Annex G

Report of the Sub-Committee on In-Depth Assessments

Members: Palka (Convenor), Allison, Baba, Baker, Bell, Branch, Burkhardt, Butterworth, Charrassin, Cipriano, Clapham, Cooke, Currey, De la Mare, De Moor, Diallo, Double, Findlay, Florez-Torres, Fortuna, Frey, Fujise, Garrigue, Goodman, Gunnlaugsson, Herr, Hughes, Ivashchenko, Jaramillo-Legorreta, Jimenez, Joon Park, Kato, Kelkar, Kitakado, Lang, Leaper, Lundquist, Maeda, Mallette, Matsuoka, McKinlay, Miyashita, Mizroch, Mogoe, Morishita, Morita, Moronuki, Murase, Øien, Okazoe, Olson, Paniego, Pastene, Punt, Reeves, S., Rendell, Rosenbaum, Širović, Skaug, Sohn, Tamura, Tsuji, Víkingsson, Wade, Walløe, Williams, Yasokawa, Yasunaga, Yoshida, Zerbini, Zharikov.

1. INTRODUCTORY ITEMS

1.1 Election of Chair
Palka welcomed the participants and was elected Chair. Kelly was originally identified as co-Chair for this sub-committee but was not able to attend the meeting, though she hoped to participate next year.

1.2 Appointment of rapporteurs
Branch, Clapham, Cooke, Herr, Murase, Palka and Wade agreed to act as rapporteurs.

1.3 Adoption of Agenda
The adopted Agenda is shown in Appendix 1.

1.4 Documents available
The documents considered by the sub-committee were SC/66b/IA01-IA21 (except SC/66b/IA03, SC/66b/IA14 and SC/66b/IA16), SC/66b/EM03, SC/66b/SD01, SC/66b/O01, SC/66b/O05, SC/66b/Rep01 and SC/66b/Rep02.

2. ANTARCTIC MINKE WHALES

2.1 Progress on ways to report on the Indo-Pacific in-depth assessment
The in-depth assessment of Antarctic minke whales was initiated in 2001 at SC/53 (IWC, 2002). In the context of the Scientific Committee, an in-depth assessment includes the examination of current stock size, recent population trends, carrying capacity and productivity. The in-depth assessment of Antarctic minke whales in the Indo-Pacific Antarctic region was completed during SC/65b. Numerous papers have been submitted over the last 16 years and discussions on them are scattered around in many volumes of Scientific Committee meeting reports. Some of these papers have been published in scientific journals. Thus, to finalise this assessment the sub-committee **recommended** that a new document synthesise these results. In following the general format being used to synthesise the Southern Hemisphere humpback whale assessment (Jackson *et al.*, 2015), a draft outline along with proposed authors is given in Table 1. The main purpose of this document is to summarise the previously available results, not details of analyses, and it is expected there will be no new or recent analyses included. An intersessional e-mail correspondence group has been established under Murase to facilitate the work (see Annex V for members and Terms of Reference).

2.2 Evaluate the possibility in initiating an in-depth assessment focusing on the South Atlantic and Antarctic Peninsula
During SC/66a, the sub-committee collated a list of potentially helpful data that could be used to initiate an in-depth assessment of minke whales in the South Atlantic and Antarctic Peninsula and concluded that, in principle, a statistical catch-at-age-type analysis could be undertaken, if it became a priority. After reviewing this list of data, the currently availability information on stock structure within the focus area and the current work load, the sub-committee **concluded** that at this time, it was not a priority to start an in-depth assessment of Antarctic minke whales in this region. However, it was noted that additional data are available for this region. Herr and Kelly indicated they will collate these and present them next year, with the idea of keeping the list of data up-to-date so that it will be easier to conduct a future assessment.

2.3 Consideration of factors that drive Antarctic minke whale distribution
This Agenda item originally addressed possible reasons for the difference between the abundance estimate of the Antarctic minke whale derived from data during the CPII (austral summer seasons of 1984/85 to 1990/91) and CPIII (1991/92 to 1995/96) time periods. Since then the Committee has agreed upon the best available abundance estimates for these two time periods and hypothesised that part of the reason there was a difference in the abundance estimates was that the percentage of the minke whale population utilising the study area varied due to a varying environment, i.e. particularly varying coverage and concentrations of sea ice and varying krill prey distributions. Because it is not possible to obtain more details of past environmental conditions, it was **recommended** not to pursue this issue further. However, insight into this issue could possibly be gained by studying the current cetacean distribution and their environment, which is further discussed under Item 2.4 and in Annex K1.

