Report of the Expert Workshop to Review the Ongoing JARPN II Programme*

The Workshop was held at the National Research Institute of Fisheries Science (NRIFS) in Yokohama, Japan from 26-30 January 2009. The list of Participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Welcome and opening remarks

Participants were welcomed to NRIFS by its Director, Dr Kiyoshi Inouye.

Bjørge, the Chair of the IWC Scientific Committee, welcomed the participants and explained that this was the first review meeting of a special research permit programme to be held under the new rules developed by the IWC Scientific Committee and approved by the Commission (IWC, 2009b), a summary of which are given as Annex D to this report. As such, the Workshop was not only important because of the subject matter, but also because it was an opportunity to test the new procedure and, if necessary, to suggest future improvements. He noted that this was a review of the first six years of an ongoing research programme. The primary tasks of the Workshop were to review: (1) the scientific work undertaken thus far against the stated objectives of the programme and to review future plans in the context of the likelihood of meeting those objectives; (2) the techniques used (lethal and non-lethal); (3) appropriate sample sizes; and (4) the effects of any catches on the relevant stocks. Where appropriate the Workshop would highlight those aspects of the programme that were of most direct relevance to the work of the IWC Scientific Committee.

1.2 Election of Chair

Bjørge was elected Chair.

1.3 Appointment of rapporteurs

Donovan co-ordinated the production of the report and individual experts acted as rapporteurs for individual agenda items, including Butterworth, Cooke, Forcada, Hall, Reilly and Waples with assistance from others as appropriate.

1.4 Meeting procedure and time schedule

Pastene outlined the logistical arrangements for the meeting.

Bjørge explained that the format would be as follows: during the first part of the day, plenary sessions would be held in which the Japanese scientists would present the papers on particular agenda items and there would be an opportunity for the expert panel (hereafter the 'Panel') to ask questions of clarification and substance regarding the work that had been undertaken or further work that was expected to be undertaken. Once this was completed, the Panel would meet in closed session to discuss its conclusions and begin to draft the report on the individual items. The objective was to try to leave the Workshop with as complete a report as possible. The draft report would be shown to the Japanese scientists for the purposes of commenting on whether there were any technical misunderstandings in the text. The report and its conclusions were the sole responsibility of the Panel. Once the report is completed, the process will follow that outlined in Annex D before submission to the Annual Scientific Committee meeting in Madeira.

2. ADOPTION OF THE AGENDA

The adopted Agenda is given as Annex B.

The report follows the agreed structure, i.e. a review of each of the objectives. However, we have also added a general item on abundance estimation (Item 7.4) in addition to more specific comments under the relevant agenda items.

Abundance data have been collected during the course of the JARPN II research programme. While the estimation of abundance *per se* is not a primary objective of the research programme, the abundance data are required, in conjunction with data on the diet and body mass of whales, to estimate the numbers, biomass and energy requirements of whales by area and season for inclusion in ecosystem models that elucidate quantitatively the role of whales in the ecosystem.

Abundance estimates are also required to assess the effects of JARPN II catches on the stocks of whales, in accordance with the Scientific Committee's mandate. This can involve abundance data collected outside the JARPN II research area (see Item 9.3).

Abundance data are also important for the interpretation of data pertaining to stock structure: to infer exchange rates between subareas from genetic or other data, the relative size of the putative subpopulations needs to be taken into account. This aspect is especially important in the conditioning of stock structure hypotheses for *Implementation Simulation Trials*.

While sightings from catcher vessels were also recorded, all abundance estimations conducted in conjunction with JARPN II were derived from data obtained from dedicated survey vessels not involved in the taking of whales. As such, this was not research involving Special Permits, and strictly speaking did not need to be evaluated in the conduct of this review.

*Presented to the meeting as SC/61/Rep1.

3. REVIEW OF AVAILABLE DATA, DOCUMENTS AND REPORTS

3.1 Workshop documents

The list of Workshop documents (SC/J09/JR1-36) is given in Annex C1. The Workshop participants thanked the Japanese scientists for fulfilling the difficult time constraints imposed by the new procedure. Having all of the documents available at the beginning of December greatly facilitated the Panel's work.

3.2 For information papers

Twelve published papers were also highlighted to be of interest to the Workshop. These were: Murase *et al.* (2007); Niimi *et al.* (2005); Niimi *et al.* (2007); Kanda *et al.* (2007); Kanda *et al.* (2006); Watanabe *et al.* (2004); Watanabe *et al.* (2007); Urashima *et al.* (2007); Fukui *et al.* (2007); Birukawa *et al.* (2008); Nishida *et al.* (2007) and Onbe *et al.* (2007).

3.3 Other available documents and data

The meeting had ready access to the relevant Scientific Committee reports and papers. A list of the available data from the programme is given as Annex E. Data are available to be requested under Procedure B of the IWC Scientific Committee Data Availability Agreement (*http://www.iwcoffice.org/sci_com/data_availability.htm*).

4. REVIEW OF JARPN II RESULTS: FEEDING ECOLOGY AND ECOSYSTEM STUDIES

4.1 Formal statement of objectives as given by the Government of Japan (based upon SC/J09/JR1)

This component of the JARPN II programme was given high priority by the Government of Japan. The broad objectives were given as: (a) prey consumption by cetaceans; (b) prey preference of cetaceans; and (c) ecosystem modelling.

A primary motive for the feeding ecology and ecosystem studies has been the major decrease in catches by Japanese fisheries (Government of Japan, 1999) from 12.8 million tons in 1988 to 5.8 million tons in 2005. In 1999, the Fisheries Agency of Japan announced the principles of its policy on fisheries and an action program to implement the policy. Highest priority was given to science-based management and sustainable utilisation of fisheries resources within Japan's EEZ. In investigating the reason for decreasing fish resources and fish catches, a number of potential factors were recognised including: over-fishing; a changing of the marine environment; and the effect of consumption by marine mammals and other animals of fish resources. To aid the recovery of the fish resources, the Government stated that investigations should be carried out taking into account the management and sustainable utilisation of the whole ecosystem including marine mammals. Some initial ecosystem model analyses indicated possible competition between cetaceans and fisheries and that the ecosystem of the western North Pacific may be affected on a large scale by trophic interactions and changes of fishing (Government of Japan, 2002b).

Not only in Japan, but elsewhere in the world, the principle of multi-species management has been discussed by various parties, including many international organisations.

At its 24th Session in 2001, COFI (FAO's Committee on Fisheries) agreed that the FAO should conduct studies on the interaction between fisheries and marine mammals. This agreement was endorsed by the 120th Session of the FAO Council and reaffirmed in the October 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem (FAO, 2001). The Reykjavik Declaration also affirmed that the incorporation of ecosystem considerations implies increased attention to predator-prey relationships and in Point 5 of the Declaration agreed that it is important, among other things:

(a) 'To advance the scientific basis for developing and implementing management strategies that incorporate ecosystem considerations and which will ensure sustainable yields while conserving stocks and maintaining the integrity of ecosystems and habitats on which they depend;
(b) identify and describe the structure, components and functioning of relevant marine ecosystems, diet composition and food webs, species interactions and predator-prey relationships, the role of habitat and the biological, physical and oceanographic factors affecting ecosystem stability and resilience; and
(c) build or enhance systematic monitoring of natural variability and its relations to ecosystem productivity' (FAO, 2001).

The FAO's current definition of an ecosystem-based approach to management is the following:

> 'An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystem and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries' (FAO, 2003).

In 2001, the IWC agreed to make the study of interactions between whales and fish stocks a matter of priority (IWC, 2002), and in 2006, the IWC Scientific Committee created a Working Group on Ecosystem Modelling; prototype ecosystem models from JARPN II were presented and discussed in 2007 (IWC, 2008c).

Under the new Japanese fisheries management regime, an ecosystem-based approach is considered important, given the diversity and dynamic inter-relationships of the marine living resources and habitats around Japan. Understanding of the marine ecosystem around Japan needs to be substantially strengthened to take the following factors into account in prescribing fisheries management measures: the decrease in fisheries yields between 1988 and 2005, the expected increase in whales around Japan since the introduction of the moratorium, and the historical major fluctuation of the pelagic fisheries resources in a process of so-called 'species replacement' in the western North Pacific.

JARPN II was designed to provide data with which to parameterise ecosystem models that are expected to provide insights into the relationships between different species in the marine ecosystem and the dynamics of the ecosystem. This includes information on the extent of the predation of marine mammal populations, which will balance the need for the effective utilisation of fisheries resources and the conservation of marine mammals (Government of Japan, 2002a); it is thus consistent with the Reykjavik Declaration (FAO, 2001).

The primary purpose of JARPN II is to study the interactions between fisheries and cetaceans in the marine ecosystem of the western North Pacific through ecosystem modelling. The output from this study can assist in the formulation of effective ecosystem-based management policies in the future. For this purpose, multidisciplinary, comprehensive surveys are required. The four large whale species chosen for the study (common minke, Bryde's, sei and sperm whales) were chosen because they occupy important niches in the pelagic zone of the North Pacific and because their populations are relatively abundant. Available data from other cetacean species are incorporated into analyses as appropriate.

4.2 JARPN II Coastal component

4.2.1 Proponents' summary

PREY CONSUMPTION BY CETACEANS

The approach requires estimates of the number of whales at a particular area and time (SC/J09/JR8) for the two coastal regions chosen, Sanriku (2005 and 2006) and Kushiro (2002-2007). These numbers do not represent estimates of *stock* abundance of the common minke whale because the sighting surveys covered only a limited area of the stock distribution, during a particular time of its migration to northern feeding grounds. Furthermore, depending of changing environmental factors, the number of whales sighted in this limited area and time could be different from year to year. These values were then used for the estimation of prey consumption by whales using data from the feeding ecology studies.

The stomach contents of common minke whales sampled off Sanriku (April-May) and Kushiro (September-October) in 2002-2007 JARPN II were analysed (SC/J09/JR9). In Sanriku region, the dominant prey species consisted of krill (*Euphausia pacifica*) and fishes (Japanese sandlance, *Ammodytes personatus* and Japanese anchovy, *Engraulis japonicus*). In the Kushiro region the dominant prey species consisted of krill (*E. pacifica*), fish (Japanese anchovy, Pacific saury, *Cololabis saira* and walleye pollock, *Theragra chalcogramma*) and squid (Japanese flying squid, *Todarodes pacificus*). SC/J09/JR9 used the stomach contents data to estimate daily consumption for various sex age classes of animals and then scaled this with the abundance estimates to provide annual consumption by common minke whales for the various prey species and then compared this with the fisheries catch.

PREY PREFERENCES OF CETACEANS

Results of a prey preference study of common minke whales in the coastal waters of Sanriku are given in SC/J09/JR10. To estimate prey preference sampling surveys of common minke whales and their prey, surveys were conducted in the same area at the same time (April). A prey preference index, Manly's α, was used in the analysis. Common minke whales fed on krill, Japanese anchovy and sandlance (adult). These are important species of local commercial fisheries. Common minke whales showed preference for adult sandlance. As previously reported in other regions, krill was not a preferable prey for minke whales. Ecosystem modelling work (see SC/J09/JR14 below) suggested that changes in the form of the functional response had a substantial effect on predation impact on sandlance by minke whales. Functional response can be estimated if long term prey preference data are available.

Results of a prey preference study of common minke whale in the coastal waters of Kushiro are presented in SC/J09/JR11. Results suggest that the slope water region of less than 18°C sea surface temperature (SST) is a rich prey environment in both the epi- and mesopelagic zones. Common minke whales might prefer the rich prey environment affected by the Oyashio not only in the continental shelf region where walleye pollock, Pacific saury, and euphausiids are distributed but also in the offshore region where Pacific saury and euphausiids are distributed. It is suggested that immature common minke whales prefer walleye pollock, while mature animals prefer Pacific saury, although both frequently fed on Japanese anchovy in some years in the area within 50 n.miles of Kushiro.

OTHER POTENTIAL INFORMATION FOR ECOSYSTEM MODELLING

Relationship between body size, maturity and feeding habit of common minke whales in the Sanriku area in spring season was reported in SC/J09/JR12. The total number of whales examined was 227 (91 males and 136 females). Three species (krill, Japanese sandlance and Japanese anchovy were found in stomachs) of which sandlance was the most dominant prey species, followed by anchovy. All the whales but two were sighted in waters with a depth of 20-100m. No obvious difference was observed in their sighting positions between males and females, immature and mature animals, and the three prey species. Examination of the frequency of prey species consumed by whales of different lengths and by whales of different sexual maturity status showed little difference.

The relationship between body size, maturity and feeding habit of common minke whales in the Kushiro area in the autumn season was reported in SC/J09/JR13. The total number of whales examined was 254 (182 males and 72 females). Occurrence of prey species in stomachs differed significantly with maturity stage. Smaller and immature whales tend to feed on walleye pollock and krill whilst larger and mature whales tend to feed on Pacific saury. Japanese flying squid was consumed only by mature whales. Japanese anchovy was equally consumed by immature and mature whales. For the coastal waters off Kushiro in the fall, the results suggested that migration and prey preference of common minke whales differed with maturity stage and that on the continental shelf and slope regions immature whales showed a greater preference for walleye Pollock and krill than mature whales.

4.2.2 Expert Panel review of results as presented

The Panel's views on this section are given under Item 4.3.2, given the similarity in the methods used in the coastal and offshore components.

4.3 JARPN II Offshore component

4.3.1 Proponents' summary

PREY CONSUMPTION BY BALEEN WHALES

The approach here was similar to that for the coastal component, i.e. a combination of abundance estimates and data from stomach contents. It involves sampling of four species of large whales: common minke whales, Bryde's whales, sperm whales and sei whales. 'Early' and 'late' season data were obtained to account for migration. The estimates are presented in SC/J09/JR15. The estimates were also intended as input for ecosystem models in the JARPN II survey area.

The stomach contents of common minke, sei and Bryde's whales sampled in the western North Pacific from May to September in 2000-2007 JARPN II, were analysed in SC/J09/JR16. The main prey species of common minke whale consisted of one copepod, two krill, two squids and eight fish. The main prey species of sei whale consisted of two copepods, three krill and four fish. The main prey species of Bryde's whale consisted of five krill, one squid and four fish. There were seasonal and geographical changes of prey species. The total prey consumption of Japanese anchovy, mackerels and Pacific saury by the three baleen whale species was estimated.

PREY CONSUMPTION AND FEEDING HABITAT OF SPERM WHALES

The stomach contents of sperm whales sampled in the western North Pacific from May to September each year from 2000 to 2007 were analysed in SC/J09/JR17. Thirty-eight prey species consisting of 33 squids, 1 octopus and 4 fishes, were identified. Sperm whales fed mainly on various deep-sea squids. The most important prey species were four squids (*Taningia danae, Histioteuthis dofleini, Belonella pacifica borealis* and the eight armed squid *Gonatopsis borealis*). Sperm whales feed mainly on prey in the mesopelagic and/or bottom/benthic zone during daytime. The seasonal prey consumption (from May to September) by sperm whales in this region was calculated to be nearly 1.2 million tons. The consumption of neon flying squid, *Ommastrephes bartrami*, was estimated to be 30,000 tons. Estimated feeding contribution rates of the surface layer to predation by sperm whales in each sub-area were ranged from 4.7 to 11.4%. The influence on the surface layer of the marine ecosystem resulting from consumption by sperm whales cannot be disregarded, because the biomass of sperm whales is large.

PREY PREFERENCE OF CETACEANS

Murase *et al.* (2007) presented a study on prey selection of common minke and Bryde's whales in the western North Pacific based on data collected in the 2000 and 2001 summer seasons. Whale sighting and sampling surveys and prey surveys using quantitative echosounder and mid-water trawl were carried out concurrently in the study. Biomasses of Japanese anchovy, walleye pollock and krill, which were major prey species of common minke and Bryde's whales, were estimated using an echosounder. The results suggested that common minke whales showed prey selection for Japanese anchovy while they seemed to avoid krill in both the offshore and coastal regions and walleye pollock in the continental shelf region. Bryde's whales showed prey selection for Japanese anchovy in August 2000 and July 2001, while they showed prey selection for krill in May and June in 2001.

Prey preferences of common minke, Bryde's and sei whales at the mesoscale were estimated (SC/J09/JR18) using data from the concurrent surveys of cetacean sampling and prey of cetaceans. The surveys were conducted as a part of the offshore component of JARPN II from 2002 to 2007. A prey preference index, Manly's α, was used in the analysis. The sum of Manly's α for all prey species is 1 and prey species with large values of Manly's α indicates preference for it. Common minke whales showed preference toward pelagic fishes as previously reported. Bryde's whales showed preference for anchovy. Sei whales showed preference for copepods. Although the prey of three baleen whale species overlapped, Manly's α suggested their trophic niches were different from each other. Common minke and sei whales coexisted in the same survey blocks but their prey utilisation patterns were different.

OTHER POTENTIAL INFORMATION FOR ECOSYSTEM MODELLING

SC/J09/JR19 presented a model for density prediction of common minke, sei and Bryde's whales in the western North Pacific during the feeding season. Data used for the model were densities estimated from dedicated sighting survey data in JARPN II, and satellite information on surface temperature, surface height and chlorophyll. The predicted density distributions by the analysis suggested spatial distribution patterns of whales and differences in the pattern among whale species.

SC/J09/JR20 examined time trend of blubber thickness in common minke, sei and Bryde's whales, and the factors influencing the energy storage in these whales. Results suggested that the blubber thickness of the common minke whale has increased during the JARPN and JARPN II period; that of sei whales has increased over the five years of the JARPN II period, while that in Bryde's whales have decreased over seven years. The feeding areas of Bryde's and sei whales showed limited overlap, and their distribution is separated by SST. Further studies were suggested to assist in the interpretation of these results.

4.3.2 Panel conclusions and recommendations

The Panel appreciates the notable amount of effort undertaken and the generally high quality of the sampling programme, resultant data and information from JARPN II studies on whale food habits and prey preferences. The sampling programme was generally well-coordinated across a wide range of vessels and platforms, and the degree of concurrently collected multi-disciplinary data was laudable. These efforts have resulted in valuable datasets that have great potential for concerted analytical work on a broad range of topics, not all directly related to the JARPN II programme objectives.

The collection of diet data is an important, if not the most important potential justification for the lethal collection of whales in JARPN II. The Panel noted that it is therefore of the utmost importance that if lethal sampling occurs, the amount of information collected is maximised; this is discussed further elsewhere in this report. The Panel **agrees** that resultant diet data have the potential to be of great value in determining whale prey preferences, for developing functional response curves when accompanied by simultaneous assessments of prey abundance, and for developing estimates of the impacts of whales on their prey. The collections of diet data from JARPN II are compatible with these goals and, in addition, may serve as indicators of the potential prey selection of these whale species in other regions of the sub-arctic oceans.

However, the Panel had **a number of concerns** over the analyses of the data and in addition **agrees** that the rationale for the sampling areas chosen required fuller justification. With respect to the analyses of the data presented, one of the Panel's major concerns relates to the lack of a full treatment of uncertainty. For this reason the Panel **does not believe** that the consumption rates and CVs presented to date can be considered reliable without further analysis. For this to occur, the JARPN II programme would need to develop and implement a thorough, systematic approach for including and representing uncertainty. This applies to each component involved in estimating the amounts and types of prey consumed, including the whale and prey abundance estimates. On the basis of data collected to date, the Panel **recommends** that additional analyses be undertaken to identify the greatest sources of uncertainty and to determine appropriate sampling and analytical strategies to address them. The steps in the estimation of consumption rates for which estimates of uncertainty are required are given in Annex F. An essential component of this will be to improve the precision of the abundance estimates that are used to extrapolate to population-level rates, for both the coastal (the possibility of regular well-designed aerial surveys should be considered) and the offshore regions (a full synoptic survey of the region should be considered). Further, it would be productive to focus on the sources or causes of variability in order to understand the mechanistic linkages involved.

A particular concern of the Panel is that only a single model (that of Sigurjónsson and Víkingsson, 1997) was used in most JARPN II papers for estimating daily consumption as a function of body mass –. This is just one of a number of possible parameterisations of the simple allometric equation originally proposed by Kleiber (1975). From a recent comprehensive review (Leaper and Lavigne, 2007), there appears to be little scientific justification for selecting any one model formulation from the range of those possible; in fact, the Sigurjónsson and Vikingsson approach produces estimates at the upper range of reasonable values. The Panel therefore **recommends** that as part of the treatment of uncertainty, the analyses of the JARPN II data should: (a) incorporate the use of several reasonable models and include the range of possible results in reporting their work; (b) use that range in subsequent analyses (including any ecosystem modelling) that employ these daily/annual consumption estimates; and (c) undertake sensitivity analyses for the range of parameter values used in the consumption equations. The results could be presented in revised papers for the 2009 Scientific Committee meeting. Whatever modelling formulations are used and ranges proposed, the scientific rationale should be clearly given. This is especially important if the results are to be used in ecosystem modelling.

A more specific concern of the Panel was that the methods used to extrapolate from daily to annual rates and amounts were not clearly explained; this should be addressed in revised papers for the 2009 Scientific Committee meeting by providing the formulae used to scale up daily, individual whale consumption rates to annual, population-level rates.

The Panel noted that in several of the papers presented, insufficient effort was placed on incorporating information resulting from other studies. There exists a considerable body of knowledge from past studies of whale feeding and 'fishery ecology' from data collected during commercial whaling and data collected and analysed during JARPN I (IWC, 2001; Kawamura, 1973; 1980; Nemoto, 1957; Nemoto and Kawamura, 1977), as well as results and insights arising from other multidisciplinary research conducted (e.g. PICES and ESSAS[1]). Incorporation of this information will strengthen the scientific basis of the work throughout the range of studies including those of whale distribution, abundance, food habits, habitats occupied, the distribution, abundance and population dynamics of their prey, etc. Whilst the review is of the JARPN II programme alone, it is important to put the JARPN II work in the context of what is known from extensive past research. This will allow a better evaluation of the JARPN II contributions to the overall state of knowledge of cetacean feeding ecology. The Panel **suggests** that, in revised papers for the 2009 Scientific Committee Meeting, the presentation of JARPN II consumption estimates is placed in the context of the broader literature on the topic of whale consumption and the broader literature of mammal consumption. In addition, it would be valuable to present the estimates of consumption by whales in terms of fisheries and prey biomass (this can provide an index of relativity and an easy and immediate sense of the magnitudes of the various processes that can affect fish stock dynamics). For example, revised papers for the 2009 Annual Meeting could show consumption of whale prey relative to stock biomass and fisheries landings (the latter was done to some extent), as diagnostics for and in conjunction with the ecosystem models (see Item 4.4).

The extensive amount of data collected under JARPN II thus far makes several approaches available to investigate interactions between the physical environment, cetaceans and prey. Using a variety of approaches would increase understanding of the processes involved in determining the distribution of prey and whales, the influence of environmental variability on whale diets, and similar such considerations. Some straightforward approaches based on empirical statistical methods would help to explore the valuable multidisciplinary data sets collected via JARPN II. This might lead to the ability to develop predictive models of these processes. In that respect, the Panel **recommends pursuing** the following medium- to long-term approaches:

- combine the oceanographic data, prey distributions and sighting survey data statistically to investigate how prey and whale distributions are associated with oceanographic conditions, and how whale distributions are related to distributions of prey – in this regard the spatial modelling approach described in SC/J09/JR36 needs to be refined and extended further;
- combine data on prey distributions as observed in the area where the whales were caught with the diet of the whales (referred to as the micro scale) statistically to evaluate how well the whale's diet reflects prey availability in the area where it was caught; and
- compare results from the approaches listed above with the results on selectivity already produced and presented at the Workshop.

