII objectives into its Main Objectives in a more sensitive way. The NEWREP-A has two Main Objectives, Objectives and sub-objectives; **ii)** *rational for the importance to detect an increase in ASM of 0.1 years/cohort within 12 years of sampling*: as detailed in Appendix 13 of NEWREP-A plan, target effect size of 0.1 was set based on the past value observed from 1955 to 1970 cohorts (i.e. half of 0.2). During that period stock status included their abundance changes substantially, and therefore, even a half magnitude of change in ASM during that period implies substantial changes in the stock status of this species and of the Antarctic marine ecosystem. In relation to ASM, a 12-year period is quite reasonable considering the fact that the ASM showed a decreasing trend over more than 10 years, from 1995 to 1970 cohorts; **iii)** *difficulties in the analysis of parameters relating body condition and stomach contents*: during the 2014 IWC SC meeting, the 'Committee 'agreed that the analyses which it had requested last year, and those requested by the JARPAII review, had been satisfactorily completed. Given the results the conclusion followed that a decline in blubber thickness and in fat weight that was statistically significant at the 5% level had occurred during the JARPA period....' (IWC, 2014). Data on body condition and stomach content weight trend will be analyzed based on NEWREP-A data and analytical approaches already agreed by the IWC SC; **iv)** *no information on transect design*: design of sighting surveys in the NEWREP-A will be similar to those used in JARPA/JARPAII and on the IDCR/SOWER. Detailed transect lines are not provided as these aid anti-whaling saboteurs; **v)** *purposes of the ecosystem models needs to be clearly defined in terms of inputs and outputs*: a multi-production model was already applied preliminary to the data on time series of Antarctic minke, fin, blue and humpback whales, crabeater seals and krill, and then a likelihood function was defined based on the data with some additional assumptions and inestimable parameters. The preliminary application enlighten the need for the use of new data, for example time series of krill abundance, which will be obtained during NEWREP-A; **vi)** *the joint CCAMLR/IWC workshop did not identified the need lethal-acquired data*: neither did the workshop lethally-obtained data as useless. Instead, life history parameters were reviewed by an expert group during the workshop, and pregnancy rates, calf production, age-at-first reproduction and survival were identified as the parameters of interest (IWC, 2010); **vii)** *ISTs to be set up and conducted by the proponents to demonstrate if the lethal sampling makes reasonable contribution to improve management*: we agree however the lengthy process of development *ISTs* is IWC SC's responsibility. We are considering alternative and simpler approaches based on SCAA for this aim; **viii)** *SCAA model does not use trends in ASM*: at this stage this is true but it should be incorporated given the ASM is influential to the numbers of mature animals, especially females, and possible future changes in the ASM affect the carrying capacity and the productivity. The ASM is of great importance for contributing information on the proportion of matured minke whales that is used for SCAA to improve performance; **ix)** *assessment of mixed sampling methods in relation to respective lethal and non-lethal sample sizes are poorly articulated*: comparative studies between lethal and non-lethal research (analytical) techniques under NEWREP-A are designed in light of achieving the two Main Objectives for example this is in the case of the feasibility biopsy sampling and age determination based on DNA-M. Plan are provided in the NEWREP-A. More details will be provided at the start of each feasibility study and the evaluation of the techniques in relation to sample sizes will be made at the mid-term review.

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