Table 1

Proposed outline of document synthesising and summarising the in-depth assessment of Indo-Pacific Antarctic minke whales. Proposed lead author is given in brackets.

1. Introduction (Palka)
2. Exploitation (Kato)
3. Surveys (Matsuoka)
4. Systematics (Kato)
5. Stock structure (Pastene)
6. Abundance (Matsuoka and Kitakado)
7. Spatial distribution (Murase)
8. Biological information (age, growth, morphology, maturity and reproduction) (Kato)
9. Population dynamics (Punt and Kitakado)
10. Food habit and energetics (Tamura)
11. Species interactions (Murase and Kitakado)
12. Pollutants and marine debris (Yasunaga)
13. Conclusion (Palka)

2.4 Distributions of baleen and toothed whales in the Antarctic relative to spatial and environmental covariates

A paper relating the distribution of baleen whales during CPII and CPIII of IWC IDCR/SOWER, with spatial and environmental covariates, has been prepared for the IWC IDCR/SOWER Special Volume (see Item 3.1). More recent field and analytical research investigating the distribution of Antarctic minke whales and other Antarctic cetaceans relative to spatial and environmental covariates has been and is currently being conducted by several researcher groups; for example, the NEWREP-A programme, Herr *et al.* (2016) which was presented this year in Annex K1, and Kelly *et al.* (2014) which was presented to the Committee in 2014. The Committee now has a Working Group on Ecosystem Modelling (EM; Annex K1) where one topic deals with this type of research. Thus, it is **recommended** that this agenda item be removed from this sub-committee's agenda and in the future, such research initially be reviewed by the EM group. This sub-committee could then utilise the results, as appropriate, to further its work.

2.5 Statistical catch at age models

SC/66b/IA08rev1 described simulation tests using an age-structured population dynamics model to generate simulated data on abundance and catch-at-age at times and with sample sizes approximately corresponding to the data available for Antarctic minke whales. A model from the same family is fitted to these simulated data using the methods of statistical catch at age analysis (SCAA) under ideal circumstances where the assumptions of the fitted model are met. The results show that parameter estimates are inaccurate and imprecise and are, for the given data characteristics, quite uninformative about maximum sustainable yield rate (MSYR) and at best only weakly informative about any trends in carrying capacity (K). This arises because the age structure of a sample from a population depends on the complex of factors relating age-selectivity, age dependence in natural mortality, trends in recruitment and the partition of density dependence between births and mortality. Given these degrees of freedom, there are multiple ways these processes can lead to very similar predicted catch-at-age data. This leads to the insensitivity of the objective function to a wide range of parameter values and hence poor estimates.

In discussion, several technical issues were clarified. Additional discussions were deferred to the Special Permit agenda items under the Committee's agenda.

3. ANTARCTIC SURVEYS

3.1 Review progress on IDCR/SOWER volume

Preparation of the volume continues, if slowly. Bannister reported that of some 30 items to be covered, excluding the Introduction and Conclusions, 20 complete or substantially complete (to review stage) versions are currently available. A major gap so far has been the chapter on Antarctic minke whales, in several sections, which has been delayed mainly through the unavailability of the chief author. That should be rectified by early in 2017. In the meantime it is proposed in September this year, immediately after the Tokyo POWER planning meeting, to repeat the two-day editorial Workshop held last year, where considerable editorial progress was made.