Additionally, performing these analyses and comparisons will also contribute to evaluation of non-lethal alternatives commonly used to investigate marine mammal – prey interactions, such as analyses of spatial associations (i.e. the aggregative response) between predators and prey, particularly in coastal regions. This is discussed further under Item 8.2.

[1]PICES, see *http://pices.int/*; and ESSAS (Ecosystem Studies of Sub-Arctic Seas), see *http://www.globec.org/structure/regional/essas/essas.htm*.

4.4 Ecosystem modelling

4.4.1 Proponents' summary

Three papers providing examples of ecosystem modelling approaches for the JARPN II area were presented. The first (SC/J09/JR14) applied to the inshore region and considered the harvesting-related implications for sandlance of predation by minke whales. The other two were for the offshore region and involved the implementation of EwE (Ecopath with Ecosim[2]) to provide a model of the whole ecosystem (SC/J09/JR21), and the development of an MRM (Minimum Realistic Model) which explicitly included three whale and two commercially harvested prey species (SC/J09/JR22).

In SC/J09/JR14, the authors developed a preliminary population dynamics model to investigate the effects of consumption by minke whales on sandlances in the Sanriku region, using a hierarchical Bayes approach. The model allows for various uncertainties making use of time series data historically collected by sandlance fisheries and researches. The impact of predation was examined in terms of MSY. The result was considerably sensitive to the used functional response forms. The authors argued that the JARPN II data could contribute toward providing necessary information to estimation of functional response forms and then explained how the future JARPN II time series data, such as consumption of sandlances by minke whales, should be used to estimate the parameters of the (global-scale) functional response curves in the Bayesian estimation framework.

SC/J09/JR21 provided the results of an initial attempt to evaluate the possible impact of whales migrating to the JARPN II survey area on Japanese fisheries resources, using the EwE software. The results suggest that in average terms: (1) when minke whales are the only species that are harvested at 4% of its biomass (catches of other species are kept constant at current catch rate), depending on the functional response form assumed for the species, it is not certain whether catch of some Japanese fisheries resources will increase or not; (2) when sei and Bryde's whales are each the only species that are harvested at 4% of their biomass, regardless of the functional response form assumed for the species, catch of anchovy, skipjack tuna, and mackerels may increase; (3) when minke, sei and Bryde's whales are all harvested at 4% of their biomass, positive amount of increase in catch is expected for most of the fish resources (i.e. anchovy, skipjack tuna and mackerels), indicating the effectiveness of harvesting several whale species simultaneously; and (4) when sperm whales are the only species that are harvested at 4% of its biomass, depending on the functional response form assumed for the species, catch of anchovy, Pacific saury, mackerels and skipjack tuna may decrease, but instead, catch of neon-flying squid may increase. Caveats pertaining to the results and the use of such ecosystem models in a management context are also discussed in the paper.

SC/J09/JR22 reported on the initial work to construct a minimum realistic model for the offshore survey area of JARPN II with difference equations. Pella-Tomlinson model was applied to three species of cetaceans (minke, sei and Bryde's whales) under $MSYR_{1+}$ = 0.02, 0.04 and 0.06. The abundance values of cetaceans prior to exploitation and at present were estimated on a yearly basis with abundance estimates from sighting surveys and catch series data. Two main prey species of the cetaceans, that were also commercially important (Japanese anchovy and Pacific saury) were age-structured in the model with information from domestic stock assessment. Other supplementary preys (krill, copepods and others) were included in the model as they had constant biomass with no seasonality. Feeding season of cetaceans was set in May-September and the daily predation was assumed to be equal over the all individual cetaceans to the necessary energy. The proportion of each prey taken by cetacean was calculated from the product of prey biomass, overlap of distribution between prey and cetacean, and prey preference of the cetacean. The overlap of distribution between prey and cetacean was estimated from JARPN II sighting surveys. The estimates of prey preference of the cetaceans were obtained from the JARPN II cooperated whale/prey surveys. After adjustment for the parameters of the model, natural deaths of Japanese anchovy and Pacific saury were separated into two parts: consumption by cetaceans and natural death.

4.4.2 Panel conclusions and recommendations

The Panel **emphasises** at the outset that the programme objective (of developing ecosystem models to the level that they could contribute in the provision of specific management advice) constitutes a major, complex and ambitious undertaking – the difficulties have been recognised by many intergovernmental bodies (including the IWC, FAO and CCAMLR). Any study anywhere in the world attempting to meet such an objective requires substantial data collection and analytical efforts; results that are sufficiently reliable to inform management advice should not be expected within at least the next few years and might possibly take considerably longer to obtain. Ecosystem models can also provide contextual information of value to managers in some circumstances. The value of considering a wide range of models has been stressed by several groups, noting that the various possible objectives for ecosystem modelling lead to different questions for which the best modelling approaches may differ (see, e.g. table A4 of Plaganyi, 2007).

More specifically related to the approaches presented to the Panel, the analyses tabled had been appropriately classified by their authors as preliminary. However, despite this, the authors generally overstated the certainty associated with their results (this is in fact a common practice in this field). The Panel **agrees** that the models as developed thus far are not yet at the stage where they can be used to draw even general conclusions and certainly cannot be used to reliably inform management advice. Nevertheless, they comprised a substantial and laudable effort, and an encouraging start to the necessary process of synthesising the data collected during the programme. Although this work might be said to have started relatively late within the time span of the programme thus far, an early emphasis more towards data collection has been a common feature of a number of similar marine programmes elsewhere. However, the Panel **agrees** that considerably more emphasis should be placed on the modelling work from now on if the objective of the programme is to have a chance of being met within a reasonable timeframe, especially with regard to the recommendations provided below.

[2]*http://www.ecopath.org/.*

The Panel **emphasises** that with respect to sperm whales, the low sample size and the logistical constraints on the size of animals taken means that the data obtained provide no meaningful input to ecosystem models.

GENERIC RECOMMENDATIONS

(1) Considerably more resources must be allocated to the modelling work – without this, the likelihood that the objective of the programme will be reached in a reasonable timeframe will be minimal. The models developed should be used to identify the areas of uncertainty with the greatest impact on model outputs of relevance to management, and hence to guide the prioritisation of future data collection and the associated sample size/sampling design.
(2) A wider range of models needs to be considered if the objectives of the programme are to be met. Further work should aim towards fitting dynamic models to time series of data, especially abundance indices.
(3) The area covered by JARPN II is not spatially homogeneous, and serious consideration should be given to developing separate models for three regions distinguished by the inshore or shelf region, the sub-Arctic oceanic region of the Oyashio current and the sub-tropical region of the Oyashio and Kuroshio transition zone.
(4) There is a need to take much wider account of uncertainty at all stages of the modelling process, including that associated with the prey consumption rates of whales (e.g. the Bayesian approach of SC/J09/JR14 should be readily extendable towards that specific end, and more generally other approaches such as sensitivity testing should be employed).
(5) The importance, ultimately, of developing models which incorporate natural variability in dynamic processes (e.g. recruitment variability for prey species) was emphasised, although it was recognised that this might not be possible for certain ecosystem modelling 'packages'.

This is in addition to taking account of uncertainty in model structure and parameter values. The complexity of ecosystems and the difficulty of modelling species interactions adequately might mean that management actions based on such models are more likely to induce unexpected instabilities than current single-species based approaches; this suggests a more cautious approach will be needed on the part of decision makers.

SPECIFIC RECOMMENDATIONS

With respect to the Bayesian analysis of SC/J09/JR14, the Panel **agrees** that if there are other predators making individual contributions to sandlance natural mortality of similar size to that estimated for minke whales, their explicit inclusion in this model must be considered. It **agrees** that Type I functional relationships are unrealistic and need not be considered further. As noted earlier, any results presented should distinguish yields of the prey species to predators and the fishery.

For the EwE approach of SC/J09/JR21, the Panel **agrees** that it is important to concentrate first on improving the Ecopath component of this EwE analysis before moving on to the next step of extending the modelling effort from a static to a dynamic model such as Ecosim.

The species included in the Ecopath analysis should be reviewed giving attention to Ecopath models developed for other regions; in particular the inclusion of gelatinous zooplankton should be considered. Furthermore the values of the parameters of this Ecopath analysis should be compared with values for those others, with attention directed towards any instances of major discrepancies. Inspection of some features of diagnostic plots (e.g. Fig. 1) of the current Ecopath results suggest the need for reconsideration of some of the parameter values, e.g. the plot of log biomass against species does not decline as rapidly as customary, suggesting perhaps that the abundance of primary producers is underestimated; for a number of species, the fraction of production consumed within the system (the ecotrophic efficiency parameter EE) is unrealistically close to the maximum possible of 1; and the *P/C* ratio (production by a species relative to its food consumption) is unrealistically high for some species.

The features noted suggest the need to rebalance the Ecopath model. Alternative approaches to doing so should be considered. For example, rather than use values for some parameters drawn from other regions, placing a bound on some relationship (e.g. $P/C<0.6$) may lead to an improved result overall.

Further analyses must take full account of the uncertainties associated with model inputs, e.g. using Ecoranger[3].

Finally, the Panel noted that the approach in SC/J09/JR22 was the most preliminary presented. Further work on MRM approaches is encouraged and should focus in particular on fitting such models to time series of data.

5. REVIEW OF JARPN II RESULTS: MONITORING ENVIRONMENTAL POLLUTANTS IN CETACEANS AND THE MARINE ECOSYSTEM

5.1 Statement of objectives as given by the Government of Japan

The general objectives for the environmental pollutant component of the programme were listed as:

(a) monitoring environmental pollutants in cetaceans and the marine ecosystem;
(b) pattern of accumulation of pollutants in cetaceans;
(c) bioaccumulation process of pollutants through the food chain; and
(d) relationships between chemical pollutants and cetacean health.

Justification and further explanation of this broad objective was also provided as summarised below (taken from SC/J09/JR1).

In 1992, the IWC decided to establish a regular agenda item for research on the effects of environmental change on cetaceans (IWC, 1993) and at the 1994 IWC Scientific Committee meeting, one of the items identified was pollution (IWC, 1995b). In particular, there is concern that pollutants may have a negative effect on the health of cetaceans resulting ultimately in a decrease in the abundance of the stocks.

Pollutants such as organochlorines (OCs) and heavy metals are generally released from land and transported to

[3]*http://www.fishbase.org/ecopath/ecorange.htm*.

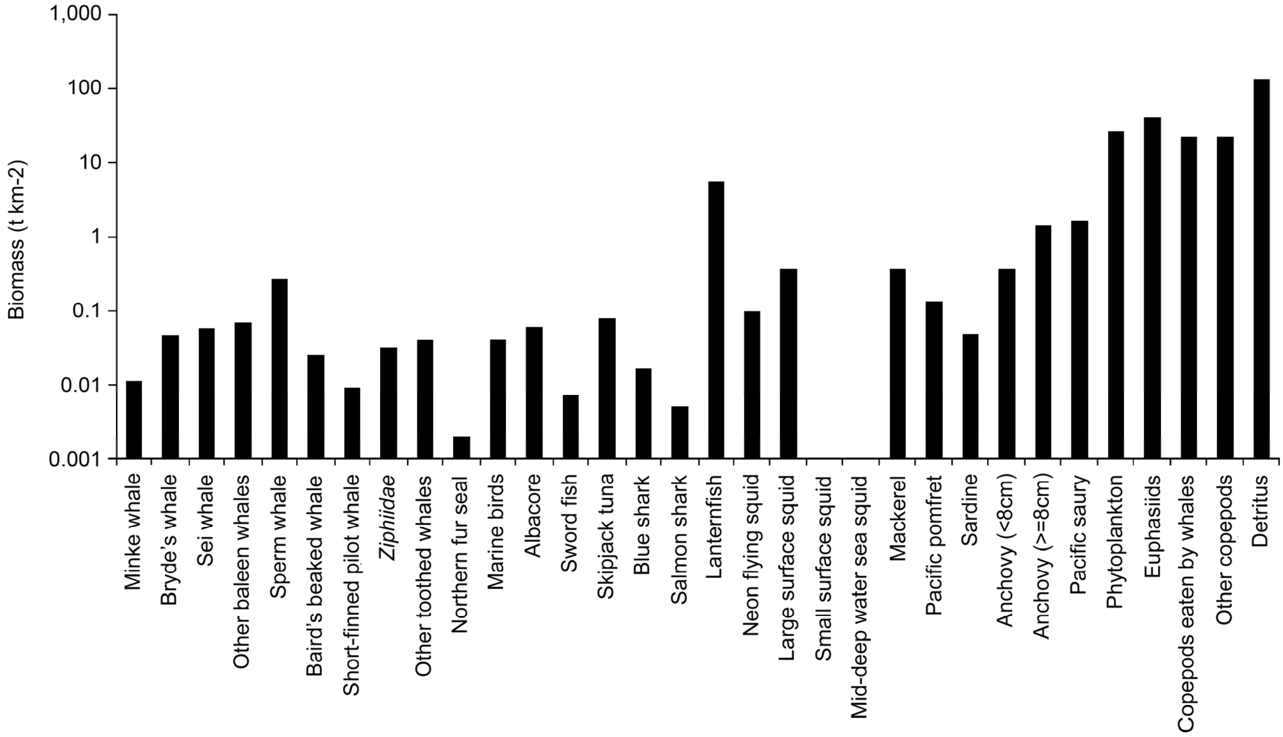

Fig. 1. Example of a simple diagnostic plot (see text).

coastal and pelagic waters in run-off as well as by atmospheric transportation and other ways. Higher trophic animals such as cetaceans generally accumulate organochlorines and toxic elements through the marine food web. The monitoring of pollutants in the marine environment through the examination of biological tissues of marine mammals is of importance since marine mammals can serve as useful biological indicators of environmental conditions. Large cetaceans may be particularly useful as they are long-lived animals migrating long-distances. Therefore pollutants can be monitored in a wide area and pollutant burdens can be integrated over time. This monitoring can be done through JARPN II surveys.

5.2 Proponents' summary

Pattern of accumulation of pollutants in cetaceans

PCBs and pesticides were measured in the blubber of sperm and sei whales collected from offshore waters of the western North Pacific in 2001 and 2002. PCBs and DDTs were the predominant contaminants in both species. Organochlorine residue levels in sei whales were one or two orders of magnitude lower than in sperm whales and were the lowest reported in whales from the Northern Hemisphere. Compositions of CHL and DDT compounds also showed species-specific differences, with sperm whales retaining a higher percentage of p,p'-DDE and a lower percentage of oxychlordane compared with sei whales. These results suggest that the differences in feeding preferences and metabolic capabilities are the major contributing factors influencing the accumulation patterns of organochlorines, in different species of marine mammals[4].

[4]Results from this study were presented to the First International Symposium on Environmental Behavior and Ecological Impact of Persistent Toxic Substances', Matsuyama, Japan March 18-20, 2004. An abstract is available.

To investigate temporal changes of mercury (Hg) levels in the western North Pacific, total Hg concentrations in muscle samples from common minke, Bryde's and sei whales were measured (SC/J09/JR23). Total Hg levels were in the order: mature common minke whales (0.22±0.07 ppm wet wt.) > mature sei whales (0.052 ±0.009) = mature Bryde's whales (0.046±0.008). Yearly changes of total Hg levels in zooplankton and pelagic fishes were not observed in the period 1995-2007. Apart from common minke whales from sub-area 9, significant yearly changes of levels in whales were not observed. For minke whales in sub-area 9, levels decreased from 1994 to 1999 but increased from 2000 to 2007. Results of a multi linear regression analysis suggested that changes of Hg levels in sub-area 9 reflect changes in food habits of minke whale rather than changes in accumulation levels in the environment. SC/J09/JR24 presented information on PCB levels in blubber samples of common minke, Bryde's and sei whales from the western North Pacific. The range of levels in these species was 0.13-4.0, 0.04-0.21 and 0.03-0.47 ppm wet wt., respectively. Yearly changes of PCB levels were not observed in common minke, Bryde's and sei whales in the period 2002-2007. Results of previous studies suggested that PCB levels had been continually decreasing in this oceanic region (1980s-1990s). Results from JARPN II suggest that the level has been stable since 2002.

Bioaccumulation process of pollutants through the food chain

SC/J09/JR23 also examined total Hg levels in prey samples of whales: two zooplanktons (krill *E. Pacifica*; copepods *Neocalanus* spp. and *Calanus* sp.), six pelagic fishes (Japanese anchovy; Pacific saury; walleye pollock; mackerels; Pacific pomfret). Total Hg levels in krill and copepods ranged from <0.001-0.013 and 0.003-0.010 ppm dry wt., respectively. Total Hg levels in the pelagic fishes were in the order: Pacific pomfret (0.232±0.027) > walleye pollock (0.045) = Pacific saury (0.039±0.016) = Japanese anchovy (adult) (0.037±0.025) > Japanese anchovy (larval fish) (0.005±0.003). No yearly changes of total Hg level were observed for krill and Japanese anchovy during the period 1995-2007. Variation of Hg levels in pelagic fishes from the western North Pacific was not related to sampling year.

SC/J09/JR24 also presented information on PCB level in air and surface seawaters from the western North Pacific. The range of levels was ND-22 pg/m^3 for air samples and 1.5-11 ng/L for sea water samples. PCB levels in seawater decreased from coastal to offshore regions. The trend in level of air samples was not clear.

Relationships between chemical pollutants and cetacean health

To examine the CYP families, related to immune-toxicity of PCB and pesticides, full-length cDNA sequences of CYP1A1, and 1A2, in common minke whales were determined (Niimi *et al.*, 2005). The deduced full-length amino acid sequence of CYP1A1 revealed higher identities with those of sheep (86%) and pig (87%), and that of CYP1A2 was most closely related to human (82%) and monkey CYP1A2 (82%) among species from which CYP1A2 has been isolated so far. Differences in certain conserved and functional amino acid residues of CYP1A1 and 1A2 between common minke whale and other mammalian species indicate the possibility of their specific metabolic function. Concentrations of organochlorine compounds (OCs) including PCBs and DDTs analysed in common minke whale liver showed no significant correlation with hepatic mRNA expression levels of CYP1A1 and CYP1A2, indicating no induction of these enzymes by such OCs.

To investigate whether or not CYP expression levels are altered by organochlorine contaminants (OCs), mRNA levels of CYPs in the liver of common minke whales were measured (Niimi *et al.*, 2007). The quantified mRNA levels were employed for the statistical analysis with the residue levels of OCs including PCBs, DDTs (p,p'-DDT, p,p'-DDD and p,p'-DDE), chlordanes (cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor and oxychlordane), HCHs (alpha-, beta- and gamma-isomers) and hexachlorobenzene that have already been reported elsewhere. Spearman's rank correlation analyses showed no significant correlation between CYP expression levels and each OC level in the common minke whale liver, implying that these environmental chemicals have no potential to alter the expression levels of these CYPs or the residue levels encountered in the whale livers may not reach their transcriptional regulation levels. This suggests that the expression of individual CYPs in the whale liver may be at basal level.

SC/J09/JR25 examined the accumulation characteristics of mercury, a toxic element, and selenium, an antagonist, as well as the inter-species difference of sensitivity to mercury toxicity. Total mercury (T-Hg), methyl mercury (MeHg) and selenium (Se) levels in the liver, kidneys and muscle were measured. T-Hg and MeHg levels were higher in the order of sperm whale > common minke whale > Bryde's whale. Se levels were higher in the order of sperm whale > Bryde's whale > common minke whale. The order of the T-Hg and Se levels in the tissues of the common minke and Bryde's whales was kidneys > liver > muscle, and that of MeHg was liver > muscle > kidneys. The order of the T-Hg and Se levels in the tissues of sperm whales was liver > kidneys > muscle.

5.3 Panel's conclusions and recommendations

The Panel **concludes** that the JARPN II pollutant studies represent a valuable contribution to our knowledge in this area and acknowledged the considerable amount of work presented. The programme is addressing its objectives and further work is recommended (see below). In general, where possible, papers should include a risk assessment statement, summarising the potential risk from exposure to the various pollutants, based on current toxicology data in model species and other wildlife in terms of the health of the animals and dynamics of the stocks.

Paper-specific comments

SC/J09/JR23[5] reported on temporal trends and factors affecting mercury levels in common minke, Bryde's and sei whales and their prey species in the western North Pacific, addressing objectives (a) and (b) above. With respect to common minke whales, only 'putative' 'O' stock animals (based on the genetic analyses discussed under Item 6) were included in the analyses.

The Panel noted that if the system is now in steady state, as the paper indicated, and redistribution of T-Hg into muscle reflects ingestion over the previous few months, as at least studies in laboratory animal models and fish appear to suggest (Dock *et al.*, 1995; Petersson *et al.*, 1991; Van Walleghem *et al.*, 2007), then these data might be used to estimate relative bioconcentration factors based on different prey species for the three predators investigated. However, it was noted that some bias might occur because animals could also be feeding elsewhere.

In this study, T-Hg levels in muscle not liver were investigated; this was because the absolute age values for the whales were not yet available, but only body length data. In such circumstances, muscle was considered a more stable monitoring tissue, less affected by age differences (and in addition only results from mature male animals were used in the trend analysis) than liver. However, the majority of previous studies on mercury trends in cetaceans investigate changes in liver concentrations rather than muscle because the liver is one of the main target organs for mercury, and levels are often highest in this tissue. The Panel **recommends**: (a) that the analyses be carried out by age when age data become available; and (b) if possible future studies also examine levels in the liver to facilitate comparison with other studies. In addition, the authors had fitted two linear models to the data, one prior to 2000 and one after 2000 (when there appeared to be no change in the concentrations with time). However, the Panel suggests that a GAM fitted to these data would be a better method for determining the change points and examining non-linear trends in the Hg levels. If possible such an analysis should be presented at the 2009 Annual Meeting.

[5]The Panel's also received a figure showing the flow of total mercury (THg) in the predators and their prey, not included in the paper. The Panel found this valuable in linking both parts of the study together and in illustrating how the concentrations found in each species are related to one another; the Panel recommends that this figure be included in a revised paper for the 2009 Annual Meeting.

SC/J09/JR24 reported on temporal trends and factors affecting polychlorinated biphenyl (PCB) levels in baleen whales and environmental samples from the western North Pacific and largely addressed objective (a) above. The Panel noted that it was not clear whether the study animals reported in the paper SC/J09/JR24 were all mature males, although it was clarified that this was the case. This should be made clear in a revised paper presented to the 2009 Annual Meeting.

The PCB concentrations reported in this study were not given on a lipid weight basis, as is the convention with these contaminants. Because they are tightly bound to the lipid fraction in the blubber, which may not be consistent over time, it is important for comparative purposes to adjust the results to the amount of lipid in the sample. Lipid proportion data were not available for all the samples and the authors had recognised that this was a problem. The Panel **recommends** that future studies must be carried out on a lipid weight basis. It also **recommends** that in future, sampling for PCBs and Hg from the same individuals is undertaken to allow combined analyses of these often co-occurring contaminants.