3.2 Review of 2015/16 NEWREP-A cruise

SC/66b/IA05 and SC/66b/EM03 report on the results of the 2015/16 NEWREP-A dedicated whale sighting survey in IWC's Antarctic Area IV (south of 60°S). Originally a survey with two sighting vessels (SV) covering Area V had been planned, but limited funds only allowed for one vessel. It was decided to cover a part of IWC's Antarctic Area IV instead. The dedicated SV successfully conducted research for 50 days, from 27 December 2015 to 14 February 2016 in the eastern part of Area IV (115°E-130°E, 25% of the Area IV) using two survey modes, based on IWC/IDCR-SOWER survey procedures. The total searching distance in the research area was 1,542.7 n.miles (2,857km), including 741.5 n.miles covered in Closing mode (NSC) and 801.06 n.miles in Independent Observer with passing mode (IO). Survey coverage was 93% in the northern stratum and 82% in the southern stratum. Five baleen whale species: blue (15 schools/27 individuals), fin (14/39), Antarctic minke (186/538), southern right (1/1) and humpback (513/1,179) and at least two toothed whale species: sperm (8/8), southern bottlenose (16/158), were sighted in the research area. Antarctic minke whales were encountered more frequently in the southern stratum, especially north of the ice edge. Humpback whales were the most frequently sighted large whale species and were widely distributed in the research area. No marine debris items were observed. The Estimated Angle and Distance Training Exercises and Experiments were completed as in previous years. A total of 69 individuals were successfully photographed including data for 21 blue, one southern right, 27 humpback whales and 20 killer whales. A total of 33 biopsy (skin and blubber) samples were also successfully collected from seven blue, seven fin, one southern right, 10 humpback and eight killer whales using the Larsen-gun system. For the first time, a feasibility study on telemetry and biopsy sampling of Antarctic minke whales was undertaken. Biopsy samples from five out of nine targeted solitary Antarctic minke whales were successfully collected. A total of 3 hours and 26 minutes was spent on the trials. The average time for obtaining a biopsy sample was 41 minutes, at low sea states (1 and 2 on the Beaufort scale) the average sampling time was less than 20 minutes. Sampling was only possible in sea states up to 5. A total of 16 trials for satellite tag deployment on Antarctic minke whales was conducted, successfully deploying three dummy tags on two whales and seven satellite tags on seven whales. A total of six biopsy samples were collected from these animals (one dummy tagged whale and five satellite tagged whales). A krill and an oceanographic survey were conducted along the tracklines of the sighting survey. Acoustic data were recorded continuously for 31 days using a quantative echosounder (EK80) operating at frequencies of 38, 120 and 200kHz. Krill net samples were taken at 29 stations using a small ring net (1m diameter, 3m length). At the same stations, CTD sampling was conducted. Oceanographic and krill data were still being analysed at the time of the report. They are intended to be used for validation of the acoustic krill data. Results will be made available to the upcoming CCAMLR-SAM workshop and considered for the planning of the survey in 2016/17. The survey procedure including IO mode data was in accordance with the Committee's guidelines. The sighting data were validated and submitted to the Secretariat. Photo-identification data were registered to the ICR database and submitted to the relevant international catalogues.

The sub-committee expressed appreciation for the successful completion of this survey and looked forward to receiving abundance estimates arising from these data, as well as results from the krill survey. The sub-committee also thanked Matsuoka for overseeing this survey on behalf of the IWC.

In discussion it was noted that the size of the net used during the krill survey was not optimal, with the diameter of the mouth being too small. This implies that it may be difficult to obtain relevant information from the trawl data of this survey. For the next survey, two vessels will be engaged and at least one will be equipped with a larger net. Moreover, in the future it is foreseen to conduct the surveys from a CCAMLR standard type vessel in order to achieve better krill data. The upcoming CCAMLR workshop will provide advice for the planning of the next krill survey and give guidance for the analyses of the krill data. For more discussion of SC/66b/EM03 see Annex K1.

3.3 Review planning of 2016/17 NEWREP-A cruise

SC/66b/IA04 presented the research plan for the NEWREP-A dedicated sighting survey in the 2016/17 austral summer season. The research plan was prepared considering the suggestions and recommendations from the NEWREP-A Review Panel regarding sighting surveys (recommendations 6 and 7), krill survey under NEWREP-A (recommendation 15), and feasibility studies on non-lethal methods (recommendations 4 and 5) - see details in IWC (2016a) and Government of Japan (2015).

The main objectives of the survey are the systematic collection of sighting data aimed to produce abundance estimates of Antarctic minke whale and other large whale species for management and conservation purposes. This information will contribute to building ecosystem models as well as providing direct input for the SCAA and the RMP. The survey is planned to be conducted in the IWC's Antarctic Management Area V (130°E-170°W) which includes the Ross Sea. Whale sightings will be collected under Normal Passing (NSP) and Independent Observer (IO) modes. A krill and oceanographic survey will be conducted along the track-lines of the sighting survey, including echo-sounder recordings, net sampling and CTD sampling. The feasibility studies of biopsy sampling and telemetry of Antarctic minke whales started in 2015/16 will be continued during this survey. Routine biopsy sampling and photo-identification of large whales will also be conducted. The duration of the survey including transit is planned to be 130 days. The number of days dedicated to research in Antarctic waters is planned to be 80 days. The survey will be conducted using two research vessels, *Yushin-Maru No. 3* (*YS3*) and an undetermined vessel with similar platforms.

Both vessels will be equipped with top barrel (TOP), independent observer platform (IOP) and upper bridge platform (UBP). While both vessels will be equipped with instruments required for the krill and oceanographic surveys, it will be ascertained that one of the vessels is equipped with a larger net than used during the 2015/16 survey and better suited for conducting krill research. Details on the krill and oceanographic survey sampling scheme are specified in Appendix 1 of SC/66b/IA04, including details of the echo-sounder survey and net sampling scheme. Both vessels will conduct the sighting survey, all other activities will be divided between the two vessels as appropriate. For the sighting activities, including experiments in IO mode, two researchers are required on board each vessel. An additional researcher to conduct the krill and oceanographic surveys is required on board the respective vessel. The survey plan follows the IWC 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme (RMS)'. SC/66b/IA04 also provides details on the stratification of the research area, trackline design, sighting effort and mode, distance and angle experiment and data entry system. The report of the sighting survey will be submitted to the 2017 IWC SC meeting.