SC/J09/JR25 investigated the accumulation of total and methyl mercury and selenium in baleen and sperm whales from the western North Pacific. One of the main findings was that demethylation abilities appeared to be different among the species, and higher selenium levels, especially in Bryde's whales, indicated they were likely to be less vulnerable to effects of MeHg than the other species. The Panel **recommends** that in a revised paper submitted to the 2009 Annual Meeting, greater emphasis is given to this important ecotoxicological finding. While the sperm whale samples (n=5) had high liver T-Hg levels, the molar ratio of Hg to Se indicated these animals were not at risk of toxic effects because of the protective effect of selenium. The Panel **emphasises** that with respect to sperm whales, the low sample size and the logistical constraints on the size of animals taken means that the obtained data cannot be used to infer general conclusions.

Although concentrations of T-Hg in liver, kidney and muscle (i.e. the main target organs) were presented, the Panel **agrees** that for total body burden estimates, additional organs would need to be included. It suggests that the authors investigate whether the available literature indicates whether the proportion found in these tissues can be derived and thus total burden estimates made. With respect to future work, the Panel **suggests** examination of T-Hg in brain tissue particularly for comparing the more coastal bycaught animals to the coastal and offshore JARPN II samples, as these would provide a valuable (perhaps more exposed) comparison group. It was observed that brain tissue is very important if the newer contaminants are to be investigated in the future. Additionally, polybrominated compounds target adrenal glands as well as fat, so contaminant levels can be as high in these organs as they are in the blubber.

The published studies of Niimi *et al.* (2007; 2005) report the molecular characterisation of various cytochrome P450 detoxification liver enzymes in minke whales and how their mRNA expression levels relate to levels of contaminants in the liver. These studies addressed the final objective (c) above. The Panel **welcomes** these results, whilst noting that these biomarkers are not necessarily indicative of health status (even though they may be induced by foreign compounds, this increased activity may not necessarily be detrimental to the animals' health). The Panel encourages the continuation of such comparative molecular phylogenetic research using mRNA isolated from fresh tissues. Many different hormones, proteins, receptors and enzymes can be characterised using these and other molecular approaches (such as microarrays) and the utility of putative biomarkers can be examined at the expression level. Despite the limitation that the contaminant exposure levels in these animals might well be too low to induce the activity of the enzymes above background, the biomarkers did not correlate with exposure.

Recommendations

(1) Any future contaminant exposure and uptake studies should be based on a balanced, structured study design with a specific number of individuals sampled within each strata (e.g. by species, sex, stage, ocean regime and location). All the necessary data on exposure and confounding variables should be obtained from all of the specifically targeted individuals and a control or comparison group should be included. In this way a more powerful and statistically robust study to address clearly stated hypotheses could be designed and carried out.
(2) Tissues should be archived (frozen at –20°C or lower if possible) for future retrospective analyses.
(3) The importance of having absolute age as an additional covariate for the interpretation of the results, both the pollutant levels and to provide further information on population structure, cannot be over-emphasised and every effort should be made to obtain such data (the Proponents informed the Panel that this is being pursued) .
(4) Consideration should be given to including coastal, 'J' stock bycaught minke whales in future studies as these would provide a valuable (perhaps more exposed) comparison group.
(5) Future studies should include data on stable isotope ratios and fatty acid profiles from a variety of tissues (for example muscle, liver, brain, blubber, skin) as these profiles, also indicative of diet, could help determine what the whales had been feeding on in the past (particularly important for assessing predator prey relationships in blubber PCBs and other persistent organic pollutants (POPs)) that are integrated in these tissues over a long timeframe, for an example see Fisk *et al.* (2001). This would help discriminate among reasons for temporal changes (i.e. dietary changes or exposure variation with constant diet).
(6) The air and water samples obtained could have been useful in a 'fate and behaviour' study but congener specific data (especially for PCBs) and other elements would need to have been included to make a substantive contribution to knowledge in this field. There are various modelling approaches that could be implemented, but more results for air and water, including the effect of weather using simultaneously collected data, are required. More resources and effort need to be allocated to this aspect of the monitoring.
(7) Simple mass balance studies (input-output estimates) would contribute to our knowledge of the partitioning and offloading of contaminants in these species and the

potential impact of changes in exposure. For this, additional analyses of blood, bile, faeces and urine are required.

(8) The contaminant results should eventually be linked to the prey consumption studies. For example, the Proponents could model the flow of Hg in the marine ecosystem (using, as one example, the approach taken by Booth and Zeller (2005), who used Ecotracer, a new routine in Ecopath, for this) and determine how changes in the flow of energy within the system might affect the flow of contaminants and their deposition rates.

6. REVIEW OF JARPN II RESULTS: STOCK STRUCTURE

6.1 Statement of objectives as given by the Government of Japan

The general objectives for the stock structure component of the programme were simply listed as:

'Stock structure of large whales:
common minke whale (*Balaenoptera acutorostrata*)
Bryde's whale (*B. edeni*)
sei whale (*B. borealis*)
sperm whale (*Physeter macrocephalus*)'

Justification and further explanation of this broad objective was also provided as follows (taken from SC/J09/JR1).

Common minke whale

There are the following two remaining issues on stock structure, which are important in the context of management under the RMP.

(A) SYSTEMATIC MONITORING OF THE OCCURRENCE OF 'J' STOCK LIKE ANIMALS IN COASTAL AREAS OF THE PACIFIC SIDE OF JAPAN (SUB-AREA 7, FIG. 2) TO DETERMINE THE DYNAMICS (SPATIAL AND TEMPORAL) OF THEIR OCCURRENCE

Assignment of individuals to stocks is particularly important in situations of geographical overlap of stocks (animals of two or more stocks occupying the same geographical area). Furthermore, individuals assigned to particular stocks by genetic analysis can be examined for other biological and ecological traits so that differences among stocks revealed to non-genetic markers can be investigated as well.

(B) PLAUSIBILITY OF THE FOUR STOCK STRUCTURE HYPOTHESES OF THE 'O' STOCK USED IN ISTS IN 2003 (FIG. 2)

Hypothesis A: three-stock scenario ('J', 'O', 'W') with the 'W' stock found only in part of sub-area 9 and only sporadically (Fig. 2-AB); Hypothesis B: two-stock scenario ('J' and 'O') with no W stock as a limiting case of Baseline A (Figure 2-AB); Hypothesis C: four-stock scenario overall, with 'OW', 'OE' and 'W' to the east of Japan. Boundaries are fixed at 147°E and 157°E and there is no mixing between the stocks (Fig. 2-C); Hypothesis D: three-stock scenario ('J', 'O', 'W'), with 'O' and 'W' mixing over 147°E and 162°E, 'O' being dominant to the west and 'W' to the east (Fig. 2-D).

In 2003, the IWC Scientific Committee gave the same high plausibility to these four hypotheses (IWC, 2004b). There was therefore a need to examine new samples (genetic and non-genetic) to evaluate the plausibility of these four stock structure hypotheses.

Bryde's whale

(A) PLAUSIBILITY OF THE FOUR HYPOTHESES ON STOCK STRUCTURE WERE USED IN THE RMP' ISTS (FIG. 3)

Hypothesis 1: this is a single stock hypothesis under which only one stock of Bryde's whale is found in the area from 130°E and 160°W (excluding the area of distribution of the East China Sea Stock) and there are no sub-stocks.

Hypothesis 2: this is a two-stock hypothesis under which Stock 1 is found in sub-area 1 and Stock 2 in sub-area 2. Sub-areas 1 and 2 are divided at 180° longitude. Under this hypothesis there are no sub-stocks.

Hypothesis 3: this is a two-stock hypothesis under which Stock 1 is found in sub-areas 1 and 2 and Stock 2 only in sub-area 2. Under this hypothesis there are no sub-stocks.

Hypothesis 4: this is a two-stock hypothesis under which Stock 1 is found in sub-area 1 and Stock 2 in sub-area 2. Stock 1 consists of two sub-stocks that mix in sub-area 1.

The IWC Scientific Committee gave different plausibility to these hypotheses as follows: Hypothesis 1: high; Hypothesis 2: high; Hypothesis 3: high; Hypothesis 4: medium (IWC, 2008b). There was therefore a need to collect and examine new samples to evaluate the plausibility of these four stock structure hypotheses, in particular to respond to remaining key questions on (a) whether or not sub-stocks occur in sub-area 1 and (b) whether or not a different stock occurs in sub-area 2. JARPN II attempted to respond to the first question.

Sei and sperm whales

These species are currently not being considered for RMP *Implementation*. The IWC Scientific Committee is currently considering undertaking an in-depth assessment of these species in the North Pacific to investigate the current population status in this oceanic region. Estimations of abundance, biological parameters and examination of the catch history are conducted on the basis of individual stocks.

The past information on stock structure of sei whales was based on marking, catch distribution, sighting, morphology of baleen plates (Masaki, 1977), and isozymes (Wada and Numachi, 1991). The information is old and limited, and it was considered non-conclusive by the IWC Scientific Committee when last examined. Therefore there is the need to update sampling and analysis on stock structure for this species in the North Pacific.

In the past, the management of sperm whales by the IWC was based on the assumption of two-stocks, western and eastern stocks divided at 180º. The most recent information on stock structure was based on analysis of whaling operation data, movement of marked whales and sighting distribution (Kasuya and Miyashita, 1988). These authors suggested two latitudinally segregated sperm whale stocks in the western North Pacific. Therefore the information on stock structure of sperm whales in the North Pacific is old and limited and there is the need to update sampling and analysis on stock structure for this species in the North Pacific.

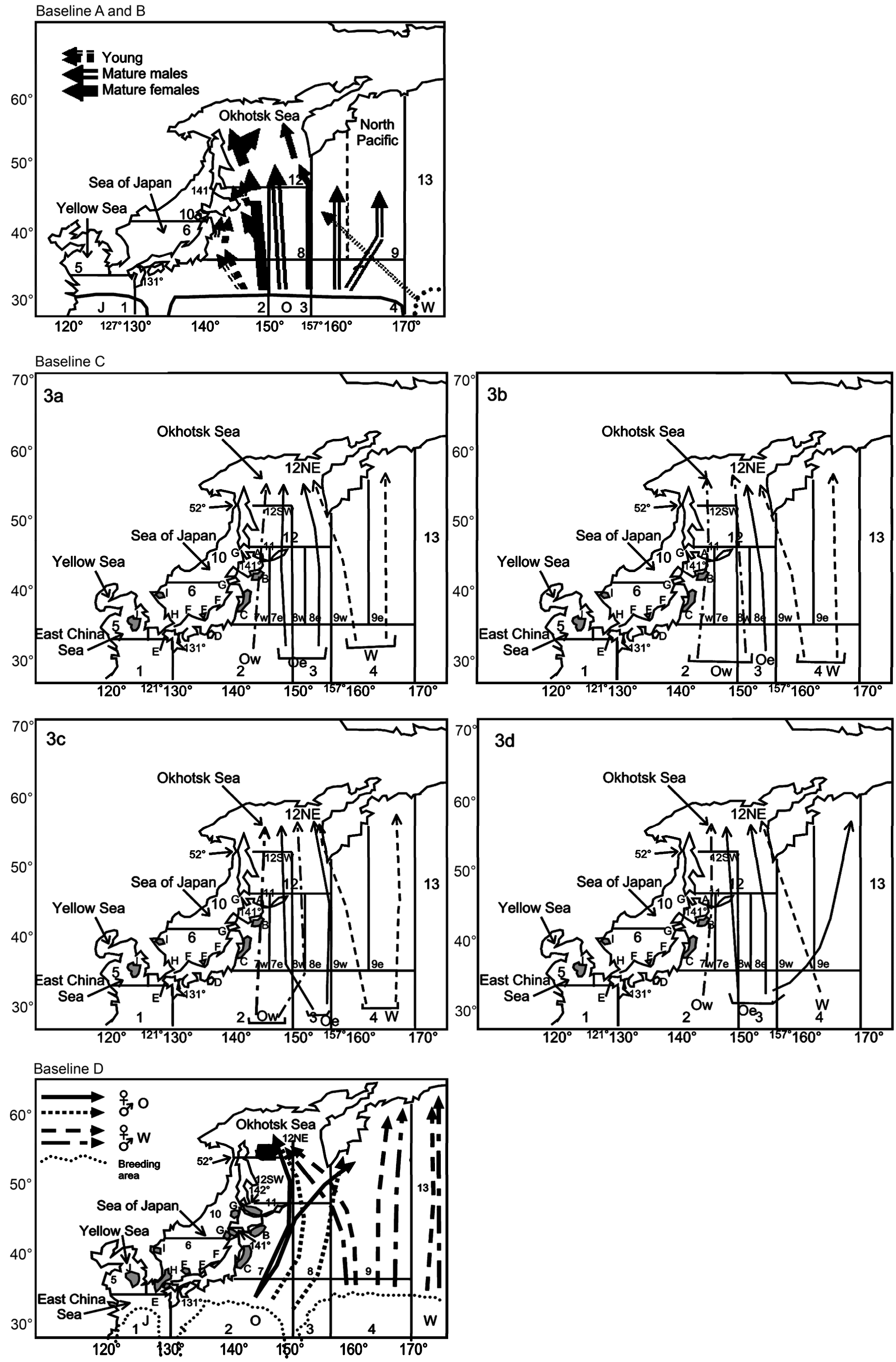

Fig. 2. Hypotheses on stock structure of North Pacific common minke whale used in the *Implementation Simulation Trials* of the RMP (IWC, 2004, p. 79). See text for details.

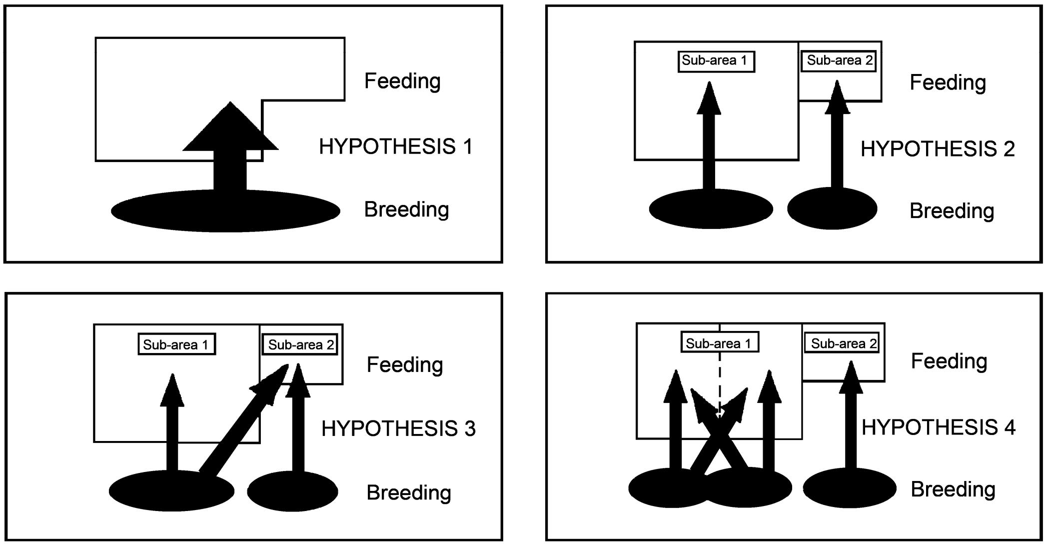

Fig. 3. Hypotheses on stock structure of North Pacific Bryde's whale used in the *Implementation Simulation Trials* of the RMP (IWC, 2008b). See text for details.

6.2 Proponents' summary

Common minke whale

SC/J09/JR26 presented the results of a study that attempted to distinguish minke whales sampled around Japan into genetically distinct stocks using a combination of microsatellite analysis and a Bayesian clustering approach. Samples of 2,542 minke whales were collected during the offshore component of JARPN and JARPN II from 1994 to 2007, during the coastal component of JARPN II from 2002 to 2007, and from bycatches in the set-net fishery along the Japanese coast from 2001 to 2007. These were analysed using 16 microsatellite loci. Results of the Bayesian clustering analysis implemented in the computer program STRUCTURE (Pritchard *et al.*, 2000b) indicated that the samples came from two genetically differentiated groups of minke whales. Approximately 91% of the individuals were assigned into the putative stocks based on their high membership probability (>90%) obtained from the program. Spatial distribution of these assigned individuals clearly indicated that these two-stocks were the 'J' and 'O' stocks that have been known to exist around the Japanese coast. In addition, it was also found that: (1) the 'O' stock individuals appeared to migrate, although rarely, to the Sea of Japan; (2) the 'J' stock individuals migrated to the 7W area off the North Pacific side of Japan and, very rarely, farther east; and (3) the SA2 (western side of North Pacific coast) was mainly occupied by the 'J' stock. Temporal distribution of the assigned bycatches collected from SA7 (eastern side of Japan, North Pacific coast) indicated seasonal movement of the whales with the number of the 'O' stock increased in spring. This study allowed better understanding of the pattern and dynamics of distribution of the minke whales inhabiting waters around Japan.

A consolidated presentation was made using the results from a morphometry study (SC/J09/JR27), a mitochondrial DNA study (SC/J09/JR29) and a microsatellite study (SC/J09/JR30). These three different kinds of analyses were used to examine the plausibility of the four baseline stock scenarios proposed during the RMP *Implementation* for the western North Pacific common minke whales (IWC, 2004) by analyzing samples of minke whales collected during JARPN II as well as JARPN conducted from 1994 to 2007; the samples from 2003 to 2007 had not been available in the *Implementation* process. All of the studies conducted the statistical tests in similar fashion to look for evidence of genetic heterogeneity in the samples: (1) genetic differences between the coastal and offshore samples collected in the same year from the 7W area; (2) among the samples collected in the different years from the same sub-area; and (3) among the samples divided and compared on the basis of proposed stock divisions from each of the four baseline scenarios.

These tests were conducted with and without the suspected 'J' stock individuals as well as with only the suspected 'O' stock individuals in the samples assigned based on SC/J09/JR26. The studies found: (1) whales from the 'J' stock existed in the 7W with low but large enough number to cause genetic heterogeneity observed in the 7W samples as well as between the 7W and other samples; (2) except the 'J' stock whales, the survey area was mainly occupied by 'O' stock; and (3) the baselines C and D were not supported because no evidence of distinct coastal stock was observed. These studies supported the baseline scenario B as the most plausible.

SC/J09/JR28 examined the status of scars on the skin of minke whales, and whether or not it is possible to identify the stock of the individual animal based on external morphological scars using samples of western North Pacific common minke whales collected by JARPN II. This study was assisted by the genetic assignment to stocks shown in SC/J09/JR26. Assignments of the number of scars were not a complete diagnostic for the minke whales samples for 'J' and 'O' stocks. However, at least there appeared a strong likelihood that animals which have no scars on the body were 'J' stock animals.

The main conclusions of papers dealing with North Pacific minke whales (SC/J09/JR26-30) can be summarised as follows.

(1) A great deal of new information has been developed, drawing on both genetic and non-genetic methods.
(2) New data provide strong support for, and additional insights regarding, what have previously been referred to as 'J' and 'O' stocks.

(3) New data do not provide support for the existence of more than these 2 stocks in the study area. In particular, no evidence was found to support hypotheses C or D considered by the IWC (IWC, 2004a).

Bryde's whale

Kanda *et al.* (2007) investigated the pattern of genetic stock structure in the Bryde's whale at the inter-oceanic and trans-equatorial levels, using microsatellites (17 loci) and mtDNA control region sequences (299bp). Samples were available from the western North Pacific (JARPN II), South Pacific (historical) and Indian Ocean (historical). While no significant differentiation was found within the western North Pacific, marked genetic differentiation was found among oceans and between South and North Pacific.

SC/J09/JR31 examined genetic variations at 17 microsatellite loci and 299bp of mitochondrial DNA (mtDNA) control region were analysed to investigate the existence of genetically differentiated sub-stocks of Bryde's whales in the sub-area 1 (stock hypothesis 4 in figure 5 of SC/J09/JR1). No evidence was found of genetic differentiation between the samples from the 1W and 1E (separated at 153ºE), indicating these JARPN II samples came from a genetically same group of Bryde's whales. The same result was found when historical samples from the central western North Pacific and around the Ogasawara Islands were incorporated into the analysis.

Sei whale

SC/J09/JR32 presented an analysis of genetic variation at 17 microsatellite loci and 487bp of mitochondrial DNA (mtDNA) control region sequences in samples of sei whales in order to describe their stock structure in the North Pacific. The samples consisted of 489 whales collected during JARPN II from 2002 to 2007 in the area between 143°E and 170°E and 301 whales collected from the 1972 and 1973 commercial whaling conducted at the North Pacific from 165°E to 139°W. Due to the condition of the DNA extracted from the archived blood samples, 14 of the 17 loci were analysed in the commercial whaling samples. Conventional hypothesis testing was conducted to look for any evidence of genetic differences among the samples. All of the tests found no evidence of genetic differences within as well as between the JARPN II and commercial whaling samples. Both females and males showed the same pattern of stock structure. This study showed that the open water of the North Pacific appeared to be mainly occupied by individuals from a single stock of sei whales.

Sperm whale

SC/J09/JR33 analysed genetic variations at 15 microsatellite DNA loci and mitochondrial DNA (mtDNA) control region sequences in samples of sperm whales collected during JARPN II from 2000 to 2007 in order to examine the effectiveness of these genetic markers for stock structure study of the species. Analyses of mtDNA and microsatellite markers in the total of 45 sperm whales demonstrated that these genetic markers were variable enough to explore stock structure of sperm whales. Statistical tests found no evidence of deviation from the expected Hardy-Weinberg genotypic proportion at all of the 15 microsatellite loci. At this point no signal of multiple stocks in the research area was found.

6.3 Panel's conclusions and recommendations

The Panel acknowledged the substantial scope of the genetic analyses undertaken under JARPN II, which provides a uniquely large data set for testing hypotheses regarding stock structure in the target species. Analyses conducted with the genetic data under JARPN II were in general sound and of a nature common to other genetic analyses within and outside the IWC Scientific Committee framework. The inclusion of morphological and morphometric studies as well as genetic information helps to provide a more well-rounded picture of stock structure. Although genetic data can provide valuable insights regarding stock structure, they have some limitations for weakly differentiated populations, as is the case for many of the species targeted by JARPN II.

Particularly in the context of weakly-differentiated populations, the Panel **acknowledges** the general difficulties in examining questions of stock structure, not the least of which is that there is no formal IWC definition of 'stock' (see the extensive deliberations in recent years within the Working Group on Stock Definition). Similarly, none of the stock structure papers provides a definition of a 'stock' or describes an objective method for determining whether a group of individuals constitutes a 'stock'. This complicates the work of the Panel in evaluating the effectiveness of the JARPN II programme in identifying stocks. In practice, however, the objective of the JARPN II programme is to assist the IWC Scientific Committee in providing information that can be used within the context of the RMP *Implementation* process and more specifically, to narrow the number of hypotheses used for western North Pacific common minke whale and Bryde's whale *Implementation Reviews*, and to assist in the proposed in-depth assessment of sei whales that may ultimately lead to the inauguration of the *Implementation* Process for these species in the North Pacific. The papers presented had focussed on this objective.