Appendix 2 of SC/66b/IA04 provides details on the feasibility study on biopsy sampling and telemetry of Antarctic minke whales. The Larsen gun will be used for the feasibility experiments of biopsy sampling of Antarctic minke whales. Priority will be given to training of research personnel with the Larsen biopsy gun on Antarctic minke whales under various sea states. In the offshore stratum, tentatively 10 biopsy trials will be conducted for each of the following wind speed ranges: 0-5; 6-10; 11-15; 16-20 (40 trails in total). In the southern stratum, three trials will be attempted the wind speed ranges: 0-5; 6-10; 11-15; 16-20; 21-25 (15 trials in total). The weight of any obtained tissue sample will be recorded.

In the second year of the feasibility study on telemetry, the focus will continue to be on development of the attachment system. For this aim, international and national experts are being consulted. Effort will be spent in developing an attachment system in consultation with the National Research Institute of Far Seas Fisheries and Lars Kleivane from Norway. A pneumatic tool (the whale tag launcher; ARTS Aerial Computers, WA, USA) and satellite tag (SPOT6; Wildlife Computers, WA, USA) will be tried on Antarctic minke whales. Tentatively six attachment trials on Antarctic minke whales are planned for each of the following wind speed ranges: 0-5; 6-10 in the offshore and the southern stratum, respectively (24 trials in total). In each trial, the school size, school behaviour, sea state, swell, wind speed and the time taken in the trial will be recorded.

After validation by ICR, sighting and associated data will be submitted to the IWC Secretariat. Other data and samples obtained during the survey will be available to Committee members through the Data Availability Agreement Procedure B.

A cruise report will be prepared just after the survey is completed and will include a list of the samples and data collected during the survey. The cruise report will be presented to the 2017 IWC SC meeting. An oversight report will be presented as an appendix to the cruise report.

The sub-committee welcomed the proposed multi-disciplinary survey involving a dedicated cetacean sighting survey, krill survey, oceanographic sampling survey, in addition to conducting biopsy and tagging experiments. The sub-committee thanked the Government of Japan for the use of two dedicated vessels for this research project.

The sub-committee **endorsed** this proposal and Matsuoka was appointed to provide IWC oversight.

4. IN-DEPTH ASSESSMENT OF NORTH PACIFIC SEI WHALES

4.1 Abundance and distribution

4.1.1 New surveys

The 2015 POWER survey (SC/66b/IA09) was conducted south of 30°, outside the sei whale summer distribution range, and no sei whales were seen. The Russian survey in the northern Okhotsk Sea (SC/66b/IA17) was also outside the previously known range of sei whales, and as expected no sei whales were seen.

A dedicated survey was conducted by the Institute of Cetacean Research (ICR) in April-June within the JARPN II research area, and 54 sei whales were seen, all in the southern half of the area (SC/66b/IA10).

4.1.2 Recent and past surveys

Recent and past surveys of direct or indirect relevance to sei whales are tabulated in Appendix 2. The surveys are grouped into: (1) surveys (or survey series) with significant sei whale sightings that have already been analysed; (2) surveys (or survey series) with significant sei whale sightings awaiting analysis; and (3) surveys with few or zero sei whale sightings.

Group 1 contains the POWER 2010, 2011 and 2012 surveys that were conducted in sei whale habitat. These have already been analysed using line transect methods (Hakamada and Matsuoka, 2015).

The Japanese Scouting Vessel (JSV) data cover the period 1964-90, and the sub-committee **agreed** that these contained potentially useful information on historical distribution. Summaries by 5° square by month have already been extracted for the data (Anonymous, 1980; Kishiro, 1998). Miyashita noted that positions in these surveys are based on the noon positions, and considered that they could be refined to a 3° square resolution, as had been done for the Antarctic data. He offered to present such an analysis next year, and proposed to divide the data into an early, middle and late period with the aim of revealing possible changes. The sub-committee **welcomed** this offer and looked forward to receiving the analysis.

The JARPN (1994-99) and JARPN II (2000-15) surveys in the area 150-170°E, from 35°N up to the boundaries of the Russian and US EEZs have mainly been analysed, but a few individual years were missing from the analyses. Matsuoka explained that in the missing years the target had been minke whales and the surveys focused on the coastal area. The US West Coast surveys have been analysed for 1991-2008, but very few sei whales were seen, and the abundance estimates are less than 100 (Barlow, 2010). Eleven sei whales were seen in the 2014 survey; hence the next abundance update will likely be a bit higher.

Group 2 includes the dedicated sightings surveys conducted by Far Seas Fisheries Research Institute (NRIFSF) in various months in various parts of the western North Pacific during 1983-2015. Summaries of these data have been presented over the years in Japanese National Progress Reports and in cruise reports to the Committee. In some surveys, considerable numbers of sei whales were seen, but these data have not yet been analysed for sei whale abundance.

The sub-committee considered these data contain potentially useful information. In view of the long period of years covered, changes in abundance and distribution could potentially be detected. Miyashita said that he would try to analyse these data in time to present results next year, but noted that it involves a large amount of work. He explained that the format of the data sheets had changed over time, which implied more work to process the earlier data. The sub-committee looked forward to seeing results next year, and **agreed** that it made sense to give initial priority to the parts of the data set that could be analysed most easily.

The sub-committee noted that one of the surveys (2005) covered the Russian EEZ east of the Kuriles and Kamchatka. Although there were only nine sei whale sightings, this was the only recent information on sei whales in that area, which had been covered by the JSVs prior to the establishment of the USSR EEZ.

The sub-committee **agreed** that no further analysis is required for the surveys in Group 3, where few or no sei whales were seen, but that they could be used to bound the area of the summer sei whale distribution as presently observed. Very few sei whales were seen in summer south of 40°N in the central North Pacific or south of 35°N in the western North Pacific. Sei whales also seem to be rare in the Okhotsk Sea and the Sea of Japan. After the end of US and Canadian whaling, sei whales had rarely been seen in US mainland and Canadian waters for a considerable time (SC/66b/IA20), at least until 2014 at which time 11 sei whales were seen.

4.2 Catch history

Information to revise the catch history was available from three sources that are discussed below.

4.2.1 Sei/Bryde's whale distinction in Japanese coastal whaling data

Sei and Bryde's whales were distinguished in BIWS statistics only from 1968, although the distinction was already made in some of the Japanese data submitted to BIWS from the 1960s.

From 1955, Japanese coastal whaling operations recorded Bryde's whales as 'southern sei', following the Omura *et al.* (1952) description of the distinction. The term 'southern sei' was gradually replaced by 'Bryde's whale' during the 1960s. The data submitted to the BIWS contained some Bryde's whales from 1962, but the Bryde's proportion is known to be incomplete up to 1968. In view of this, the catch series developed for the Bryde's whale assessment (Allison, 2008) was instead taken from the NP forms and from Japanese catch statistics by land-station, company and area for the 1955-67 period. An approximate division of pre-1955 catches into sei and Bryde's whales had been made by extrapolating the catch with known species breakdown to other years based on location and month.

Mizroch reported that she had, in consultation with Ohsumi in 2012, examined a sample of company logbooks, and found that the southern/northern sei breakdown differed substantially from the sei/Bryde's breakdown submitted to BIWS in some years. For example, in 1962 the total of 1,229 sei/Bryde's whales was split 1,063/166 in the BIWS data but 725/504 in the logbooks.

The sub-committee **agreed** that encoding of the logbook data to improve accuracy of the sei/Bryde's breakdown should be undertaken. This would start with the 1955 records and move forward to 1968, since when the BIWS figures seem to be reliable. The data are held at NRIFSF. Yoshida undertook to conduct this work, in consultation with Allison.

Yoshida also agreed to re-examine the sei/Bryde's breakdown that was effected for the Bryde's whale assessment (Allison, 2008), in the light of the new information gained from the logbooks, and new insights from our improving understanding of sei and Bryde's whale habitat preferences, and to present a paper to next year's meetings with a revised sei and Bryde's whale catch series. In the case of the Bryde's whale assessment, high and low catch series had been compiled to span the range of uncertainty. This would also be an option for sei whales.

4.2.2 Individual catch records for 1938-52

Allison reported that the IWC catch database has no individual records for Japanese coastal catches prior to 1946. From 1946 onwards, the IWC database has individual records, but these are incomplete (lacking, for example, positions) and subject to transcription errors made by BIWS.