The Panel **emphasises** that with respect to sperm whales, the low sample size means that the obtained data provide no meaningful input to stock structure discussions.

Recognising the general difficulties, the Panel identified a number of limitations to the analyses presented as listed below. It later provides detailed suggestions for addressing these limitations.

(1) The genetic analyses rely heavily on hypothesis testing and *P* values, with limited consideration and discussion of effect sizes (e.g. F_{ST} values or other measures of the degree of genetic differentiation). Most of the statistical tests used evaluate the null hypothesis that all individuals come from a single panmictic population. This is a reasonable (and common) starting point for evaluations of genetic data but rarely is sufficient to fully inform questions related to stock structure. Informed management decisions about the consequences of harvest generally depend on at least a qualitative assessment of the degree of demographic linkage between putative populations or stocks. This requires additional information and analysis beyond that provided by tests of heterogeneity. See Waples and Gaggiotti (2006) and Palsbøll *et al.* (2007) for discussion of these issues.
(2) The main conclusions in the papers presented are based on a failure to find evidence of population

differentiation or stock structure. To evaluate how strongly negative results support a single stock hypothesis, statistical power to detect heterogeneity, as well as alternate explanatory hypotheses, need to be assessed. Although large amounts of genetic data have been collected under JARPN, the absence of an assessment of statistical power makes it impossible to reduce the plausibility of any of the current stock hypotheses proposed for minke and other baleen whales in the North Pacific (although an initial examination of this problem for western North Pacific Bryde's whales was presented by Kitakado *et al.*, 2005a; 2005b). Inclusion of an assessment of statistical power would add substantially to the analyses conducted and aid in the selection of stock hypotheses proposed by the IWC Scientific Committee for this area. The use of STRUCTURE to estimate relative probabilities for the number of stocks present was noted, although it is known that STRUCTURE can produce unreliable results under some circumstances (IWC, 2007).

(3) The low levels of genetic structure identified by the JARPN II analyses might be due to substantial deviations from the mutation-drift-migration equilibrium assumed in most of the analyses undertaken. The mtDNA data yielded low estimates of nucleotide diversity but high haplotypic diversity, which is consistent with a recently [in evolutionary terms] exponentially expanding population (slatkin and Hudson, 1991), and thus non-equilibrium. The data should be subjected to assessments of possible deviations from population genetic equilibrium, and methods to estimate gene flow that allow for non-equilibrium conditions should be explored.

(4) Most of the assessments involve a large number of tests conducted separately for each locus and/or various combinations of samples. Although the authors of the various papers have recognised this issue and made formal adjustments for multiple testing, the Bonferroni correction (Rice, 1989) used is known to be conservative, with the result that true departures can go undetected. This issue also affects the strength of the conclusions one can draw from the failure to find significant differences.

In the light of this, the Panel **agrees** that it is not possible to conclude, as the Proponents did, that the number of hypotheses proposed during the *Implementations* for western North Pacific common minke whales and Bryde's whales has been unequivocally reduced. However, this does not mean that such conclusions may not be the ultimate outcome of the additional analyses recommended below; that remains to be seen.

While recognising the considerable value of the stock structure work already undertaken, the Panel has the following specific recommendations/suggestions for ways in which the scientific benefits from JARPN II stock-structure research can be enhanced. Some of these recommendations should be easy to implement; others will take more time and effort.

6.3.1 Simple issues

(1) The genetic assessments should include a brief description of procedures to ensure data quality. This section should refer to the recently discussed IWC guidelines for DNA data quality (IWC, 2009a).

(2) The revised papers should include estimates of genetic divergence (along with levels of uncertainty) in addition to probabilities of homogeneity[6].

(3) *P* values (and divergence estimates) should be reported for all loci combined rather than for each locus separately. In addition to providing more useful information and increasing statistical power, this will help reduce issues related to multiple testing.

(4) Multiple testing issues will still arise in some cases. In general, use of the False Discovery Rate (Benjamini and Yekutieli, 2001) could be preferable to the Bonferroni correction, as it is less conservative and does not sacrifice as much power. Another strategy that can be useful is to exercise discretion in the number of pairwise comparisons that are evaluated – for example, by only comparing samples that are geographically proximate and hence most likely to be connected demographically. See Økland *et al.* (2008) for an example of this approach.

(5) Provide more details[7] on the analyses involving the program STRUCTURE (Pritchard *et al.*, 2000a).

(6) Include a brief discussion of experimental design with respect to sampling. Although the rationale for the sampling design is discussed in other papers (especially SC/J09/JR3 and JR4), it would benefit these evaluations to have a short discussion explaining how the design specifically addresses uncertainties related to stock structure, e.g. whether the spatial and temporal coverage of samples of minke whales has been sufficient to test adequately the alternative stock structure hypotheses under consideration by the IWC.

6.3.2 More extensive matters – some of which might ideally be addressed in time for the 2009 Annual Meeting[8]

(1) The original justification for considering hypothesis C (and to some extent D) for common minke whales was primarily based on results from the Boundary Rank analyses (Taylor and Martien, 2002) – it would be informative to redo those analyses using the new data (including taking into account information on assignment of animals to 'J' stock) to see if evidence for a narrow coastal stock remains.

(2) Previous analyses of 1999 and 2000 Korean bycatch samples suggested that they differed from other 'J' stock samples. It is important to integrate these samples into the new datasets to see if this heterogeneity still exists.

[6]Some information on this issue was kindly developed by the proponents during the Workshop.

[7]Specific examples include: color figures showing assignment probabilities for each individual (for k=2 and k=3); indicators of convergence of MCMC estimations including information about repeatability of assignment probabilities of individuals to the putative 'J' and 'O' stocks (and unassigned categories) in different runs (e.g. CV of assignment probabilities for the same individuals across multiple MCMC estimations and comment on whether the same individuals consistently end up being unassigned or if there is a different mix of individuals in each run); more detailed geographical plots of the distribution of 'J', 'O', and unassigned individuals; include unassigned individuals in plots.

[8]The issues concerning deviations from population genetic equilibrium and statistical power also apply to the Bryde's and sei whale. Note: Points (1) and (2) are important but it is not necessarily the responsibility of JARPN II to undertake them.

(3) Assessments of power using simulated data should be undertaken (see Annex G). It should be relatively straightforward to simulate data to evaluate power to detect a specified fraction of a putative stock (e.g. the hypothetical W stock of NP minke whales) in an overall sample. This analysis would require specifying a range of genetic divergence values (e.g. F_{ST} values) for the putative stock. More challenging but still feasible would be simulations to evaluate the power of STRUCTURE (Pritchard *et al.*, 2000a) to detect various mixture fractions of closely related stocks. Although strictly speaking power is a frequentist concept and STRUCTURE uses Bayesian methodology, it should be possible to construct a power analogue that reflects robustness to delivering what, with simulated data, is known to be the correct answer. In this case, the specific question could be: how large a proportion of the samples could be from another population and still result in a situation in which *K*=1 is favoured with high probability? These simulations could be carried out using the programs *SimCoal* (Laval and Excoffier, 2004), *ms* (Hudson, 2002), EasyPop[9] (Balloux, 2001) or other freely available software. The statistical power to detect a second stock that is under-represented in a sample will depend upon the fraction of these individuals in the total sample and how genetically divergent they are. This implies that simulations either are conducted as a sensitivity test (i.e. assessing a range of combinations of the sample proportion and degree of genetic divergence) or by deciding upon a minimum case (e.g. the minimum detectable fraction should be X% at a degree of divergence equivalent to a migration rate at Y migrants per generation).

(4) Tests for population genetic (drift-mutation-migration) equilibrium should be undertaken. High haplotype diversities coupled with low nucleotide diversities indicate deviations from population genetic equilibrium.

(5) Estimations of divergence between sample partitions should be undertaken using non-equilibrium approaches. An example of such an approach is IM by Hey and Nielsen (2004); the estimates of dispersal emerging from IM may be used in the power assessment simulations suggested above. It is probably advantageous to conduct initial estimations between the potentially most divergent sample partitions (e.g. most extreme parts of the range). These methods improve the approach previously used to estimate dispersal rates for the common minke whale *Implementation Simulation Trials* (Taylor and Martien, 2004).

(6) With genotypes from 17 microsatellite loci in 2,500 individuals, it may be possible to detect pairs of individuals that are related, as was the case among a smaller set of samples genotyped at the same number of loci in the North Atlantic fin whale (Skaug and Daníelsdóttir, 2006). The spatial distribution of related individuals can provide information directly relevant to stock structure considerations; Økland *et al.* (2008) have demonstrated the use of such an approach. Notably, such analyses provide information about contemporary stock structure and do not rely upon assumptions of population genetic equilibrium.

(7) Multivariate analyses of morphological data could be informative with respect to stock structure. Many multivariate classification methods (such as cluster analysis, discriminant analysis, SIMPER and ANOSIM) now include permutation tests. Another option would be to use a principle components (or similar) analysis of individuals that does not require *a priori* decisions about group membership. PCA does not attempt to define groups but can reveal patterns in the data related to time or place of sampling.

(8) Data on contaminants in western North Pacific minke whales have been reported (Fujise, 1996) and were used as further support for the baseline C stock structure hypothesis (Taylor and Martien, 2004). The use of past and present contaminant data should continue to be pursued as part of an integrative study of stock structure.

6.3.3 Longer term

Notwithstanding the practical difficulties associated with attaching satellite tags to minke whales, the increasing success of satellite tagging programmes for several whale species (e.g. see Weller, 2008[10]) suggests that efforts should be made to establish such a programme for western North Pacific common minke whales. Information such a programme might produce could be very valuable in allowing the IWC to narrow the range of plausible stock-structure hypotheses.

7. REVIEW OF JARPN II RESULTS: REVIEW OF OTHER CONTRIBUTIONS TO IMPORTANT RESEARCH NEEDS

7.1 Oceanography

7.1.1 Statement of objectives and Proponents' summary

The Government of Japan stated (Government of Japan, 2002b, p.34) that during JARPN II, oceanography surveys will be obtained using XCTD (Expendable Conductivity, Temperature and Depth Sensors), CTD and EPCS (Electric Particle Counting and Sizing System).

More specific objectives included:

(1) clarify the geographical distribution patterns of prey species of common minke whale in relation to oceanographic features; and

(2) clarify the geographical distribution patterns of common minke whale in relation to prey environment and oceanographic features (SC/J09/JR11).

Oceanographic data collected during the cruises included: on the sighting and prey sampling vessels in the coastal and offshore study areas, water column profiles of temperature, salinity, and density using XBTs (expendable bathythermographs), XCTDs, and CTDs; and only on the *Shonan Maru* No. 2, the continuous measurements of surface water temperature, conductivity, chlorophyll, dissolved oxygen and particles using EPCS. Oceanographic data were not collected on the whale sampling vessels.

SC/J09/JR34 summarised the oceanographic conditions of the western North Pacific from 2002 to 2007 in the

[9] *http://www.unil.ch/webdav/site/dee/shared/softs/EASYPOP_201_userguide.pdf* (Balloux, 2001).

[10] *http://www.mmc.gov/pdf/final_tagging_82608.pdf.*

JARPN II coastal and offshore study areas using the CTD and XCTD data collected during the cruises as well as data from the Global Temperature and Salinity Profile Program (GTSPP) that were incorporated in FRA JCOPE, an operational ocean forecast system. Oceanographic fronts and water bodies were classified by surface currents and subsurface temperature, salinity and density gradients. Year to year variations in the spatial distributions and strengths of the various fronts, warm core rings, and water bodies were described.

In addition to this overall description of the oceanographic characteristics in the study areas, a few other studies investigated relationships with respect to oceanographic characteristics. SC/J09/JR11 described preferred temperature ranges and distributions of the potential prey species and common minke whales in relationship to the major water bodies, fronts and bottom depths in the Kushiro coastal study area.

SC/J09/JR13 compared the distributions of potential prey species and maturity status of common minke whales relative to their distribution on the continental shelf, continental slope, and offshore waters in the Kushiro coastal study area.

SC/J09/JR19 developed density prediction models on a monthly 1 × 1° degree grid for common minke, sei and Bryde's whales in the Western North Pacific in their feeding season using NPMR (non-parametric multiplicative regression models) which included satellite derived SST, chlorophyll, and sea surface height as potential predictor variables.

SC/J09/JR35 identified the SST ranges where most blue, fin, and North Pacific right whales were seen during the JARPN and JARPN II sightings surveys during 1994 to 2007.

SC/J09/JR36 estimated the abundance of North Pacific sei whales using SV and JSV sightings data in a hierarchical GAM of the interactions between school density and the following environmental factors: satellite derived SST, sea surface height anomalies, and sea surface chlorophyll concentration, and CTD/XCTD derived water temperatures and salinities at 50, 100 and 200m depths.

Murase *et al.* (2007) briefly discussed the distribution patterns of Japanese anchovy, walleye Pollock and krill in relationship to the Kuroshio-Oyashio transition zone and the continental slope and continental shelf zones.

The Proponents recognised that their studies which relate oceanographic features to distributions of prey and whales are in progress. Before these relationships can be identified, the underlying data need to be collected and processed. At the time of this review, most of the initial oceanography data processing has been completed, which will now allow future analyses that relate oceanographic features to important aspects of the whale ecosystem.

7.1.2 Panel's conclusions and recommendations

The Panel **congratulates** the Proponents for simultaneously collecting *in situ* sea surface and water column characteristics while conducting the whale and prey surveys, recognising the practical challenges of coordinating these sampling methods on the same ship at the same time. Such simultaneous collections represent the best way to obtain a direct comparison between oceanographic features and the distributions of the various trophic level components. The Panel **welcomes** these analyses as a good initial attempt at investigating relations with oceanographic features and they encourage the analyses to be continued and expanded. The programme is addressing its objectives and continued work is recommended.

At the practical level, the Panel concurred with the suggestion of the authors of SC/J09/JR34 that the salinity CTD data must be corrected/calibrated using the water samples that were simultaneously collected with the CTD data.

The Panel welcomed SC/J09/JR19, which predicted the density spatial-temporal patterns of common minke, sei and Bryde's whale distributions, as a good initial example of attempting to integrate several data types to investigate the relationships between whale densities and oceanographic features. The use of NPMR modelling techniques is appropriate, particularly if there are complex interactions among the ecological factors.

To improve this approach, the Panel **recommends** that the authors incorporate into the index of density, the sightability of detected groups (e.g. effective strip half widths that include appropriate covariates such as weather conditions). As for all modelling exercises, it is important to test whether the chosen model is an improvement over a null, uninformative model and to validate the model results. Approaches to such validation could include: comparison of the modelled results not only with index of densities from the present study but also with data that were collected from other years (e.g. JARPN or other survey data) and exploration of cross-validation type techniques. The Panel **recommends** that more of these types of analyses (including using other appropriate modelling techniques such as GAMs or logistic regressions) be conducted. The shipboard oceanographic data that were collected should be considered in future models, as was suggested by the authors of SC/J09/JR19. Potential additional oceanographic/biological features that could be investigated include modelling the satellite or *in situ* measurements of chlorophyll to estimate primary productivity. Other examples of potential future analyses that investigate relationships with oceanographic features are described in Item 8.2.

GENERAL RECOMMENDATIONS

To further investigate oceanographic relationships, the Panel **recommends** that the JARPN II data be pooled or compared with other datasets (e.g. JARPN I or other historical surveys) when possible. This will increase the sample size and increase the possibility of data covering periods of changing relationships (e.g. previous regime changes), thus allowing patterns to be detected.

The Panel also **suggests** that the Proponents consider conducting future oceanographic surveys over an area larger than at present, not only to further investigate oceanographic relationships, but also to improve abundance estimates for a variety of species.

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

7.2 Distribution of large whales

7.2.1 Statement of objectives and Proponents' summary

The Government of Japan stated that during JARPN II, sighting records will be collected for all cetaceans and in addition to sighting records, photo-ID, observations of whale behaviour, especially feeding behaviour, will be recorded (Government of Japan, 2002b, p.33).

Results related to the distribution and abundance of the four target species are discussed elsewhere in the Panel report. SC/J09/JR35 reported the Density Index (DI: individuals/100 n.miles) and monthly distribution pattern of blue, fin, humpback and right whales from May to September in the western North Pacific based on JARPN (1994-1999) and JARPN II (2000-2007) sighting data. Among four species, fin whales were most frequently sighted, and next were blue, humpback and right whales in order. Northward migration patterns of whales were observed for these species. Additionally, sighting areas of these species were spread out compared to the previous information except for right whales. SC/J09/JR1 summarised the photo-identification data collected during the programme: 24 schools of humpback whales, 22 schools of North Pacific right whales and 65 schools of blue whales had been photographed.

7.2.2 Panel conclusions and recommendations

The Panel **welcomes** SC/J09/JR35 and the analyses of the distribution. To investigate relationships with oceanographic variables and improve abundance estimates of a variety of species, the Proponents could consider conducting future surveys that cover an area larger than that of the present JARPN II sampling area.

Using the sightings data collected over the 1994-2007 period for the variety of large whales, the Panel **recommends** investigation of whether these data can be used to provide information on trends. It also **recommends** that the photo-identification data be worked up and comparisons made with catalogues elsewhere in the North Pacific.

7.3 Other research

7.3.1 Proponents' summary

REPRODUCTIVE BIOLOGY AND PHYSIOLOGY

Watanabe *et al.* (2004) presents a study to obtain new information on relationships among serum testosterone (T), estradiol-17β (E_2), follicle-stimulating hormone (FSH), and luteinizing hormone (LH) concentrations and histology of seminiferous tubules in captured common minke and Bryde's whales during the feeding season. Results indicated that the low serum T concentrations reflect the inactivity of spermatogenesis in both baleen whales, and that it is not possible to assess gonadal activity in either species using serum sex hormone concentrations during the feeding season.

Watanabe *et al.* (2007) investigated whether spermatozoa of Bryde's whale can retain the capacity for oocyte activation and pro nucleus formation as well as chromosomal integrity under cryopreservation by using intra cytoplasmic sperm injection (ICSI) into mouse oocytes. Results showed that motile Bryde's whale spermatozoa are competent to support embryonic development.

Urashima *et al.* (2007) examined samples of milk from a Bryde's whale and a sei whale. Milk samples of these species contained 2.7 g/100 mL and 1.7 g/100 mL of hexose, respectively. Both contained lactose as the dominant saccharide. The dominance of lactose in the carbohydrate of these milks is similar to that of minke whale milk and bottlenose dolphin colostrum, but the oligosaccharide patterns are different from those of these two species, illustrating the heterogeneity of milk oligosaccharides among the Cetacea.

Fukui *et al.* (2007) presented a study aimed at producing common minke whale embryos. The study was based on minke whale samples collected in the coastal research component off Kushiro. Results indicated that a 40 h IVM (*in vitro* maturation) culture produces significantly higher rates of *in vitro* maturation than a 30 h IVM culture for common minke whale oocytes. Following ISI (intra-cytoplasmatic sperm injection), some oocytes cleaved to the 16-cell stage, but no further development was observed.

Birukawa *et al.* (2008) examined kidney samples of common minke, sei, Bryde's and sperm whales to determine the nucleotide sequences of mRNAs encoding UT (urea transporters). Urea transport in the kidney is important for the production of concentrated urine. It was speculated that different phosphorylation sites found in whale UT-A2s may result in the high concentrations of urinary urea in whales, by reflecting their urea permeability.

GENETICS

Nishida *et al.* (2007) reconstructed cetacean phylogeny using a 1.7-kbp fragment of the non-recombining Y chromosome (NRY), including the SRY gene and a flanking non-coding region. The topology of the Y-chromosome tree is robust to various methods of analysis and exhibits high branch-support values, possibly due to the absence of recombination, small effective population size, and low homoplasy. The Y-chromosome tree indicates monophyly of each suborder, Mysticeti and Odontoceti, with high branch support values.

Onbe *et al.* (2007) examined the amino-acid sequences of the T-domain region of the *Tbx4* gene, which is required for hindlimb development. Cetaceans have lost most of their hindlimb structure, although hindlimb buds are present in very early cetacean embryos. They investigated whether the Tbx4 gene has the same function in cetaceans as in other mammals. The study concluded that the *Tbx4* gene maintains its function in cetaceans, although full expression leading to hind limb development is suppressed.

7.3.2 Panel conclusions and recommendations

The Panel **welcomes** the results of these additional research projects, noting that they have resulted in publications in peer-reviewed journals.

7.4 Abundance

7.4 1 Summary of results to date

Survey procedures and summaries of the surveys conducted to date are described in SC/J09/JR2. The Sanriku coastal area was surveyed in April-May each year, the Kushiro coastal area in September-October, and the offshore area in May-August. The entire JARPN survey was surveyed in two years in 2002-03 and 2004-05, and in each year 2006 and 2007.

Abundance estimates for the JARPN II area have been obtained for minke, sei and Bryde's whales using both conventional stratification (SC/J09/JR8, JR15) and spatial modelling using NPMR (SC/J09/JR19) and GAMs (SC/J09/JR36, Appendix 2). Distribution maps have been produced for fin, humpback and right whales (SC/J09/JR35).

In addition to the surveys in the JARPN II area, the Okhotsk Sea was surveyed in 2003 and the Russian EEZ east of Kuril and Kamchatka was surveyed in 2005. The estimates of abundance that were used for the assessment of the effects of JARPN II catches on the minke whale 'O' stock include estimates for the Okhotsk Sea and Kamchatka-Kuril, on the assumption that these animals are from the same stock as the JARPN II area (SC/J09/JR36).

The Sea of Japan has also been surveyed during the JARPN II period, including a survey in the Russian EEZ in 2006. The results of the surveys have been used to obtain estimates of abundance of the 'J' stock, which are used in the assessment of the effect of JARPN II catches on the 'J' stock (SC/J09/JR36).

7.4.2 Analysis and comment

While the Panel did not examine this in great detail, the dedicated survey procedures appear to be in accordance with IWC Scientific Committee guidelines for abundance data for use in the RMP (IWC, 2005); $g(0)$ has been estimated from independent observer (IO) data for minke whales (Okamura *et al.*, 2008b), and is assumed to be 1.0 for larger baleen whales.

The timing and distribution of survey effort has changed from year to year (see maps in SC/J09/JR2) due to weather and logistic constraints, and also to fill in holes left in previous surveys. This means that monthly and annual effects may be confounded to some extent in the data series. This might limit the value of the data to analyse such variations.

7.4.3 Recommendations

Recommendations for the conduct of sightings surveys and methods of analysis are regularly made by the IWC Scientific Committee, and the Panel did not attempt to duplicate this work.

The abundance data collected in the JARPN II area are primarily for the purpose of determining the density and distribution of whales with respect to their consumption of resources. The Panel emphasised the great importance of the abundance data for the consumption estimates. As noted under Item 4, the confidence intervals for the abundance estimates are generally wide, especially in the coastal area; the Panel **recommends** that increased effort to obtain better estimates should be a high priority.