Mizroch had discovered by chance that the individual records for the years 1938-52 had been transcribed under the direction of R. Gilmore, in a project starting in 1948 (*cf* letter from Gilmore to US authorities dated 2 June, 1948). The raw data as well as a number of summary reports and maps were given to Rice after Gilmore retired. Since Rice retired, the boxes of data have been housed in the library at the Alaska Fisheries Science Center's Marine Mammal Laboratory in Seattle, WA. They are believed to contain around 20,000 records. A substantial fraction of these are 'sei' whales (but these are not distinguished from Bryde's whales). Mizroch provided scans of samples of data sheets. The individual records seem to be comprehensive, containing positions of each whale.

There was some discussion in the sub-committee over the providence and reliability of these data. Mizroch and Allison considered that the records appear to be authentic, and do not look like they have been compiled by uninterested clerks or soldiers. They also agree broadly with the BIWS data for the post-1946 data, apart from some obvious errors in the latter, although the Gilmore data contain more details. Yoshida considered it likely that the original Japanese records could be found in the NRIFSF archives.

From the data sheet printed headings visible on the scans, it appears that the data were compiled under the US authority in place at the time, and thus are theoretically still the property of the US government. The sub-committee nevertheless considered it desirable that the original records eventually be shipped to Japan for permanent archiving at the NRIFSF, after they have been encoded by the IWC.

After considerable discussion, the sub-committee considered that the data should be included in the IWC catch database. However, the logistic process to do so is still being finalised.

Yoshida agreed that he would try to locate the data for this period in the existing Japanese archives, and, when the data have been encoded at the IWC, to cross-check a sample of the records to see how well they compare.

4.2.3 Revisions to USSR catch data

The catches of the former USSR North Pacific fleet have been revised using original data collected by biologists. The revisions resulted in a reduction of the recorded sei whale catches from 11,363 to 7,698, because sei whales had been used as a cover for protected species (Ivashchenko *et al.*, 2013). The revisions have been included in version 6.0 of the IWC catch database released May 2016.

4.2.4 Marking data

Allison reported that *Discovery* marking data for the North Pacific have now been coded at the Secretariat.

A total of 3,423 marks were placed from 1949 to 1981, of which 2,262 were in sei whales. There were a total of 181 recoveries, including 143 from sei whales. There are outstanding questions of interpretation for nine records.

The last mark recovery from a Bryde's whale was in 1981. There were no mark recoveries either in commercial whaling from 1982-87 nor in JARPN, when no sei whales were caught. In addition, there were also no mark recoveries in JARPN II, which did catch sei whales. The maximum time between marking and recovery was 25 years for Bryde's whales and 12 years for sei whales.

The sub-committee **expressed** some concern about possible species misidentification between sei and Bryde's whales in the early years. Miyashita explained that he was personally involved in marking in the early 1980s, but he could not vouchsafe for the accuracy of species identified in the earlier years.

Allison noted a tendency to retrospectively 'correct' the marking record when the recovery did not match. The sub-committee **recommended** that marking records associated with Bryde's recoveries be carefully checked that they were not logged as sei whales at the time. The sub-committee thanked Allison and her staff for the encoding work, and thanked Miyashita and Yoshida for consultation on the data.

4.3 Stock structure hypotheses

Last year the sub-committee had agreed to proceed on the basis of two alternative hypotheses: (i) a single stock for the entire North Pacific; and (ii) the five-stock hypothesis presented in SC/66a/IA14.

SC/66b/SD01 presented results of additional genetic analyses that had been recommended by the JARPN II review Workshop held in February 2016. Results of additional STRUCTURE analyses supported the hypothesis of a single stock of Bryde's whale in sub-areas 1 and 2, which contradicts the results of the hypothesis testing of significant mtDNA and microsatellite differences between sub-areas 1 and 2. This reflects the well-documented difficulty that STRUCTURE has in detecting weakly differentiated populations. In the case of sei whales, results of the STRUCTURE and hypothesis testing were similar, and they support the existence of a single stock in the pelagic region of the North Pacific.

The technical details of this paper were reviewed by the Stock Definition sub-committee (see Annex I).

SC/66b/IA20 is a revised version of Mizroch *et al.* (2015). The main change to the stock hypothesis is that the proposed Aleutian stock is now thought likely to have extended into the Gulf of Alaska ground, but that there was likely to have been some overlap there with the northeast Pacific migratory stock which had formerly been a target of Canadian land stations. The authors noted an apparent failure of sei whale abundance to recover in some former whaling areas such as coastal Japan, Aleutians, coast of Alaska, and the Canadian and US west coast. This was considered evidence that there was some separation of stocks in these areas from the North Pacific pelagic stock.

In discussion, the sub-committee noted that the catch maps in SC/66b/IA20 showed only the pelagic catches, but there were also very substantial catches from Japanese land stations. Furthermore, the gap in catch distribution between the commercial pelagic and coastal catches was a consequence of regulations that were designed to minimise competition between coastal and pelagic whaling operations by prohibiting pelagic catches west of 159°E. A revised map (see Appendix 3) showing also the coastal and JARPN II catches shows a more continuous distribution of catches from the coast of Japan right across to the Gulf of Alaska. The map does not show the pre-1946 catches for which individual positions are lacking.

The sub-committee **agreed** that the genetic information was consistent with a single stock in the area covered by the samples. However, it noted that all the samples had been taken from the area of just one of the stocks proposed in SC/66b/IA20, namely the North Pacific pelagic stock. Therefore, they could not distinguish between the single-stock and the 5-stock hypotheses.

Several members commented that the stock structure had not necessarily been static, but may have changed over time due to oceanographic changes. For example, the apparent disappearance of sei whales from the California coastal grounds following the end of whaling there in 1970 may have been related to an oceanographic shift. The results of the spatial habitat suitablity modelling (Sasaki *et al.*, 2013) could be used to help understand changes in distribution over time. The analysis of historical abundance data (see Item 4.1.2) may also throw light on this question.

Overall, the sub-committee considered that the evidence for the proposed 5-stock hypothesis was weak, being based on mainly circumstantial considerations such as differential recovery, with only limited support from marking data.

The lack of genetic samples from four of the five putative stocks is a major information gap. It was also considered doubtful that the Aleutian-Gulf of Alaska stock could be well differentiated from the North Pacific pelagic stock, because both putative stocks may migrate south through the same regions, although winter destinations for the putative Aleutian/Gulf of Alaska stocks are unknown at present. On the other hand, it was noted that one single stock in such a vast area as the North Pacific basin would be a unique scenario for a baleen whale: no other such case is known.

In conclusion, the sub-committee **agreed** to proceed, in this situation of uncertainty, with both the single and multi-stock alternatives. This is consistent with the approach taken by the sub-committee for the blue whale case. For the multi-stock hypothesis the sub-committee **agreed** to use the five putative socks proposed in SC/66b/IA20. The two hypotheses are thus:

(1) single stock in entire North Pacific; and
(2) five-stock hypothesis: Japan coastal; North Pacific pelagic; Aleutian – Gulf of Alaska; northeast Pacific migratory; and California coastal.

Tentative simplified boundaries for the five-stock hypothesis are shown in Appendix 4. These have been chosen with a view to facilitating the assignment of catches and abundance data to stocks. The proposed boundary between the North Pacific pelagic and Japan coastal stocks is far enough offshore that the coastal catches fall well within the area of the putative coastal stock. The sub-committee **emphasised** that using these boundaries for modelling purposes should not result in them becoming institutionalised, given concerns voiced within the sub-committee on the five-stock hypothesis itself.

4.4 Stock assessment model formulation

Punt presented an outline modelling framework for fitting a single or multi-stock population model to the available catch, abundance and marking data (Appendix 5). The sub-committee **endorsed** the proposed model structure. However, there was considerable discussion as to whether it was sensible to proceed with this work before the potentially substantial revisions to the catch history had been accomplished. The Chair noted that the population modelling work tends to require some iteration, and that it was important to get it started, so as not to delay the assessment even further. It is important that at least some results are available for review at next year's meeting. It will not involve significant extra work to incorporate revisions to the catch history or other input data at a later stage. The sub-committee **agreed** that a two-year budget request should be entered for the population modelling, but to leave open at this stage as to how much of this would be accomplished in the first year.

4.5 Work plan

The sub-committee **agreed** that the intersessional e-mail group appointed last year should continue to overview progress with the agreed tasks: (a) revisions to catch history; (b) analysis of past sighting data; and (c) review initial results from the population modelling and agree any changes that may be required following initial attempts to fit the data (see Annex V).