In addition, total abundance estimates are an essential component of estimating total population sizes for the determination of the expected effect of catches on the stocks. As discussed under Item 9.3, the Review Panel **cautions** against extrapolations from the JARPN II area for this purpose.

8. REVIEW OF JARPN II RESULTS: THE RELATIONSHIP OF THE RESEARCH TO RELEVANT IWC RESOLUTIONS AND DISCUSSIONS

A summary of the relevant recent resolutions is given in Annex H, based on Zeh *et al.* (2005).

8.1 Research on the ecosystem and environmental change

8.1.1 Summary of Proponents' view (from SC/J09/JR1)

Resolution 1994-13 (IWC, 1995a) encouraged Contracting Governments/Scientific Committee to study environmental changes and impact on cetaceans. Resolution 1995-10 (IWC, 1996b) encouraged Contracting Governments to study the effects of pollutants on cetaceans as recommended by the Bergen workshop. Resolution 1997-7 (IWC, 1998a) encouraged Contracting Governments to continue to provide information on environmental changes and potential effects on cetaceans. Resolution 1999-4 (IWC, 2000) requested Contracting Governments to provide the Scientific Committee with data on contaminants in cetaceans.

JARPN II included the monitoring and assessment of chemical pollutants in whales and their environment. Information on feeding ecology is important for examining the effects of environmental changes. Therefore JARPN II is investigating several of the topics mentioned in these Resolutions.

Resolution 1998-7 (IWC, 1999) invited Japan to take full advantage of the existing mechanisms for cooperation between national research programs and the Scientific Committee's Standing Working Group on environmental concerns.

Japan has accepted this invitation positively and will cooperate by providing the information on environmental research obtained in JARPN II.

8.1.2 Panel conclusions and recommendations

The Panel **agrees** that many of the objectives of JARPN II are relevant to Resolutions of the Commission and that scientific results have been submitted to the Scientific Committee, as requested in several of the Resolutions.

8.2 Utility of the lethal techniques used by JARPN II compared to non-lethal techniques

8.2.1 Summary of Proponents' view (from SC/J09/JR1)

Resolution 1995-9 (IWC, 1996a) had recommended Contracting Governments to use non-lethal methods and instructed the Scientific Committee to review scientific permit research in the light of the use of non-lethal methods. One of the main characteristics of JARPN II is the combination of both lethal and non-lethal surveys and analyses, which is important for achieving the main objective of the research programme, i.e. feeding ecology and ecosystem studies as discussed under Item 4; some biological information from whales can be obtained only through the lethal approach.

General discussions on lethal versus non-lethal approaches in whale research under special permits have occurred several times in the IWC Scientific Committee in the past (IWC, 1998b; 2008a).

To estimate prey preferences of cetaceans, examination of stomach content data is the only way to identify prey species consumed and quantify prey consumption (e.g. SC/J09/JR9; 16 and 17). However, the feeding ecology of baleen whales can be studied using several methods other than examination of stomach contents. Barros and Clarke (2002) categorised those methods as follows: direct observation of feeding; traditional methods (analysis of vomit, scat, stomach and intestine contents); fatty acids; stable isotopes; genetic identification of scat; and videotaping of feeding behaviour.

In recent years, telemetric studies (e.g. satellite tags, time-depth recorders) have also been used for feeding ecology studies (e.g. Croll *et al.*, 1998). Direct observation of feeding is limited to above the sea surface or short duration underwater observation by scuba survey. Given the diversities and vertical distribution patterns of prey species of minke, Bryde's and sei whales, the direct observation method is not applicable to those species. Haug and Lindstrøm (2002) compared the traditional methods with the rest of the new methods. They concluded that the new methods have not proven to provide detailed quantitative information on the diet of individual animals and must be supplemented with traditional methods. Identifying and measuring items in gastrointestinal contents with a combination of methods could reinforce the reliability of any conclusions.

Regarding environmental studies (see Item 5) some pollutants are organ-specific and therefore studying different organs for different pollutants will provide valuable information. Furthermore, studies on the effect of pollutants on the health of whales require examination of target organs. The level of some lipophilic pollutants can be measured from blubber samples obtained by biopsy sampling. However, biopsy sampling is a difficult method for collecting samples over the whole research period and area of JARPN II. This is because sampling efficiency is affected by wind force, the particular research area and the targeted school size. The difficulty of obtaining biopsy samples could be also different among whale species, depending on body size, swimming speed and pattern of movement.

To understand the pattern of accumulation of pollutants in whales, it is important to have access to some biological information about the whales under investigation such as sex, reproductive status, body length, weight of stomach contents, some of which can be obtained only by using the lethal approach. A previous study attempted to assess reproductive status by examining hormone metabolites in faecal samples of the right whale (Rolland *et al.*, 2005). However there are practical difficulties for obtaining faecal samples.

Studies on stock structure under JARPN II (see Item 6) are based on both genetic and non-genetic approaches. The non-genetic approach used in JARPN II (for common minke whale at this stage) is morphometrics, which requires that accurate body measurements be obtained from whales sampled. Genetic analysis on stock structure based on DNA can be carried out by using biopsy samples. As explained above, there are some practical problems with the use of biopsy sampling.

8.2.2 Panel conclusions and recommendations

Both lethal and non-lethal methods are often used to address the same question (for example stock structure, diet and contaminant exposure), even if they do not always provide precisely the same data. The number of new non-lethal techniques being developed is increasing apace and the Panel **recommends** that a proper evaluation of the use of non-lethal and lethal techniques in any long-term programme such as this should occur periodically at appropriate intervals – this applies both to the development of new analytical techniques and to technical developments that allow appropriate samples to be collected from free-ranging animals. Clearly, it also involves regular careful analysis of appropriate sample sizes (see Item 9.2) over a long-term programme, since additional data from lethal sampling may become less important/unnecessary, in terms of meeting objectives, as the programme progresses.

A full comparison of the various lethal and non-lethal techniques requires *inter alia* an analysis of the bias and precision of the estimates obtained using the different approaches in the light of stated quantitative objectives or sub-objectives; often the data to allow such a comparison are not available (see recommendation below) and/or objectives are insufficiently stated/quantified (see Item 9.2.1). In addition, for a complex multi-disciplinary research programme such as JARPN II, an evaluation of appropriate techniques (lethal or non-lethal) must include an integrative analysis to ensure maximised efficiency from both a scientific and logistical perspective. The Panel was not in a position to evaluate this in detail in the absence of knowledge of available resources and the outcome of analyses detailed under Item 9.2 to assist with an evaluation of sampling strategies and sizes. Any comparative analysis must also take into account any biases arising out of the relevant sampling strategies.

Given these important difficulties and information gaps (not all of which are specific only to this particular programme), the Panel does not consider its evaluation below to comprise a full quantitative evaluation as described in the preceding paragraph; that is not possible given the available data. Rather, it presents a very brief initial evaluation/commentary on the available techniques in the context of the primary stated objectives of JARPN II that are presently addressed with lethal techniques.

FEEDING ECOLOGY

A suite of non-lethal methods are available for studying diet and foraging ecology of marine mammals (e.g. Barros and Clarke, 2002). However, proper evaluation of their value relative to lethal sampling is in many cases difficult, as few studies have properly and quantitatively compared the results of the different approaches; in fact for many approaches appropriate measures of precision are as yet lacking. The primary rationale for stomach sampling, which requires killing the animal, is the qualitative and quantitative information on prey composition (e.g. species, age) and stomach fullness that it provides, all of which are valuable when studying consumption and functional relationships between marine mammals and their prey. However, as has been noted elsewhere (See Item 4 and reviews such as those of Leaper and Lavigne, 2007), such data also have their limitations and these must be recognised in any analyses. Combinations of several methods applied simultaneously to the same animals are a particularly powerful approach (Karnovsky *et al.*, 2008).

The following list very briefly summarises the most common non-lethal methods used in feeding ecology studies and the information they provide:

- *Direct observations of feeding.* Primarily give information only on surface feeding whales and even then may rely on inference. Cameras mounted on marine mammals can provide information on prey encounters (e.g. Bowen *et al.*, 2002a; Bowen *et al.*, 2002b), but the difficulties in deploying cameras on fast-moving whales such as the rorquals, even if it proved possible, would probably result in substantially reduced sample sizes in terms of individuals, although potentially increasing the number of feeding events observed per individual.
- *Analyses of faeces* is a common approach to studying diet in seals (e.g. Casper *et al.*, 2007) and the examination of DNA in faeces to determine the presence or absence of important prey groups has been applied to several cetacean species (e.g. Gales and Jarman, 2002; Jarman *et al.*, 2006). The feasibility of obtaining sufficient samples, particularly on the high seas for the JARPN II target species, would need to be evaluated.
- *Analyses of stomach samples from bycaught or especially stranded individuals* is possible but care must be given to using the results due to *inter alia* non-random sampling, reduced spatial coverage and the compromised state of stranded animals that may have affected their ability to feed before stranding.
- *Analysis of fatty acid composition* from biopsy samples is a promising method both in terms of qualitative and quantitative assessment of diet, which reflects the diet integrated over a period of around 1.5-3 months (Nordstrom *et al.*, 2008). Providing quantitative (i.e. proportional) contribution of different prey species, this method could be used for quantifying functional relationships. However, the method may still need improvements in separating contributions from related species, and in calibrating tuning levels (Nordstrom *et al.*, 2008). Practical aspects of taking biopsy samples in the JARPN II context are discussed under the section on genetic studies.
- *Analyses of stable isotopes* on tissues from biopsy samples quantify trophic level and indicate relative contributions to the diet of different potential primary sources in a trophic network. This method integrates diet information over weeks/month (e.g. Das *et al.*, 2003a; 2003b). While stable isotope analysis does not quantify the diet, it provides a valuable tool for ground-truthing the trophic level estimated obtained from other methods. Again, practical aspects of taking biopsy samples in the JARPN II context are discussed below.
- *Analyses of spatial associations* between whales and their prey from synoptic surveys simultaneously recording whale and prey distribution may provide information on which prey species are targeted, particularly in areas/systems with few, spatially segregated prey species (Mauritzen *et al.*, In press). Such an approach could yield quantitative information on the proportion of whales targeting the different species, but should be combined with more quantitative methods for estimating prey composition or trophic level.

POLLUTANT STUDIES

A number of pollutant analyses can be undertaken on samples obtained non-lethally (i.e. biopsy samples) that can be used to monitor temporal and spatial trends in the levels of certain contaminants that are deposited in skin and blubber, although the range of contaminants is limited. In addition, many persistent environmental contaminants co-occur, so monitoring a subset of elements and POPs (persistent organic pollutants) should be sufficient to detect changes in several pollutants. However, this would not be possible for all contaminants. In particular, studies on the newer groups of emerging compounds and the more complex toxicological, mass balance and health studies could not be undertaken using data from biopsy sampling alone at least at present. Biomarkers (such as metabolising enzymes) are expressed in skin as well as liver so biopsy samples could be used once the relationship between skin expression and liver expression has been established. Validation of the use of biopsy samples was an important component of the IWC's POLLUTION 2000+ programme and was undertaken successfully for some small cetacean species (Reijnders *et al.*, 2007). The limitations of bycaught and especially stranded animals for pollutant studies have been well documented elsewhere (Reijnders *et al.*, 1999).

GENETIC STUDIES

For genetic studies, skin and outer layer blubber samples may be collected by non-lethal remote biopsy sampling methods from free-ranging baleen whales. Biopsy sampling from free-ranging baleen whales is now commonplace and thousands of biopsies have been collected in this manner; this includes (although relatively few) minke whales. Current methods consist of relatively light equipment (e.g. 150lbs draw-weight crossbows) and the collection of samples is typically conducted from light open boats at close range. Heavier, rifle-based, long-range biopsy equipment for high seas conditions have been developed as well (e.g. the 'Larsen gun' used *inter alia* on the IWC SOWER cruises).

Analyses of genomic DNA are readily conducted on skin biopsy samples, which yield more than adequate amounts of genomic DNA. In contrast, gene expression analyses (which are based upon analyses of mRNA levels) may be tissue-specific and thus not possible using skin biopsies.

PRACTICALITIES OF BIOPSY SAMPLING IN THE CONTEXT OF JARPN II[11]

The effort required for collecting skin biopsies in principle should be comparable to (or less than) the effort required for lethal sampling, provided the biopsy equipment has been developed to allow efficient collection on the high seas. However, a significant proportion of the sampling carried out during JARPN II is conducted on the high seas, and thus under conditions that are appreciably more challenging than the majority of current skin biopsy sampling projects, which typically are undertaken in coastal areas. The IWC Antarctic SOWER cruises (large vessels on high seas) have successfully obtained samples from a number of large whales including southern right whales, blue whales, fin whales and humpback whales, and have also undertaken an experiment with Antarctic minke whales. It would be valuable to examine the available biopsy sampling and effort data from the SOWER cruises to examine the efficiency of this further.

[11]As detailed later in this section, biopsy samples can be used to address aspects of a number of the objectives of JARPN II. This discussion of practicality is equally relevant there. Of course, the mass of the sample may become relevant if multiple analyses are required.

The main limitation of biopsy collection on the high seas from large vessels is the limited range and low mass of current projectile units (which carry the biopsy tip). A heavy projectile is less sensitive to high winds and thus development of biopsy equipment for use on the high seas would need to aim at developing heavier projectile units than those currently employed in most biopsy systems. The use of heavier projectile units would necessitate the use of more powerful delivery units in order to obtain the necessary range and trajectory. However, adding mass and power to the projectile unit increases the risk of unwarranted penetration and damage to the target animal; the collar (preventing penetration beyond the depth of the biopsy tip) needs be of an appropriate size. If further lethal sampling is undertaken during JARPN II, this would provide an opportunity to test the potential impact of heavy, high-powered biopsy system upon whole animals.

In summary, provided that the practical difficulties in obtaining biopsy samples on the high seas can be overcome, then analyses of genomic DNA are readily conducted on skin biopsy samples which yield more than adequate amounts of genomic DNA.

GENERAL CO-VARIATES

Many analyses related to all of the objectives of JARPN II benefit from more detailed knowledge of the individuals from which the samples come (e.g. age, reproductive status, sex and health). Some of these can only be obtained from dead animals, but techniques to obtain such information from biopsy samples (and perhaps faecal samples) are increasing (Jarman *et al.*, 2006; Jarman *et al.*, 2003; Rolland *et al.*, 2005). At present, sex is the easiest to obtain from biopsy samples but others, such as age are in development and appear very promising, at least for some species (Herman *et al.*, 2007; Herman *et al.*, 2008).

GENERAL CONCLUSIONS AND RECOMMENDATIONS

The Panel **recommends** that a full evaluation of the applicability of lethal and non-lethal techniques be undertaken as soon as possible after the relevant work recommended elsewhere in this report has been undertaken. Such a full evaluation *inter alia* requires information on the following:

(1) Specified and quantified objectives and sub-objectives (see recommendation under Item 9.2.1);
(2) Analysis of the precision (and any associated biases) of the estimates obtained for the relevant parameters by each of the lethal and non-lethal techniques (see recommendations under Item 4 and at the end of this section);
(3) Evaluation of the practicalities and logisitics of the field (and, if relevant, laboratory) techniques in the context of the *integrated* objectives, sub-objectives and analyses proposed.

The Panel recognises that at present, certain data, primarily stomach content data, are only available via lethal sampling. However, *if* lethal sampling is deemed necessary by Proponents for a research programme, the Panel considers that there is an obligation to maximise the information obtained from those animals and to re-evaluate the need for such sampling at appropriate intervals.

As noted above, the ability to fully evaluate and compare non-lethal methods in a quantitative manner is severely limited by a lack of appropriate data. In addition, examination of the effects of post-mortem time and conditions on various analyses of tissue samples would allow an evaluation of the suitability or otherwise of tissue from stranded or bycaught animals (e.g. see the POLLUTION 2000+ programme). The Panel **recognises** that such an objective (i.e. to quantitatively compare lethal and non-lethal research techniques) is not part of the present JARPN II programme. However, it **considers** that a well-designed and implemented programme to evaluate and compare lethal and non-lethal methods, especially those directly related to the existing JARPN II objectives summarised above, would provide extremely valuable and important scientific information that will greatly assist scientific research worldwide as well as improve the ability of future Panels and Proponents to objectively address this Term of Reference. It will provide a unique opportunity to compare results of stomach analyses with non-lethal estimates that can be obtained from the same time and place. This provides a way of evaluating the reliability and efficiency of the non-lethal methods.

The Panel therefore **strongly recommends** that Japan considers the addition of an objective to quantitatively compare lethal and non-lethal research techniques *if* it decides to continue a lethal sampling programme. Appropriate samples can be archived for future analysis if necessary. Whilst recognising the sensitivities surrounding this issue, the Panel respectfully requests that *if* lethal sampling programmes occur, the IWC or an appropriate scientific body or bodies may wish to consider collaborating in the design of a well specified study to fully evaluate lethal and non-lethal techniques.

9. ADVICE ON ONGOING SPECIAL PERMIT RESEARCH

9.1 Practical and analytical methods, including non-lethal methods, that can improve research relative to stated objectives

The report details a number of practical and analytical recommendations and suggestions that will improve the research, under each of the relevant agenda items.

9.2 Appropriate sample sizes to meet the stated objectives, especially if new methods are suggested under Item 9.1

9.2.1 Proponents' view (from SC/J09/JR1)

Sample sizes of minke, sei and Bryde's whales were set for estimating prey consumption with good precision (coefficient of variation, CV=0.2), in the same way as in the case of the Norwegian research programme (NMMRP, 1992). The sample size of sperm whale was set as a minimum level necessary for obtaining qualitative information for a feasibility study.

The CV of stomach content weight of three baleen whales from the first six years of JARPN II can be summarised as follows (see SC/J09/JR1, Annex 6 for details):

(a) Target CV was satisfactory in most cases for minke whales. This means that the sample sizes of minke whales for both offshore and coastal component seem to be appropriate.
(b) CVs were larger than the target in most cases for sei whales. This means that the sample size was

smaller than the appropriate number, which could reflect diversity of prey species.

(c) CVs were not satisfactory in more than half of the cases for Bryde's whales. This means that the sample size might be slightly smaller than the appropriate number.

9.2.2 Panel conclusions and recommendations

GENERAL COMMENT

The Panel notes that many of the parameter estimates the research is designed to obtain, such as the prey consumption of whales, are subject to various sources of uncertainty not all of which are related to sample size. A pre-specified level of precision will not necessarily be achievable with any sample size. Furthermore, sample size is necessarily constrained by considerations of the effect of catches on the stocks. Sampling design can be as or more important than sample size.

For each objective of the research, it is necessary to specify the quantities of interest that need to be determined to achieve those objectives. For each quantity of interest, all the sources of uncertainty in its estimation should be identified and quantified, and in particular it should be determined which of these are functions of sample size.

This analysis should be conducted for each objective. The results of such an analysis can be used to determine:

(i) how much the research has contributed, in quantitative terms, to achieving the objectives;
(ii) what further quantitative progress towards the objectives can be expected from completing the programme;
(iii) the extent to which increasing/decreasing sample size would enhance/reduce the rate of progress towards achieving the objectives; and
(iv) the extent to which the sample design is the most appropriate for achieving the objective and in particular for maximising the information gained from the chosen sample size.

The analysis is also required for a quantitative comparison of the performance of lethal or non-lethal methods.

Although this issue was briefly addressed by the Proponents in SC/J09/JR1, this was not undertaken sufficiently; a much more thorough approach is warranted and should be carried out as soon as possible. Until this is completed, the Panel is **not able** to provide appropriate scientific advice on the appropriateness of the sample sizes.

The Panel recognises that a full evaluation of sample sizes for an integrated study is a major undertaking and provides the following guidance to the Proponents to assist in this process. In each case, the Panel **recommends** that the development of refined, more quantified sub-objectives for each component of the programme should be undertaken as a priority; this lack of such sub-objectives is a general weakness of the present JARPA II programme and limits the Panel's ability to review it more thoroughly.

FEEDING ECOLOGY

Determining the appropriate sample size is contingent on properly estimating the uncertainty surrounding the key parameters that are ultimately to be used in the modelling process (e.g. see Item 4). Annex F outlines an appropriate approach to do this. Some but not all of the sources of uncertainty are related to sample size.

In addition, the spatial and temporal variation in diets and more generally whale food habits must not be lost, when estimating the impacts of whales on prey stocks. In this regard, the presentations of JARPN II results that take into account coastal and offshore regions is valuable. However, in regions where many whales are foraging on a common prey, there is probably less need for extensive sample sizes than where diets are diverse. To meet its objectives, the programme should try to maximise the information obtained over the entire JARPN area. Thus, considering ways to enhance, improve and ultimately arrive at the optimal sampling design will require considering such covariates as stock, season, sex, size, oceanographic conditions, prey field, and relative location. Additionally, issues of pseudoreplication of whale sampling should be considered in this context (Okamura *et al.*, 2008a).

STOCK STRUCTURE

Determining the appropriate sample size and strategy will depend on the results of the power analyses discussed under Item 6 and summarised in Annex G. This will also inform on the geographical and temporal distribution of samples required. It is already clear (see discussions under Items 6 and 9) that it is important that samples be obtained from the Okhotsk Sea with respect to determining the proportions of 'O' and 'J' stock animals, given the implications for the abundance estimates of the assumptions regarding 'O' stock.

POLLUTANT STUDIES

Given the results obtained thus far, it would be valuable to undertake power analyses to determine the relationship between sample size and the ability to detect changes at various levels should they occur. Further evaluation of covariates such as age and sex is important to determine which animals should be chosen for more extensive sampling. In terms of sampling strategy, the value of examining the same individuals for each of the contaminants is emphasised (see Item 5).

9.3 Effects on stocks in light of new knowledge on status of stocks

In discussing this item, the Panel noted that there is no specific guidance from the IWC Scientific Committee as to the appropriate way in which to provide advice of the effects of scientific permit catches on stocks, particularly for ongoing programmes that do not have an official endpoint. Although it notes the past difficulties in trying to develop an agreed method, the Panel notes that advice on this matter would be valuable for both future expert panel reviews under the Annex P protocol and for the Proponents themselves. As a minimum, the Panel **recommends** that for comparison, results should be provided for model runs in which research catches are equal to zero. This is particularly relevant to cases where there is other anthropogenic mortality (e.g. bycatches), as is the case for western North Pacific minke whales. An expression of objectives under various circumstances would go some way toward addressing this (e.g. with respect to rates of increase of populations believed to be below some given percentage of unexploited population size).

9.3.1 Proponents' analyses

SC/09/JR36 examined the effect on whale stocks of future planned JARPN II catches. The general approach used was application of the HITTER procedure: given a time series of past catches, trajectories were computed to pass through a recent estimate of abundance for values of $MSYR_{1+}$ of 1%, 2%, 3%, 4% and 5%, and then projected for 20 years into the future under the continuation of JARPN II catches at the current sample size. These computations were repeated for the lower 90% confidence limit for the abundance estimate. With one exception (the 'J' stock of minke whales for $MSYR_{1+}$ = 1% for the lower 90% limit on the recent abundance estimate), the trajectories showed an increase over the next 20 years for the catches proposed.

COMMON MINKE WHALES

The calculations presented assumed two-stock scenarios, A and B, involving 'J', 'O' and 'W' stocks, without further structure, motivated primarily on the absence of indications of such further structure in hypothesis tests making use of genetic data. However there remain complications as to how abundance estimates and past catches are best to be split between these two-stocks. Some smaller parts of the Okhotsk Sea were treated as containing only 'J' stock animals, but historic commercial catches were considered to consist of 'O' stock whales only, unless taken in the Sea of Japan or Yellow Sea and so assigned to the 'J' stock. A *g*(0) estimate of 0.732 (Okamura *et al.*, 2008b) was applied throughout.

BRYDE'S WHALES

The HITTER calculations assumed either a single stock in the western North Pacific, or one stock in each of subareas 1 and 2, in accordance with the hypotheses developed by the Scientific Committee for *Implementation Simulation Trials*. In addition to the HITTER runs, runs were performed at the IWC Secretariat of each of the eight base-case *IST* operating models for western North Pacific Bryde's whales. The HITTER runs and the *ISTs* used the catch series and abundance estimates that have been accepted by the IWC Scientific Committee.

SEI WHALES

Based on the results of genetic analyses reported in SC/J09/J32, it was assumed that the western North Pacific (west of 180°) contained a single stock of sei whales. In fact no differences were found throughout the whole North Pacific. The Proponents therefore considered restricting the analyses to the western North Pacific alone to be suitably precautionary. Abundance estimates from dedicated surveys in the JARPN II area were extrapolated to the western North Pacific using JSV (Japanese scouting vessel) data collected during 1972-1988. The extrapolation was conducted separately for the early (May-June) and late (July-August) periods. The extrapolation factor (the ratio of the extrapolated estimate to the JARPN II survey estimate) was 2.83 and 3.04 for the early and late periods respectively, resulting in extrapolated estimates of 21,612 and 16,341.

An extrapolation of the JARPN II estimates to the entire North Pacific using a GAM analyses with various geographic covariates was also conducted. This yielded a similar abundance estimate for the entire North Pacific as that obtained when extrapolating to the entire North Pacific using JSV data (~60,000 animals). These estimates were not used for assessing the effects of catches on the stock. No GAM estimate was computed for the area west of 180°.

SPERM WHALES

The Proponents noted that the take level at 10 animals was less than 0.1% of the abundance estimate and hence it can be assumed that the planned catches will have no negative effect on the stock.

9.3.2 Panel comments and recommendations

GENERAL

Although the appropriate lower bound to use for MSYR in RMP trials is currently under review, the current situation remains that a value of $MSYR_{mat}$=1% is accorded medium plausibility by the Scientific Committee. The Panel thus **recommends** that calculations of the effect of catches should also include results for this value of MSYR. The Panel noted that the choice of $MSYR_{1+}$ or $_{mat}$ is an ongoing matter being discussed within the IWC Scientific Committee.

The Panel further **recommends** that in circumstances where *Implementation Simulation Trials* (*ISTs*) have recently been developed for a species in a region, these provide the best basis for evaluating the effect of catches on stocks, as: (1) they constituted the Scientific Committee's best appraisal of the range of plausible dynamics for the stocks; and (2) they were based on all appropriate population abundance and related data. Calculations of the effect of scientific catches need not be carried out for every *IST* for a particular stock (or group of stocks), but should at least include the baseline trials covering the major stock structure hypotheses, together with any robustness trials reflecting stock status appreciably worse than for any of these baseline trials. This approach was followed for Bryde's whales in SC/J09/JR36. Note that this is not the same as using the RMP to provide catch advice.

COMMON MINKE WHALES

Ideally the *IST* approach should also be followed for common minke whales, for which *ISTs* have been developed (IWC, 2004b), but there is the difficulty that those trials are now somewhat dated. Considerable further data that could be used in conditioning and in reconsidering the plausibility of the existing alternative stock structure hypotheses has become available since those *ISTs* were developed by the Scientific Committee.

SC/J09/JR36 considers only two of the four primary stock structure hypotheses of the *ISTs* for minke whales, arguing that the new genetic evidence excludes the other two. As discussed under Item 6.2, the Panel considered that further analyses needed to be tabled before such a definitive conclusion might be drawn. Until that work has been presented, the Panel **recommends** that the effect of catches is examined for all four hypotheses.

The Panel noted that of the abundance estimate of 37,170 animals for the 'O' stock used in the computations of SC/J09/JR36, most (88%) come from Russian waters of the Okhotsk Sea based on a survey conducted in 2003, for which there are no genetic samples (by comparison the abundance estimate for the JARPN II area is less than 3,000). The assessments of the effect of JARPN II catches on the 'O' stock are thus highly dependent on the assumption that the whales in the Okhotsk Sea (apart from the SW part, which was assigned in SC/J09/JR36 to the 'J' stock) belong to the 'O' stock. In quantitative terms, the single factor that could make the greatest contribution to enhancing confidence in the assessment of the effect of JARPN II catches on the 'O' stock would be new data to support this assumption. The Panel thus **recommends** that a new full survey of the Okhotsk Sea is undertaken with a concerted effort being made to obtain biopsy samples of common minke whales for genetic comparison with the JARPN II samples (recognising the difficulties in obtaining biopsy samples). Should unexpected genetic differences be found[12], a re-examination of the *IST* stock structure hypotheses would become necessary.

Given the above, the Panel considered that the approach adopted for minke whales in SC/J09/JR36 required further sensitivity tests, including alternative plausible assignments of incidental catches and of the abundance estimate for the Okhotsk Sea between the 'O' and 'J' stocks. Further computations were kindly carried out for the Panel by the Proponents to address these two specific issues (the results are appended to SC/J09/JR36). The two alternative approaches to dividing the Okhotsk Sea abundance estimates were (1) to assume 50% of the whales in sub-area 11 and 25% of those in sub-area 12 belonged to the 'J' stock, and (2) to assume 5% and 0% respectively for these allocations. The Panel **agrees** that the results of the HITTER runs under these assumptions showed no instances of conservation concern for the 'O' stock. However, the Panel **notes with concern** that for the 'J' stock for the latter of these options and use of the lower 90% confidence limit for abundance, there was a decline in abundance for $MSYR_{1+}$ = 2% which became severe for $MSYR_{1+}$ = 1%. It notes that the primary source of the anthropogenic removals for 'J' stock is bycatches, not scientific permit catches. This reiterates the general comment made earlier of the value in producing the results of runs for scientific permit catches =0 for comparative purposes.

The Panel **concludes** that the information available did **not** constitute a sufficient basis to provide advice of the effect of planned JARPN II catches on common minke whale stocks. It also noted that the approach used in SC/J09/JR36 required *ad hoc* assumptions concerning disaggregation of 'J' and 'O' stock animals, and the results were in one sense overly conservative because restriction to a single set of abundance estimates led to confidence intervals that were wider than if all available abundance estimates had been taken into account. Use of the *ISTs* for projections is the preferred approach, but as elaborated above the existing *ISTs* are now dated.

Given this, the Panel thus **recommends** that the hypotheses underlying these *ISTs* and their conditioning should be reviewed and updated by the Scientific Committee **as a matter of urgency**, given the extensive new information made available from the JARPN II programme. Such updated *ISTs* should form the basis for projections of stock abundance under JARPN II catches which could reliably inform appraisals of the effect of the JARPN II catches on stocks. Such projections should be carried out both including and excluding JARPN II catches so that the contributions of the JARPN II and incidental catches to any negative trends in abundance can be distinguished.

[12]Historical biological data had been used to decide that there were no additional stocks to the 'O' and 'J' stocks during the *IST* development e.g. sex ratio data (Wada, 1989) and migration patterns (Hatanaka and Miyashita, 1997). In addition, the Panel was informed that genetic analysis showed no genetic difference in the microsatellite allele frequencies between the 'O' stock individuals from the SA11 and SA7-9 (N. Kanda, ICR, personal communication). Hence the use of the term 'unexpected'.

BRYDE'S WHALES

Apart from the generic issues of the use of $MSYR_{1+}$ vs $MSYR_{mat}$, the Panel found no problems with the assessment of the effects of JARPN II catches on the Bryde's whale stock(s) provided in SC/J09/JR36.

The Panel noted that a recent attempt (Kitakado, 2009) to extract trend information from the Bryde's whale data (which in principle might help to narrow down the range for MSYR) yielded a trend estimate with very wide confidence intervals (-3% to +11% p.a.).

SEI WHALES

The Panel noted that an important part of the evaluation involves the historic catch series. Given the well known problems with respect to the identification of sei and Bryde's whales in the earlier catch period, it believes it would have been appropriate to take advantage of the work undertaken during the Bryde's whale *Implementation* on catch series. The Panel **recommends** that the Secretariat be requested to produce the corresponding catch series for sei whales based on the work conducted for the Bryde's whale series, and that this be used in the assessments of the sei whale stock.

While welcoming the presented analyses of the genetic data that suggested little stock structure in North Pacific sei whales, as discussed under Item 6.2, the Panel believes further analyses are required before firm conclusions can be reached with respect to stock structure.

However, the Panel's greatest **concern** over the analysis in SC/J09/JR36 is related to the extrapolation of the abundance estimate outside the survey area (this represented an increase in abundance by a factor of about three with a low CV to the 180° boundary). The Panel noted that the CV of the extrapolation factor was based on jacknife sampling of the JSV data using year as the sampling unit. This approach can underestimate the uncertainty in the extrapolation in at least three respects:

(1) it does not take into account the inter-annual process variance in the abundance ratio between the two areas, which may be important because the JARPN II time series is still quite short;
(2) it assumes no serial correlation in sei whale distribution from year to year (a phenomenon that the Panel considered *a priori* to be likely); and
(3) it ignores the possibility that there may have been a substantive regime shift between the 1970s-1980s (when the JSV data were collected) and the current decade when the JARPN II surveys were conducted, which could render the relative abundances as found by the JSV inapplicable to the present.

In addition, apart from the possibility of ecological changes, the distribution of sei whales in the 1970s and 1980s may have been distorted by the then recent heavy catching.

Inspection of the GAM plots in SC/J09/JR36 suggested that a three-fold increase in abundance when moving from the JARPN II area (north of 35°N and W of 170°E) to the full western north Pacific (north of 30°N and W of 180°) is greater than one would expect (indeed it would have been instructive to compute an abundance figure for the western North Pacific using the GAM approach for comparison).

In the absence of recent survey data for the whole area, the Panel **recommends** that the assessment of the effect on stocks be repeated without the extrapolation, based on the JARPN II boundary at 170°E, using an assumed range for MSYR(mature) of 1-4%, recognising that this might be considered conservative. The catch series could be recomputed for this boundary, although this is not considered essential. The Panel is thus **unable** to provide a complete scientific review of the effects of catches upon western North Pacific sei whales until this additional work is undertaken.

The Panel **suggests** that the sei whale sightings data be examined for evidence of trend, as has been done for Bryde's whales (see above), while recognising that resulting confidence intervals might be too wide to draw much inference.

SPERM WHALES

The Panel concurs that the effect on the stock of the small JARPN II takes is negligible. However, given the comments made elsewhere in the report, the scientific value of these small and unrepresentative takes of sperm whales is severely questioned.

9.4 Time of further review

Given the comments and additional analyses that the Panel has recommended with respect to calculations of sample size (Item 9.2) and the effect of catches on some of the stocks (Item 9.3), the Panel **notes** that the present review cannot be fully completed at this time. The IWC should consider the most appropriate way to ensure that this review is completed.

With respect to a further review, the Panel believes that the timing should be related to the establishment of interim objectives for the programme; following Scientific Committee discussions of the review process, this further review would probably occur within about six years.

10. SUMMARY AND CONCLUSIONS

The Panel **stresses** that its primary task at this meeting was to provide an objective scientific review of results of the JARPN II programme thus far and plans for future work, in the light of the stated objectives, including consideration of lethal and non-lethal methods; its task was not to provide either general condemnation or approval of lethal sampling research under scientific permit in general - consideration of this would require discussion of some issues well beyond the purview of a scientific panel.

The Panel **emphasises** that this summary and conclusions section should not be seen as a replacement for the more comprehensive discussions in the body of the report.

The Panel **thanks** the Proponents of JARPN II for the extensive documentation of both published and unpublished work that was presented to it well in advance of the meeting, as well as the thorough presentations given during the Workshop summarising the work undertaken. It also appreciated the courtesy and openness with which questions and queries were answered.

The Panel recognises that an enormous amount of scientific work has been undertaken in the field, laboratory and in analysis during the first six years of the programme. It also notes that this is the first part of an ongoing research programme and that assessing progress against what are, in some cases at least, rather general long-term objectives is challenging. The Panel therefore **recommends** that for any long-term programme such as this, in addition to long-term objectives, proponents should determine specific, shorter-term objectives that are quantified to the extent possible. Lack of such objectives hinders any thorough review and is a weakness of the programme. This is also relevant to sample size considerations as indicated below.

10.1 Review of work undertaken to date

The first stage of the review process was to examine results of the first six years of the JARPN II programme.

The first broad objective concerns feeding ecology and ecosystem modelling, with the ultimate goal of being able to provide multispecies management advice. The Panel **recognises** that this is an extremely ambitious task from a data collection and an analysis/modelling perspective. As has been stated within and outside the IWC, obtaining results sufficiently reliable to inform management advice should not be expected within at least the next few years and could require considerably more time. The review is thus one of ongoing work and, while progress has been made by the Proponents, considerably more work is required, particularly with respect to estimates of parameters for non-cetacean components of the ecosystem and analytical and modelling techniques.

With respect to prey consumption and prey preferences of baleen whales, the Panel **recognises** the high quality of the field and laboratory work undertaken. The data collected have the potential to be of great value in informing ecosystem modelling in both a generic and quantitative manner. However, when reviewing the analyses presented, the Panel was concerned that insufficient work has been undertaken to address the full level of uncertainty (this is true for a number of the objectives, not merely those relevant to feeding ecology); recommendations to remedy that are included in the report (e.g. see Item 4.3.2). In conclusion, therefore, although progress has been made, the Panel does **not** believe that the estimates of cetacean consumption rates presented to the Workshop can be considered reliable until further analyses have been undertaken.

With respect to the ecosystem modelling work, varying degrees of progress have been made using three modelling approaches. The Panel **welcomes** this work and notes that, as the authors stated, in all cases the modelling was in the exploratory stage. The Panel **emphasises** that this is generally true of all ecosystem modelling work currently underway throughout the world, and agrees that the models as developed thus far are **not** yet at the stage where they could be used to draw even general conclusions; they certainly cannot be used to reliably inform management advice. Nevertheless, they comprised a substantial and laudable effort, and an encouraging start to the necessary process of synthesising the data collected during the programme. However, the Panel **agrees** that if there is to be a reasonable chance of meeting the programmes objectives in a reasonable time-frame, it is essential that considerably more emphasis be placed on the modelling work from now on, and it made a number of recommendations in that regard (see Item 4.4.2).

The second broad objective relates to monitoring of environmental pollutants in cetaceans and the marine ecosystem. The Panel **concludes** that the JARPN II pollutant studies represent a valuable contribution to knowledge in this area and acknowledges the considerable amount of work presented. The ongoing programme has been addressing its objectives, and further work has been recommended (see Item 5.3). In general, where possible, papers should include a risk assessment statement summarising the potential risk to cetaceans based on current toxicology data in 'model' species and other wildlife in terms of the health of the animals and dynamics of the stocks.

The third broad objective relates to stock structure issues. The Panel **acknowledges** the large amount of new genetic data collected and the substantial number of analyses undertaken under JARPN II, which provide a uniquely large data set for testing hypotheses regarding stock structure in the target species. Analyses conducted with the genetic data under JARPN II were in general sound and of a nature common to other genetic analyses within and outside the IWC Scientific Committee framework. The inclusion of morphological and morphometric studies as well as genetic information helps to provide a more well-rounded picture of stock structure. Although genetic data can provide valuable insights regarding stock structure, they have some limitations for weakly differentiated populations, as is the case for many of the species targeted by JARPN II. Particularly in the context of weakly-differentiated populations, the Panel **acknowledges** the general difficulties in examining questions of stock structure.

Recognising these general difficulties, the Panel identified a number of limitations to the analyses presented and made some detailed suggestions for addressing these (see Item 6.2). In light of this, the Panel **agrees** that it is not possible at this time to conclude, as did the Proponents, that the number of hypotheses proposed during the *Implementations* for western North Pacific common minke whales and Bryde's whales has been reduced. However, the Panel noted that such conclusions might be possible after considering the outcome of the additional analyses recommended; but that remains to be seen. The Panel **agrees** that the genetic and other analyses do (and will in the future) assist in the formulation/narrowing of hypotheses for use in RMP *Implementation Simulation Trials*.

The Panel **welcomes** the information on the simultaneous collection of *in situ* sea surface and water column characteristics obtained while conducting the whale and prey surveys. It **recognises** the practical challenges of coordinating these sampling methods on the same ship at the same time. The Panel made a number of recommendations for future work including, in the longer term, that the oceanographic data collected on the cruises (bottom depth, water column temperature, salinity, and density) and satellite derived data (such as SST, chlorophyll, and sea surface height) be integrated into future analyses.

The Panel also **welcomes** the collection of sightings data for non-target species and the analyses of their distribution, along with photo-identification studies. To investigate relationships with oceanographic factors and improve abundance estimates for a variety of species, the Proponents should consider conducting future surveys that cover an area larger than the present JARPN II research area. The Panel also made recommendations with respect to trend analyses and the photo-identification data.

A number of other published research papers were presented that were in addition to the primary work of JARPN II on reproductive biology, physiology, and cetacean phylogeny.

10.2 Relationship of the programme to the IWC and Commission resolutions

After concluding its review of the ongoing work, the Panel then considered the relationship between the JARPN II research and the IWC. With respect to ecosystem and environmental change research, the Panel **agrees** that many of the objectives of JARPN II are relevant to Resolutions of the Commission and that, as requested in several resolutions, scientific results have been submitted to the Scientific Committee on a number of relevant issues including those of feeding ecology, pollutant studies, abundance and stock structure.

As is well known, the issue of lethal versus non-lethal research is one that remains controversial within and outside the IWC. A major contributory factor to this is that the issue is not only a scientific question. However, the Panel's expertise is of a scientific nature and its comments are confined to scientific matters. A full comparison of various lethal and non-lethal techniques requires an analysis of the information content of the estimates obtained using different approaches, in the context of stated quantitative objectives or sub-objectives; often the data to allow such a comparison are not available (see recommendations under Item 8.2.2) and/or objectives are insufficiently stated/quantified (see Item 9.2.1). In addition, for a complex multi-disciplinary research programme such as JARPN II, an evaluation of appropriate techniques (lethal or non-lethal) must include an integrative analysis to ensure maximised efficiency from both a scientific and logistical perspective. The Panel was not in a position to evaluate this in detail in the absence of knowledge of the logistical resources required and the outcome of analyses detailed under Item 9.2 to assist with an evaluation of sampling strategies and sizes.

Given these important difficulties and information gaps (not all of which are specific to this particular programme only), the Panel was not in a position to complete this item on its Agenda. It nevertheless made a number of recommendations in this regard. The Panel **recommends** that a full evaluation of the relative merits of lethal and non-lethal techniques be undertaken as soon as possible after the relevant work recommended elsewhere in this report has been completed. Such a full evaluation *inter alia* requires information on the following.

(1) Specified and quantified objectives and sub-objectives (see recommendation under Item 9.2.1).
(2) Analysis of the precision of the estimates obtained for the relevant parameters by each of the lethal and non-lethal techniques (see recommendations under Item 4 and at the end of this section).
(3) Evaluation of practicalities of field (and, if relevant, laboratory) techniques in the context of the integrated objectives, sub-objectives and analyses proposed.

The ability to fully evaluate and compare non-lethal methods in a quantitative manner is severely limited by a lack of appropriate data. The Panel therefore **strongly recommends** that Japan considers the addition of an objective to quantitatively compare lethal and non-lethal research techniques *if* it decides to continue a lethal sampling programme. Whilst recognising the sensitivities surrounding this issue, the Panel respectfully requests that *if* lethal sampling programmes occur, the IWC Scientific Committee, together with other appropriate scientific bodies, might wish to consider collaborating in the design of a well specified study to fully evaluate lethal and non-lethal techniques.

10.3 Sample size

An evaluation of sample sizes depends on each of the objectives being better specified, with an identification of those quantities that need to be estimated to achieve the objectives. For each such quantity, the sources of uncertainty to which the estimate is subject should be identified, including both those which are sample-related and those which are not sample-related. The precision of the estimate and its relation to sample size and sampling design should be determined. Such an analysis is a pre-requisite for an evaluation of the appropriateness of the sample size and sampling design.

Although this issue was briefly addressed by the Proponents in SC/J09/JR1, this was not undertaken sufficiently; a much more thorough approach is warranted and should be carried out as soon as possible. Until this is completed, the Panel is **not able** to provide scientific advice on the appropriateness of the sample sizes.

The Panel recognises that a thorough review is a major undertaking and it provided guidance to the Proponents to assist in this process. The Panel **recommends** that the development of refined, more quantified sub-objectives should be undertaken as a priority; the lack of such objectives is a weakness of the present JARPA II programme and limits our ability to review its future plans adequately.

10.4 Effects on the status of the stocks

In discussing this item, the Panel noted that there is no specific guidance from the IWC Scientific Committee as to the appropriate way to provide advice on effects of scientific permit catches on stocks. Advice from the Scientific Committee on this matter would be valuable for both future expert panel reviews under the new Protocol for reviewing special permits (IWC, 2009b) and for the Proponents themselves. As a minimum, the Panel **recommends** that for comparison, results should also be provided for projections for which research catches are equal to zero as well as for catches equal to the proposed catches. This is particularly relevant to cases where other anthropogenic mortality occurs (e.g. bycatches), as is the case for western North Pacific minke whales. An expression of performance against possible conservation objectives by Proponents and/or the IWC under various situations would go some way to addressing this (e.g. with respect to rates of increase of populations believed to be below some given percentage of unexploited population size).

Although the appropriate lower bound to use for MSYR in RMP trials is currently under review, the current situation is that a value of $MSYR_{mat}$=1% is accorded medium plausibility by the Scientific Committee. The Panel thus **recommends** that calculations of the effect of catches should also include results for this value of MSYR. The Panel noted that the choice of $MSYR_{1+}$ or $_{mat}$ is an ongoing matter being discussed within the IWC Scientific Committee.

The Panel further **recommends** that in circumstances where *Implementation Simulation Trials* (*ISTs*) have recently been developed for a species in a region, these provide the best basis for evaluating the effect of catches on stocks; they constitute the Scientific Committee's best appraisal of the range of plausible dynamics for the stocks, having been based on all appropriate population abundance and related data. Note that this is **not** the same as using the RMP to provide catch advice.

10.4.1 Common minke whales

The Panel **concludes** that the information available did **not** constitute a sufficient basis to provide advice on the effect of planned JARPN II catches on common minke whale stocks. Use of the *ISTs* for projections is the preferred approach, but as elaborated above, the existing *ISTs* are now dated.

Given this, the Panel thus **recommends** that the hypotheses underlying these *ISTs* and their conditioning should be reviewed and updated by the Scientific Committee **as a matter of urgency**, given the extensive new information made available from the JARPN II programme. Such updated *ISTs* should form the basis for projections of stock abundance under JARPN II catches, which might reliably inform appraisals of the effect of the JARPN II catches on stocks. Such projections should be carried out both including and excluding JARPN II catches so that the contributions of the JARPN II and incidental catches to any negative trends in abundance can be distinguished.

In addition, although not strictly part of a review of JARPN II, the Panel **emphasises its concern** that the results of some of the HITTER runs involving the depleted 'J' stock presented by the Proponents revealed a decline in abundance for $MSYR_{1+}$=2% which became severe for $MSYR_{1+}$=1%. It notes that the primary source of the anthropogenic removals for 'J' stock is bycatches, not scientific permit catches. This provides further support for the need to complete the in-depth assessment of 'J' stock as soon as possible, along with a full *Implementation Review* for western North Pacific minke whales.

10.4.2 Bryde's whales

The Panel **accepts** the assessment of the effects of JARPN II catches on Bryde's whales provided by the Proponents and agreed that this level of take does not pose a problem to the stocks.

10.4.3 Sei whales

The Panel had a number of **concerns** over the analysis on the effect on sei whale stocks provided by the Proponents - particularly extrapolation of the abundance estimate outside the survey area (this represented an increase in abundance by a factor of about three with a low CV) to the 180° boundary. In the absence of recent survey data for the whole area, the Panel **recommends** that the assessment of the effect on stocks be repeated without the extrapolation, based on the JARPN II boundary at 170°E, and using an assumed range for MSYR(mature) of 1-4%, while recognising that this might be considered conservative. The catch series (adjusted in light of the Bryde's whale *Implementation* approach to the historical problems regarding the species identification of sei and Bryde's whales) should be recomputed for this boundary, although this is not considered essential. The Panel is **unable** to provide a complete scientific review of the effects of catches upon western North Pacific sei whales until this additional work is undertaken.

10.4.4 Sperm whales

The Panel **concurs** that the effect on the stock of the small JARPN II takes is negligible. However, given the comments made elsewhere in the report, the scientific value of these small and unrepresentative takes of sperm whales is **severely questioned**.

10.5 Further review

Given the comments and additional analyses that the Panel has recommended with respect to calculations of sample size and the effect of catches on some of the stocks, the Panel **agrees** that the present review cannot be fully completed at this time. The Scientific Committee should consider the most appropriate way to ensure that this review is completed.

Until this review has been completed, it would be premature to advise when a further review should be conducted.

11. ADOPTION OF REPORT

The report was adopted by e-mail.

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Annex A

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Annex B

Agenda

1. Introductory items
    - 1.1 Welcome and opening remarks
    - 1.2 Election of Chair
    - 1.3 Appointment of rapporteurs
    - 1.4 Meeting procedure and time schedule
2. Adoption of the agenda
3. Review of available data, documents and reports
    - 3.1 Workshop documents
    - 3.2 For information papers
    - 3.3 Other available documents and data
4. Review of JARPN II results: Feeding ecology and ecosystem studies
    - 4.1 Formal statement of objectives as given by the Government of Japan (based upon SC/J09/JR1)
    - 4.2 JARPN II Coastal component
        - 4.2.1 Proponents' summary
        - 4.2.2 Expert Panel review of results presented
    - 4.3 JARPN II Offshore component
        - 4.3.1 Proponents' summary
        - 4.3.2 Panel conclusions and recommendations
    - 4.4 Ecosystem modelling
        - 4.4.1 Proponents' summary
        - 4.4.2 Panel conclusions and recommendations
5. Review of JARPN II results: Monitoring Environmental Pollutants in Cetaceans and the Marine Ecosystem
    - 5.1 Statement of objectives as given by the Government of Japan
    - 5.2 Proponents' summary
    - 5.3 Panel's conclusions and recommendations
6. Review of JARPN II results: Stock structure
    - 6.1 Statement of objectives as given by the Government of Japan
    - 6.2 Proponents' summary
    - 6.3 Panel's conclusions and recommendations
        - 6.3.1 Simple issues
        - 6.3.2 More extensive matters – some of which might ideally be addressed in time for the 2009 Annual Meeting
        - 6.3.3 Longer term
7. Review of JARPN II results: Review of other contributions to important research needs
    - 7.1 Oceanography
        - 7.1.1 Statement of objectives and Proponents' summary
        - 7.1.2 Panel's conclusions and recommendations
    - 7.2 Distribution of large whales
        - 7.2.1 Statement of objectives and Proponents' summary
        - 7.2.2 Panel conclusions and recommendations
    - 7.3 Other research
        - 7.3.1 Proponents' summary
        - 7.3.2 Panel conclusions and recommendations
    - 7.4 Abundance
        - 7.4 1 Summary of results to date
        - 7.4.2 Analysis and comment
        - 7.4.3 Recommendations
8. Review of JARPN II results: the relationship of the research to relevant IWC resolutions and discussions
    - 8.1 Research on the ecosystem and environmental change
        - 8.1.1 Summary of Proponents' view (from SC/J09/JR1)
        - 8.1.2 Panel conclusions and recommendations
    - 8.2 Utility of the lethal techniques used by JARPN II compared to non-lethal techniques
        - 8.2.1 Summary of Proponents' view (from SC/J09/JR1)
        - 8.2.2 Panel conclusions and recommendations
9. Advice on ongoing special permit research
    - 9.1 Practical and analytical methods, including non-lethal methods, that can improve research relative to stated objectives
    - 9.2 Appropriate sample sizes to meet the stated objectives, especially if new methods are suggested under Item 9.1
        - 9.2.1 Proponents' view (from SC/J09/JR1)
        - 9.2.2 Panel conclusions and recommendations
    - 9.3 Effects on stocks in light of new knowledge on status of stocks
        - 9.3.1 Proponents' analyses
        - 9.3.2 Panel comments and recommendations
    - 9.4 Time of further review
10. Summary and conclusions
    - 10.1 Review of work undertaken to date
    - 10.2 Relationship of the programme to the IWC and Commission resolutions
    - 10.3 Sample size
    - 10.4 Effects on the status of the stocks
        - 10.4.1 Common minke whales
        - 10.4.2 Bryde's whales
        - 10.4.3 Sei whales
        - 10.4.4 Sperm whales
    - 10.5 Further review
11. Adoption of report

Annex C

List of Documents

SC/J09/JR

1. Pastene, L.A., Hatanaka, H., Fujise, Y., Kanda, N., Murase, H., Tamura, T., Miyashita, T. and Kato, H. The Japanese Whale Research Program under Special Permit in the western North Pacific Phase-II (JARPN II): origin, objectives and research progress made in the period 2002-2007, including scientific considerations for the next research period. 73pp.
2. Kiwada, H., Kumagai, S. and Matsuoka, K. Methodology and procedure of the dedicated sighting surveys in JARPN II – Offshore and coastal component of Sanriku and Kushiro. 16pp.
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4. Tamura, T., Matsuoka, K. and Fujise, Y. Methodology and survey procedure under the JARPN II - offshore component- with special emphasis on whale sampling procedures. 16pp.
5. Yonezaki, S., Nagashima, H., Murase, H., Yoshida, H., Bando, T., Goto, M., Kawahara, S. and Kato, H. Methodology and procedures of surveys of prey of common minke whales JARPN II - Coastal component of Sanriku. 6pp.
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7. Murase, H., Watanabe, H., Yonezaki, S., Tamura, T., Matsuoka, K., Fujise, Y. and Kawahara, S. Methodology and procedures of cetacean prey surveys in JARPN II – Offshore Component. 11pp.
8. Hakamada, T., Matsuoka, K. and Miyashita, T. The number of western North Pacific common minke whales (*Balaenoptera acutorostrata*) distributed in JARPN II coastal survey areas. 12pp.
9. Tamura, T., Konishi, K., Goto, M., Bando, T., Kishiro, T., Yoshida, H., Okamoto, R. and Kato, H. Prey consumption and feeding habits of common minke whales in coastal areas off Sanriku and Kushiro. 18pp.
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12. Yoshida, H., Kishiro, T., Goto, M., Bando, T., Tamura, T., Konishi, K., Okamoto, R. and Kato, H. Relationship between body size, maturity, and feeding habit of common minke whales off Sanriku in spring season, from 2003-2007 whale sampling surveys under the JARPN II coastal component off Sanriku. 20pp.
13. Kishiro, T., Yoshida, H., Tamura, T., Konishi, K., Kanda, N., Okamoto, R. and Kato, H. Relationship between body size, maturity, and feeding habit of common minke whales off Kushiro in autumn season, from 2002-2007 whale sampling surveys under the JARPN II coastal components off Kushiro. 25pp.
14. Okamura, H., Nagashima, H. and Yonezaki, S. Preliminary assessment of impacts on the sandlance population by consumption of minke whales off Sanriku region. 20pp.
15. Hakamada, T., Matsuoka, K. and Miyashita, T. Distribution and the number of western North Pacific common minke, Bryde's, sei and sperm whales distributed in JARPN II Offshore component survey area. 18pp.
16. Tamura, T., Konishi, K., Isoda, T., Okamoto, R. and Bando, T. Prey consumption and feeding habits of common minke, sei and Bryde's whales in the western North Pacific. 36pp.
17. Tamura, T., Kubotera, T., Ohizumi, H., Konishi, K. and Isoda, T. Feeding habits of sperm whales and their impact on neon flying squid resources in the western North Pacific. 22pp.
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19. Konishi, K., Kiwada, H., Matsuoka, K., Hakamada, T. and Tamura, T. Density prediction modeling and mapping of common minke, sei and Bryde's whales distribution in the western North Pacific using JARPN II (2000-2007) data set. 20pp.
20. Konishi, K., Tamura, T., Goto, M., Bando, T., Kishiro, T., Yoshida, H. and Kato, H. Trend of blubber thickness in common minke, sei and Bryde's whales in the western North Pacific during JARPN and JARPN II periods. 4pp.
21. Mori, M., Watanabe, H., Hakamada, T., Tamura, T., Konishi, K., Murase, H. and Matsuoka, K. Development of an ecosystem model of the western North Pacific. 49pp.
22. Kawahara, S. A minimum realistic model in the JARPN II offshore survey area. 22pp.
23. Yasunaga, G. and Fujise, Y. Temporal trends and factors affecting mercury levels in common minke, Bryde's and sei whales and their prey species in the western North Pacific. 13pp.

24. Yasunaga, G. and Fujise, Y. Temporal trends and factors affecting PCB levels in baleen whales and environmental samples from the western North Pacific. 10pp.
25. Yasunaga, G. and Fujise, Y. Accumulation features of total and methyl mercury and selenium in tissues of common minke, Bryde's and sperm whales from the western North Pacific. 11pp.
26. Kanda, N., Goto, M., Kishiro, T., Yoshida, H., Kato, H. and Pastene, L.A. Individual identification and mixing of the J and O stocks around Japanese waters examined by microsatellite analysis. 9pp.
27. Hakamada, T. and Bando, T. Morphometric analysis on stock structure in the western North Pacific common minke whale (*Balaenoptera acutorostrata*). 13pp.
28. Goto, M., Kanda, N., Pastene, L.A., Bando, T. and Hatanaka, H. Differences in cookie cutter shark-induced body scar marks between J and O-stocks of common minke whales in the western North Pacific. 7pp.
29. Goto, M., Kanda, N., Kishiro, T., Yoshida, H., Kato, H. and Pastene, L.A. Mitochondrial DNA analysis on stock structure in the western North Pacific common minke whales. 10pp.
30. Kanda, N., Goto, M., Kishiro, T., Yoshida, H., Kato, H. and Pastene, L.A. Microsatellite analysis of minke whales in the western North Pacific. 14pp.
31. Kanda, N., Goto, M. and Pastene, L.A. Stock structure of Bryde's whales in the western North Pacific as revealed by microsatellite and mitochondrial DNA analyses. 8pp.
32. Kanda, N., Goto, M., Yoshida, H. And Pastene, L.A. Stock structure of sei whales in the North Pacific as revealed by microsatellite and mitochondrial DNA analysis. 14pp.
33. Kanda, N., Goto, M. and Pastene, L.A. Genetic characteristics of sperm whales sampled during JARPN II from 2000 to 2007 as revealed by mitochondrial DNA and microsatellite analyses. 5pp.
34. Okazaki, M., Inagake, D., Masujima, M., Murase, H., Watanabe, H., Yonezaki, S., Nagashima H., Matsuoka, K., Kiwada, H. and Kawahara, S. Oceanographic conditions of the western North Pacific based on oceanographic data collected during the JARPN II. 13pp.
35. Matsuoka, K., Kiwada, H., Fujise, Y. and Miyashita, T. Distribution of blue (Balaenoptera musculus), fin (*B. physalus*), humpback (*Megaptera novaeangliae*) and North Pacific right (*Eubalaena japonica*) whales in the western North Pacific based on JARPN and JARPN II sighting surveys (1994 to 2007). 12pp.
36. Hakamada, T. Examination of the effects on whale stocks of future JARPN II catches. 51pp.

Annex D

Extract from Guidelines for Review of Scientific Permits*

2. THE REVIEW PROCESS

Intersessional specialist workshop

The initial review of a new proposal, or interim and final reviews, shall take place at a small specialist workshop with a limited but adequate number of invited experts (who may or may not be present members of the Scientific Committee). A limited number of scientists associated with the proposal should attend the workshop in an advisory role, primarily to present the proposal and answer points of clarification. It is important that the composition of the specialist group is considered balanced and fair. The choice of experts shall be made by the Chair, Vice-Chair and Head of Science in conjunction with a Standing Steering Group (SSG) established by the Chair at an Annual Meeting, with special emphasis on the field and analytical methods provided in the proposal and estimation of the effect of catches on the stocks(s). The SSG shall be selected by the Chair, Vice-Chair and Head of Science, such that it represents an appropriate range of experience and expertise within the Scientific Committee. The selection process for the specialist group shall occur in the manner described below.

Procedure for periodic and final reviews

For ongoing research without a defined final year, a periodic review shall take place in accordance with either the advice provided under Item (5) of the workshop (see below) to review new proposals or on the advice of a periodical review workshop and taking into account the availability of the proponents. The final review shall take place no later than three years after the final take under Special Permits. The periodic and final reviews shall be based on documents provided by the proposers and other members of the Scientific Committee **six months** before the Annual Meeting at which the Workshop report is to be presented. Information on the analytical methods likely to be used in documents presented to the Workshop that might assist with the selection of appropriate experts shall be circulated **nine months** before the Annual Meeting.

*Excerpts from IWC (2009).

The Chair shall circulate the information on the analytical methods to the Vice-Chair, Head of Science and SSG, normally within **1 week** of receipt.

(1) The SSG shall examine the information available on the field and analytical methods and, normally within **2 weeks**, suggest names for consideration for the Specialist Workshop (if these experts are not members of the Committee they shall include a rationale for their choice) and the suggestions will be available to all SSG members.
(2) The Chair, Vice-Chair and Head of Science will develop a proposed final list (with reserves) for consideration by the SSG within **2 weeks** and begin the process of establishing the time and venue of the Workshop taking into account the availability of the proposed experts and experts associated with the proposal.
(3) The SSG will send final comments within **1 week**.
(4) The Chair, Vice-Chair and Head of Science will agree a final list (with reserves); the proposal (with a note concerning any restrictions) will be sent to the selected experts and reserves - the process thus far will have taken about 6 weeks since the information on analytical methods has been received.
(5) The full documents shall be circulated no later than **6 months** before the Annual Meeting.
(6) Responses to those documents shall be submitted no later than **1 month** before the Workshop.

The Workshop will take place at least **100 days** before the Annual Meeting. In addition to the selected experts it will include at least one of the Chair, Vice-Chair and Head of Science, one of whom shall chair the workshop.

Availability of data relevant to the periodic or final review

Applications for the access to data for the purpose of periodic or final review, should follow the recommended approach of Procedure B of the IWC Scientific Committee Data Availability Agreement (IWC, 2004). For data provided under the DAA, the conditions for data recipients are outlined in the agreement. Applications made by members of the Scientific Committee and other participants at the Specialist Workshop should be considered promptly and normally accepted within two weeks of the application.

Terms of reference of the Specialist Workshop for periodic and final reviews

The primary objective of the specialist workshop will be to review the scientific aspects of the research under Special Permits in the light of the stated objectives following the guidelines in the *pro forma* provided by the Secretariat. In particular, the Specialist Workshop shall evaluate:

(1) how well the initial, or revised, objectives of the research have been met;
(2) other contributions to important research needs;
(3) the relationship of the research to relevant IWC resolutions and discussions, including those dealing with the respective marine ecosystem, environmental changes and their impact on cetaceans and Committee reviews of special permit research;
(4) the utility of the lethal techniques used by the Special Permit Programme compared to non-lethal techniques; and
(5) in case of periodic review, provide advice on:

    (i) practical and analytical methods, including non lethal methods, that can improve research relative to stated objectives;
    (ii) appropriate sample sizes to meet the stated objectives, especially if new methods are suggested under item (i);
    (iii) effects on stocks in light of new knowledge on status of stocks; and
    (iv) when, in the case of ongoing programmes, a further review should occur.

Reports of Workshops (applies to new proposals, periodic reviews and final reviews)

The Chair is responsible for the level and nature of participation of the scientists involved in the proposal, which should be limited to: (1) providing information to the invited experts in addition to that contained in the proposal or research results; and (2) answering questions posed by the invited experts. The specialist group should attempt to reach consensus on the individual issues referred to above, but where this is not possible, the rationale behind the disagreement should be clearly stated in the Workshop report. The final report of the Workshop shall be completed at least 80 days prior to the Annual Meeting and will be made available to the proponents.

Circulation to the Scientific Committee

The original special permit proposal, *or* the original result documents from ongoing or completed special permit research, the report of the specialist workshop, and any revised permit proposal (following the agreed protocol), *or* any revised results, from the Contracting Government shall be submitted to Scientific Committee members no later than **40 days** before the Annual Meeting. The revised proposal, or revised results, will also be submitted to the members of the specialist group and they will be invited to submit joint or individual comments on that revision to the Annual Meeting.

REFERENCES

International Whaling Commission. 2004. Report of the Scientific Committee. Annex T. Report of the data availability working group. *J. Cetacean Res. Manage. (Suppl.)* 6:406-08.

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Annex E

Summary of Available Data for JARPN II

Taken from SC/J09/JR1 (*= database complete)

I. Sighting data – coastal and offshore components

DB		Total sample size
	Angle and distance experiment data (no. of experiments)	3,807
*	Photo ID humpback whales (no. of schools photographed)	24
*	Photo ID right whales (no. of schools photographed)	22
*	Photo ID blue whales (no. of schools photographed)	65
*	Sighting data (no. of schools)	9,426
*	Effort data (n.miles)	439,047
	Weather data (no. observations)	66,260

II-1. Biological data – common minke whale – offshore component

		Number of whales		
DB	Data and sample	Male	Female	Total
*	Sampling date	661	79	740
*	Sampling location	661	79	740
*	Body length	661	79	740
*	Body proportion	661	79	740
	Skull (length and breadth)	656	78	734
	Body scar record	661	79	740
	Parasites, external occurrence record	661	79	740
	Parasites, internal occurrence record	661	79	740
*	Sex	661	79	740
*	Body weight	661	79	740
*	Organ weights	158	23	181
*	Blubber thickness	661	79	740
*	Girth	661	79	740
*	Maturity stage	661	79	740
	Corpora albicantia and lutea (number)	-	79	79
*	Lactation condition	-	79	79
*	Testis weight	661	-	661
*	Stomach contents (IWS format)	661	79	740
*	Stomach contents weights	661	79	740
*	Main prey species in stomach contents	661	79	740
*	Freshness of stomach contents	661	79	740
	Foetus, number	-	79	79
	Foetus, sex	-	-	35
	Foetus, body length	-	-	35
	Foetus, body weight	-	-	35
	Ear plug	661	79	740
*	PCB concentrations (blubber)	347	-	347
*	Total Hg levels (liver)	77	-	77
*	Total Hg, methyl Hg and Se levels (liver)	35	5	40
*	Total Hg, methyl Hg and Se levels (kidney)	35	5	40
*	Total Hg, methyl Hg and Se levels (muscle)	35	5	40
*	Mitochondrial DNA control region sequences	655	79	734
*	Nuclear DNA microsatellite (16 loci)	654	79	733

II-2. Biological data – sei whale – offshore component

DB	Data and sample	Number of whales		
		Male	Female	Total
*	Sampling date	238	251	489
*	Sampling location	238	251	489
*	Body length	238	251	489
*	Body proportion	238	251	489
	Skull (length and breadth)	232	243	475
	Body scar record	238	251	489
	Parasites, external occurrence record	238	251	489
	Parasites, internal occurrence record	238	251	489
*	Sex	238	251	489
*	Body weight	238	251	489
*	Organ weights	63	64	127
*	Blubber thickness	238	251	489
*	Girth	238	251	489
*	Maturity stage	238	251	489
	Corpora albicantia and lutea (number)	-	251	251
*	Lactation condition	-	251	251
*	Testis weight	238	-	238
*	Stomach contents (IWS format)	238	251	489
*	Stomach contents weights	238	251	489
*	Main prey species in stomach contents	238	251	489
*	Freshness of stomach contents	238	251	489
	Foetus, number	-	251	251
	Foetus, sex	-	—	115
	Foetus, body length	-	—	115
	Foetus, body weight	-	—	115
	Ear plug	238	251	489
*	PCB concentrations (blubber)	15	-	15
*	Total Hg levels (liver)	30	-	30
*	Total Hg, methyl Hg and Se levels (liver)	-	-	-
*	Total Hg, methyl Hg and Se levels (kidney)	-	-	-
*	Total Hg, methyl Hg and Se levels (muscle)	-	-	-
*	Mitochondrial DNA control region sequences	238	251	489
*	Nuclear DNA microsatellite (17 loci)	238	251	489

II-3. Biological data – Bryde's whale – offshore component

DB	Data and sample	Number of whales		
		Male	Female	Total
*	Sampling date	166	227	393
*	Sampling location	166	227	393
*	Body length	166	227	393
*	Body proportion	166	227	393
	Skull (length and breadth)	161	222	383
	Body scar record	166	227	393
	Parasites, external occurrence record	166	227	393
	Parasites, internal occurrence record	166	227	393
*	Sex	166	227	393
*	Body weight	166	227	393
*	Organ weights	56	71	127
*	Blubber thickness	166	227	393
*	Girth	166	227	393
*	Maturity stage	166	227	393
	Corpora albicantia and lutea (number)	-	227	227
*	Lactation condition	-	227	227
*	Testis weight	166	-	166
*	Stomach contents (IWS format)	166	227	393
*	Stomach contents weights	166	227	393
*	Main prey species in stomach contents	166	227	393
*	Freshness of stomach contents	166	227	393
	Foetus, number	-	227	227
	Foetus, sex	-	-	127
	Foetus, body length	-	-	127
	Foetus, body weight	-	-	127
	Ear plug	166	227	393
*	PCB concentrations (blubber)	15	-	15
*	Total Hg levels (liver)	20	-	20
*	Total Hg, methyl Hg and Se levels (liver)	21	22	43
*	Total Hg, methyl Hg and Se levels (kidney)	21	22	43
*	Total Hg, methyl Hg and Se levels (muscle)	21	22	43
*	Mitochondrial DNA control region sequences	166	227	393
*	Nuclear DNA microsatellite (17 loci)	166	227	393

II-4. Biological data – sperm whale – offshore component

		Number of whales		
DB	Data and sample	Male	Female	Total
*	Sampling date	13	32	45
*	Sampling location	13	32	45
*	Body length	13	32	45
*	Body proportion	13	32	45
	Skull (length and breadth)	13	30	43
	Body scar record	13	32	45
	Parasites, external occurrence record	13	32	45
	Parasites, internal occurrence record	13	32	45
*	Sex	13	32	45
*	Body weight	13	32	45
*	Organ weights	8	22	30
*	Blubber thickness	13	32	45
*	Girth	13	32	45
*	Maturity stage	13	32	45
	Corpora albicantia and lutea (number)	-	32	32
*	Lactation condition	-	32	32
*	Testis weight	13	-	13
*	Stomach contents (IWS format)	13	32	45
*	Stomach contents weights	13	32	45
*	Main prey species in stomach contents	13	32	45
*	Freshness of stomach contents	13	32	45
	Foetus, number	-	32	32
	Foetus, sex	-	-	7
	Foetus, body length	-	-	7
	Foetus, body weight	-	-	7
	Ear plug	13	32	45
*	PCB concentrations (blubber)	-	-	-
*	Total Hg levels (liver)	-	-	-
*	Total Hg, methyl Hg and Se levels (liver)	3	2	5
*	Total Hg, methyl Hg and Se levels (kidney)	3	2	5
*	Total Hg, methyl Hg and Se levels (muscle)	3	2	5
*	Mitochondrial DNA control region sequences	13	32	45
*	Nuclear DNA microsatellite (15 loci)	13	32	45

II-5. Biological data – common minke whale – coastal component off Kushiro

		Number of whales		
DB	Data and sample	Male	Female	Total
*	Sampling date	182	72	254
*	Sampling location	182	72	254
*	Body length	182	72	254
*	Body proportion	182	72	254
	Skull (length and breadth)	181	72	253
	Body scar record	182	72	254
	Parasites, external occurrence record	182	72	254
	Parasites, internal occurrence record	-	-	-
*	Sex	182	72	254
*	Body weight	182	72	254
*	Organ weights	11	3	14
*	Blubber thickness	182	72	254
*	Girth	182	72	254
*	Maturity stage	182	72	254
	Corpora albicantia and lutea (number)	-	72	72
*	Lactation condition	-	72	72
*	Testis weight	182	-	182
*	Stomach contents (IWS format)	182	72	254
*	Stomach contents weights18272254			
*	Main prey species in stomach contents	182	72	254
*	Freshness of stomach contents	182	72	254
	Foetus, number	-	72	72
	Foetus, sex	-	—	4
	Foetus, body length	-	—	4
	Foetus, body weight	-	—	4
	Ear plug	181	71	252
*	PCB concentrations (blubber)	-	-	
*	Total Hg levels (liver)	46	-	46
*	Total Hg, methyl Hg and Se levels (liver)	-	-	-
*	Total Hg, methyl Hg and Se levels (kidney)	-	-	-
*	Total Hg, methyl Hg and Se levels (muscle)	-	-	-
*	Mitochondrial DNA control region sequences	181	72	253
*	Nuclear DNA microsatellite (16 loci)	182	71	253

II-6. Biological data – common minke whale – coastal component off Sanriku

		Number of whales		
DB	Data and sample	Male	Female	Total
*	Sampling date	91	136	227
*	Sampling location	91	136	227
*	Body length	91	136	227
*	Body proportion	91	136	227
	Skull (length and breadth)	89	133	222
	Body scar record	91	136	227
	Parasites, external occurrence record	91	136	227
	Parasites, internal occurrence record	-	-	-
*	Sex	91	136	227
*	Body weight	91	136	227
*	Organ weights	4	5	9
*	Blubber thickness	91	136	227
*	Girth	91	136	227
*	Maturity stage	91	136	227
	Corpora albicantia and lutea (number)	-	135	135
*	Lactation condition	-	136	136
*	Testis weight	89-89		
*	Stomach contents (IWS format)	91	136	227
*	Stomach contents weights	89	133	222
*	Main prey species in stomach contents	91	136	227
*	Freshness of stomach contents	91	136	227
	Foetus, number	-	135	135
	Foetus, sex	-	—	30
	Foetus, body length	-	—	30
	Foetus, body weight	-	—	30
	Ear plug	91	136	227
*	PCB concentrations (blubber)	-	-	-
*	Total Hg levels (liver)	29	-	29
*	Total Hg, methyl Hg and Se levels (liver)	-	-	-
*	Total Hg, methyl Hg and Se levels (kidney)	-	-	-
*	Total Hg, methyl Hg and Se levels (muscle)	-	-	-
*	Mitochondrial DNA control region sequences	91	136	227
*	Nuclear DNA microsatellite (16 loci)	91	136	227

III. Pollutant data (environmental and prey species samples) – offshore component

DB	Item	Number of samples
*	Organochlorine compounds (air)	6
*	Organochlorine compounds (sea water)	7
*	Total Hg compounds (copepods)	5
*	Total Hg compounds (Krill)	17
*	Total Hg compounds (Larval of anchovy)	6
*	Total Hg compounds (Adult of anchovy)	20
*	Total Hg compounds (Pacific saury)	41
*	Total Hg compounds (mackerels)	5
*	Total Hg compounds (Pacific pomfret)	3
*	Organochlorine compounds (walleye pollock)	2

IV-1. Oceanographic data – offshore component

DB	Item	Number of samples
	Marine debris (sighting survey, days)	56
*	Temperature and salinity (XCTD survey: 2000-07)	38
*	Temperature and salinity (CTD survey: 2000-07)	593
*	Midwater trawl (no. of hawls)	141
*	MOCNESS (no. of hawls)	24
*	IKMT (no. of hawls)	30
*	NORPAC (no. of hawls)	75
*	Echo sounder (km: 2002-07)	12,838

IV-2. Oceanographic data – coastal component off Sanriku

DB	Item	Number of samples
*	Temperature and salinity (XCTD survey: 2003-07)	11
*	Temperature and salinity (CTD survey: 2003-07)	149
*	Midwater trawl (no. of hawls)	57
*	Bongo net (no. of hawls)	5
*	IKMT (no. of hawls)	17
*	Sampling by fishing (no. of stations)	2
*	Echo sounder (km; 2005 and 2006 seasons)	2,775

IV-3. Oceanographic data – coastal component off Kushiro

DB	Item	Number of samples
*	Temperature and salinity (CTD survey: 2002-07)	109
*	Midwater trawl (no. tow)	133
*	MOCNESS survey (no. tow)	-
*	IKMT survey (no. tow)	6
*	NORPAC net survey (no. tow)	-

Annex F

Characterising the Uncertainty in the Estimation of Food Consumption of Baleen Whales by Prey Type

SC/J09/JR9 describes the approach used for estimating consumption from diet samples of minke whales collected in the coastal part of JARPN II. Ranges are given for the estimates of consumption, but these account for only part of the uncertainty in the estimates. It is important to estimate, at least approximately, the overall level of uncertainty in consumption estimates.

This Annex aims to list the main sources of uncertainty in the estimates that should be taken into account when estimating the overall CV of consumption estimates.

The estimation of total consumption by prey species in the study area involves the steps listed below. The uncertainty associated with each step should be quantified.

Due to lack of a sufficiently strong diurnal signal in stomach fullness that might enable stomach throughput times to be determined, consumption estimates rely on considerations of energy requirements. The stomach content data are used to quantify the proportional contribution of each prey species or species group to the diet.

'Prey type' is by species of prey for the main prey species, otherwise by groups of species.

Where an item is based on data, CVs should be estimated by sub-sampling the appropriate units. Where data are lacking and an item has to be guessed, a plausible range should be given with a rationale. Nominal CVs can be estimated by assuming that the plausible range represents ± 2 SE on an appropriate scale.

Estimates of consumption can only be evaluated when each of the listed sources of variance has been taken into account. When this has been done, estimates of consumption from different methods (e.g. lethal vs non-lethal) can be compared.

When comparing two estimation approaches, the calculation steps should be divided into those which are (a) common to both methods (i.e. same data and method); (b) different for each method.

STEPS FOR WHICH VARIANCE ESTIMATES ARE REQUIRED

1. Per capita consumption in area of interest

1.1 Parameter uncertainty in the relationship between energy consumption and body mass (multiple and exponent)

The quoted SEs of 'best' published curve can be used, or a meta-analysis of several published curves.

1.2 Residual variance of species values around the mean curve

The nominal variance around the curve (calculated from the data used if not given) can be used as a conservative approach, although it is in principle an overestimate of process error, due to the contribution of observation error.

1.3 Proportion of annual energy requirement obtained during summer feeding season

1.4 Length of summer feeding season (to get daily energy requirement)

Due to lack of data, plausible ranges should be given for each of the above, with a rationale. In considering plausible ranges, the energy storage capacity of the species should be considered (e.g. Blix and Folkow, 1995, for common minke whales). The less the weight gain in the main feeding season, the greater the required intake during the rest of the year.

Residence time in the study area is not required if abundance data are expressed in terms of the average number of whales present in the study area during the study season.

1.5 Variance in mean body mass (stratified by sex and life stage, e.g. mature/immature)
Alternatively, the allometric formula for energy requirement can be applied to each individual and the variance of nominal energy requirement calculated.

2. Diet composition
The first step is to identify appropriate sampling units and subunits, for the purpose of variance estimation. The sampling units could be time-space cells, such as 1° square by week, or cells more appropriate for the data set. The subunits should be the individual whales.

The relative proportions of each of the main prey groups (fish, squid, zooplankton) can be estimated only from fresh material, subject to assumptions on relative stomach residency times.

The steps in the calculation that are subject to variance include:

2.1 Average undigested biomass of each main prey group in the forestomach

2.2 Mean residence time of each main prey group in the forestomach

2.3 Average energy content per unit biomass of prey by prey type
For refining the estimates of the relative proportion of each species within the main groupings (a) fish and (b) squid, the following data can be used:

2.4 Average body weight of undigested prey items by species

2.5 Relative frequencies of each species by counts of individuals and/or hard parts
Because the majority of stomachs contain only one prey type, the estimation of relative proportions in mixed-species stomachs probably accounts for a relatively small part of the uncertainty in total consumption estimates.

3. Abundance (to scale up per capita consumption to population consumption)
3.1 Variance (and possibly covariances) in estimates of abundance (mean number of whales present) in survey season by sub-area and time period, including g*(0) variance, and process error*
Standard stratum-specific variance estimates can be used, but if a common $g(0)$ factor is applied to all strata, then first the variance of the uncorrected total estimate should be calculated, and then the $g(0)$ factor and its variance applied to the total estimate.

Alternatively, a multi-year/area estimation procedure can be applied, for example for Bryde's whales (Kitakado *et al.*, 2008).

REFERENCES

Blix, A.S. and Folkow, L.P. 1995. Daily energy expenditure in free living minke whales. Acta Physiol. Scand. 153(1): 61-6.

Kitakado, T., Shimada, H., Okamura, H. and Miyashita, T. 2008. *CLA* abundance estimates for western North Pacific Bryde's whales and their associated CVs with taking the additional variance into account. Paper SC/60/PFI3 presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 27pp. [Paper available from the Office of this Journal].

Annex G

Conducting Power Tests using Coalescent Simulations

In this example we illustrate the use of coalescent simulations to assess the ability of a genetic analysis (in this case STRUCTURE - Pritchard *et al.*, 2000) to detect the presence of multiple populations.

Coalescent simulations work back in time from the present. Accordingly, if one population diverged into two x generations ago, this is coded in the simulations as two populations merging x generation before the present. A population expansion in forward time becomes a population contraction in backward time.

Coalescent approaches are in general based upon the assumption of 'ideal' Wright-Fisher populations, where the most notable deviations from cetaceans are non-overlapping generations, and random mating. For the specific purpose of this assessment, these deviation are unlikely to have a major effect. Both aspects essentially reduce the effective population size (N_e), and thus reducing population size in the simulation accordingly would capture the effects of these deviations from a Wright-Fisher population.

One user friendly coalescent simulation program is SimCoal 2[13] (Excoffier *et al.*, 2000), which has the additional advantage that the data output is in the Arlequin format. One aspect that sets SimCoal apart is that multiple coalescent events per generation are possible (which would be the case if a large part of the population has been sampled). Most coalescent simulation programs only accommodate one coalescent event per generation.

For the purpose of assessing the ability of STRUCTURE to detect multiple populations, this example will aim at the case where a sample contains individuals from two populations in different proportions.

In order to conduct simulations for this purpose under SimCoal 2 the following input parameters are required:

[13] *http://cmpg.unibe.ch/software/simcoal2/.*

Sample size from each population. Sample sizes are in number of gene copies, which in a haploid system (e.g. mtDNA) equals the number of sampled individuals, but is twice the number of sampled individuals for diploid loci.

Population sizes. This is the effective and not census, population size (i.e. N_e). As above in gene copies.

Migration rates. These are written as full matrices. The values entered are the probability that a gene copy is an immigrant (m). The product of population size and migration rates mNe is the number of immigrants per generation into the target population (which may be derived from the observed F_{ST} estimates assuming population genetic equilibrium).

Historical events. Changes in migration rates and population sizes. In a two population model, the two populations have to be merged into one at some point in the past or the simulation will run infinitely long. The further back in the past the populations merge, the less the deviation from drift-mutation equilibrium will be.

In addition, the kind of loci (e.g. DNA sequence data or microsatellite loci), the degree of linkage among loci and the mutation rate (u) need be specified. In addition, for microsatellite loci one can also specify some additional mutational parameters.

In most cases neither the effective population size nor the mutation rate is known. However, what is often termed the 'scaled mutation rate' may be estimated from the observed data. The scaled mutation rate (θ) is the expected number of mutations between two gene copies in a population and is the product of the effective population size (N_e) and the mutation rate (u). For mtDNA θ=2$N_{ef}\,\mu$, where Nef denotes the effective population size of females. For autosomal diploid loci, θ=4$N_{ef}\,\mu$, where N_e is the effective population size (male and females). θ may be estimated from different aspects of the data (most based upon an assumption of population genetic equilibrium). For instance, if one assumes an infinite site [mutation] model then θ equals the nucleotide diversity. For microsatellite loci θ is equal to twice the variance in the number of repeats.

Accordingly the product of N_e and u used in the simulations should equal that inferred from the data (e.g. the nucleotide diversity for mtDNA or twice the variance in repeat size for microsatellite loci). One should check simulated data if they generate the expected outcomes, e.g. observed hetetrozygosity, number of alleles and genetic divergence.

Data sets are then generated by SimCoal 2 for each combination of parameter values, and the data are then analysed using the relevant program (i.e. STRUCTURE in this case).

In the file above data are simulated from two populations, each of an effective population size of 6,500 gene copies. The number of 6500 gene copies translates into an effective population size of 3,250 diploid individuals, which in turn translates into a census population size (N_c) of ~20,000 if the ratio of N_e/N_c is ~1/6. In this case the migration is symmetrical, with equal rates in both directions. The rate was set at 0.01, which then translates into ~32 immigrants per generation. The samples sizes are 125 diploid individuals from one population and 2,375 from the other population, yielding a ratio of 1:20 of the two populations in the combined sample of 2,500 individuals. Here we have encoded a total of 16 microsatellite loci each in a separate linkage block (i.e. all loci are unlinked) and each with a mutation rate of 0.0005. The mutation rate need not be the same for each locus but different blocks with different numbers of loci, recombination rates and mutation rates may be specified.

Table 1

Example of a parameter input file for SimCoal 2.

```
//Input parameters for the coalescence and recombination simulation program : simcoal2.exe
2 samples to simulate
//Deme sizes (haploid number of genes)
6500
6500
//Sample sizes
250
4750
//Growth rates
0
0
//Number of migration matrices: If 0 : No migration between demes
1
//Migration rates matrix 0:
0.0000    0.0100
0.0100    0.0000
//Historical event: time, source, sink, proportion of migrants, new deme size, new growth rate, new migration matrix
1
1000    0    1    1    1    0    0
//Number of independent (unlinked) chromosomes, and "chromosome structure" flag:  0 for identical structure across chromosomes, and 1 for different structures on different chromosomes.
16    0
//Number of contiguous linkage blocks in chromosome 1:
1
//Per Block: Data type, No. of loci, Recombination rate to the right side locus, plus optional parameters ***see detailed explanation here***
MICROSAT    1    0.0000    0.0005    0
[EOF]
```

The genotype data produced by SimCoal 2 are in the Arlequin (Excoffier *et al.*, 2005) format and need to be reformatted into the STRUCTURE format. Software is continuously being published to convert between formats, or if none is available it is a relatively simple matter to write a small routine for this purpose.

Simulations differ from analyses of observed data, by the fact that a large number of data sets need be analysed. Hence software that may run in batch mode is preferable. SimCoal is able to run in batch mode. If the published version of a piece of software cannot run in batch mode, it is often useful to contact the author who may have a batch version (these are often command-line versions and less user friendly, which is why they are often not distributed widely).

In the above example the ability of STRUCTURE to detect the presence of two populations will depend upon the relative proportions of the two populations in the sample, their effective population sizes and the degree of migration between the populations (assuming no change in divergence time and that the number of loci and samples is given). Simulations should cover reasonable ranges of these parameters and for each combination of parameter values a sufficient number of simulations need be conducted to obtain a reasonable of the probability of detection. In the present case it will mainly be a matter of detecting under which parameter values STRUCTURE fails to detect the presence of two populations, i.e., the fraction of the first population is low and the migration rates high when the number of samples and loci is given.

The procedure for assessing the necessary amount of data (loci and samples) for tests of homogeneity and characterising proportions of different stocks in areas of mixing is similar to that outlined above, adding sample size and number of loci to the parameters that are assessed and using the appropriate analytical approach to generate the distribution of estimates from the simulated data sets.

There are a number of simulation programs in addition to SimCoal 2, some of which are individual-based such as EASYPOP[14].

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Excoffier, L., Laval, G. and Schneider, S. 2005. Arlequin ver. 3.0: an integrated software for popultion genetics data analysis. *Evol. Bioinf. Online* 1: 47-50.

Excoffier, L., Novembre, J. and Schneider, S. 2000. SIMCOAL: a general coalescent program for the simulation of molecular data in interconnected populations with arbitrary demography. *J. Hered*. 91: 506-09.

Pritchard, J.K., Stephens, M. and Donnelly, P. 2000. Inference of population structure using multilocus genotype data. *Genetics* 155: 945-59.

Annex H

Recent Resolutions of the Commission Relevant to this Review*

This Annex does not repeat the full text of the Resolutions (full references are given) but rather focuses on those action paragraphs that may have some relevance.

Resolutions dealing with the Antarctic marine ecosystem and/or environmental change including pollution

Resolution on the Environment and Whale Stocks (IWC, 1996b)

ENCOURAGES Contracting Governments to continue to cooperate in providing information on the potential effects both direct and indirect of pollutants on cetaceans as these become known by forwarding them to the Secretariat.

Resolution on Environmental Change and Cetaceans (IWC, 1998)

ENCOURAGES Contracting Governments to continue to provide available information on environmental changes as identified above and their known or potential ecological effects on cetaceans through annual Progress Reports and attendance of experts at meetings of the Scientific Committee;

DIRECTS the Scientific Committee, through the SWGEC, to provide regular up-dates to the Commission on environmental matters that affect cetaceans and, in particular, those that relate to non-natural mortalities relevant to implementation simulation trials or future RMP catch limit calculations or that require the action of the Commission within future five year periods of validity of catch limit calculations;

ENCOURAGES Contracting Governments to carry out relevant non-lethal research within domestic and collaborative multinational and multi-disciplinary programmes and also to provide new and additional funds to support the work of the Scientific Committee and SWGEC in this regard.

Resolution on Health Effects from the Consumption of Cetaceans (IWC, 2000b)

REQUESTS the Scientific Committee to receive, review and collate data on contaminant burdens in cetaceans … and to report on this matter to the Commission.

Resolutions dealing with Scientific Committee reviews of Special Permit research

Resolution on Whaling under Special Permit (IWC, 1996a)

RECOMMENDS

- that scientific research intended to assist the comprehensive assessment of whale stocks and the implementation of the Revised Management Procedure shall be undertaken by non-lethal means;
- that scientific research involving the killing of cetaceans should only be permitted in exceptional circumstances where the questions address critically important issues which cannot be answered by the analysis of existing data and/or use of non-lethal research techniques;

REQUESTS the Scientific Committee, with respect to all Special Permit research programmes:

- to undertake a comprehensive review of all existing programmes notified to it and report its views on whether such programmes remain justifiable in the light of the recommendations above and, in particular, on whether any lethal scientific research substantially contributes to answering critically important questions which cannot be answered by other means;
- to consider all new programmes submitted to it in the light of the above recommendations;
- to undertake annual reviews of all programmes and to undertake more intensive reviews of all long-term programmes at five year intervals;
- to structure its reviews of programmes to:

[14]Available at: *http://www.unil.ch/webdav/site/dee/shared/softs/EASYPOP_201_userguide.pdf.*

*Based on Zeh *et al.* (2005).

Identify the relationship between programme objectives and research needs previously identified by Scientific Committee;

- evaluate the likelihood of the programme meeting its objectives by providing reliable answers to the questions posed;
- identify, where a proposal specifies lethal methods, non-lethal methods and alternative sources of data which might be used in meeting the research objectives;

AGREES, should a continuing or proposed special permit research programme not, in the view of the Commission, satisfy the criteria specified in this Resolution to so notify the Contracting Government concerned;

RECOMMENDS that Contracting Governments, in providing the Secretary with proposed special permits and in submitting reports on research programmes to the Scientific Committee for review, specify how each proposed special permit or programme satisfies the above recommendations;

REQUESTS each Contracting Government to ensure that all scientific information and data available to it with respect to whales and whaling, including results of research conducted pursuant to Articles IV and VIII of the Convention, are submitted promptly to the Scientific Committee for review, analysis and consideration;

Resolution on Special Permits for Scientific Research (IWC, 2000a)

REQUESTS the Scientific Committee, with respect to all Special Permit Research Programmes, to provide advice to the Commission, on the research to be undertaken pursuant to any proposed Special Permit or that has been undertaken in respect of any Special Permit, as to whether the information sought in the research programme under each Special Permit is:

- required for the purposes of management of the species or stock being researched; and
- whether the information sought could be obtained by non-lethal means.

REFERENCES

International Whaling Commission. 1996a. Chairman's Report of the Forty-Seventh Annual Meeting. Appendix 10. IWC Resolution 1995-9. Resolution on whaling under special permit. *Rep. int. Whal. Commn* 46:46-47.

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International Whaling Commission. 2000b. Chairman's Report of the Fifty-First Annual Meeting. Appendix 5. IWC Resolution 1999-4. Resolution on health effects from the consumption of cetaceans. *Ann. Rep. Int. Whaling Comm.* 1999:53.

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