5. SPERM WHALES

5.1 Review new data

SC/66b/IA01 followed up on work conducted last year (Ivashchenko and Clapham, 2015) in which comparisons of verified Soviet length data with those reported by Japanese factory fleets demonstrated the implausibility of the latter, and indicated systematic mis-reporting of North Pacific sperm whale catches to the IWC. In the current paper, the authors conducted a similar analysis for pelagic sperm whale catches in the Southern Hemisphere, comparing true Soviet length data from the *Yuri Dolgorukiy* factory fleet during 1960-75 to data for the same period reported to IWC by Japan. Prior to implementation of the International Observer Scheme (IOS) in 1972, the Soviet fleet caught 5,536 females, of which only 153 (2.8%) were at or above the minimum legal length of 11.6m. In contrast, during the same period, Japan caught 5,799 females but reported that 5,686 (98.5%) were of legal size. Categorising lengths into half-meter bins shows that 5,133 of the Japanese whales - or 88.5% of the entire length distribution - were reported as being between 11.6 and 12.0m. Large females (>12m) were also 22 times more common in the Japanese catches relative to the Soviet takes. The authors concluded that this unrealistic length distribution, together with the fact that Japanese fleets were supposedly able to catch 37 times the number of legal-sized females as the Soviet fleet, indicates extensive falsification of sperm whale catch data by Japan. Further evidence of mis-reporting was that females >11.5m dropped to 9.1% of the Japanese catch after 1971, when the IOS made cheating much more difficult. That 99.6% of 10,433 males in the pre-IOS catch were also reported as of legal size (significantly higher than the equivalent Soviet figures) was suggested to indicate that falsification and illegal catches were not confined to females. Overall, the study concluded that the Japanese sperm whale data in the IWC catch database are unreliable and should not be used in population assessments.

In discussion, it was determined that there was broad similarity in the coverage, with fleets sometimes operating in the same general areas. It had been noted that the issue of problems with these data had been raised by others in the past. For example, it has been determined that oil yield data had been falsified to cover up catches of undersized whales, problems with male lengths had been found, and there were indications that the sex data may have also been falsified (as they were in the Japanese coastal fishery and for the Soviet catches). Discussions during SC/66a had suggested a possible way to crudely reconstruct the catch record using oil yields (IWC, 2016c, pp.238). It was also noted that the true Soviet data offered a means to examine questions regarding distribution and group composition (among other topics) because the catches were completely non-selective and covered all elements of the population.

Alexander *et al.* (2016) discusses the genetic structure of sperm whales worldwide. The sperm whale provides an interesting example of a long-lived species with few geographic barriers to dispersal. Worldwide mtDNA diversity is relatively low, but highly structured among geographic regions and social groups, attributed to female philopatry. However, it is unclear if this female philopatry is due to geographic regions or social groups, or how this might vary on a worldwide scale. To answer these questions, mtDNA information was combined for 1,091 previously published samples with 542 newly obtained DNA profiles (394 bp mtDNA, sex, 13 microsatellites) including the previously un-sampled Indian Ocean, and social group information for 541 individuals. The study found low mtDNA diversity (π=0.430%), reflecting an expansion event <80,000 years BP, but strong differentiation by ocean, among regions within some oceans, and among social groups. In comparison, microsatellite differentiation was low at all levels, presumably due to male-mediated gene flow. A hierarchical AMOVA showed that regions were important for explaining mtDNA variance in the Indian Ocean, but not the Pacific, with social group sampling in the Atlantic too limited to include in analyses. Social groups were important in partitioning mtDNA and microsatellite variance within both oceans. Therefore, both geographic and social philopatry influence genetic structure in the sperm whale, but their relative importance differs by sex and ocean; this reflects breeding behaviour, geographic features, and perhaps a more recent origin of sperm whales in the Pacific. By investigating the interplay of evolutionary forces operating at different temporal and geographic scales, the authors suggested that sperm whales represent a unique example of a worldwide population expansion followed by rapid assortment due to female social organisation.

Mizroch and Rice (2013) had analysed Japanese pelagic whaling data and *Discovery* mark data to evaluate the historical distribution and movements of sperm whales in the North Pacific. Previously, it had been assumed that there were discrete 'stocks' of sperm whales based on intervals between historical areas of concentration which had been thought to indicate subpopulation boundaries. This paper proposed that there is one nomadic pelagic stock across the pelagic North Pacific. This assumption is congruent with recent genetics studies (Alexander *et al.*, 2016) which found no obvious divisions between separate demes or stocks within the pelagic North Pacific. The analysis showed that female sperm whales in the North Pacific were found much farther north than had previously been assumed. At present, females are rarely seen in the pelagic North Pacific, leading the authors to conclude that the effects of extensive illegal takes of females are still apparent at the present time, many years after whaling ceased. The pelagic population shows little if any signs of recovery. The impacts of the removal of so many females may be disproportionately negative because of the social ecology and mating system of this species.

The sub-committee noted that the different dispersal and distribution patterns of males and females, together with the complex maternal social structure as well as oceanographic influences on distribution, complicated any assessment of sperm whales. Peter Best's so-called 'sperm whale paradox' has suggested that the species appeared to have been depleted by what was likely lower historical catches relative to the modern era, which would imply the expansion of sperm whales could be a more recent phenomenon. However, the genetic data has suggested that the expansion pre-dated the historical fishery. It was noted that the scale of the catches of sperm whales in the North Pacific, where almost 315,000 were caught, was huge; this, together with the Soviet practice of taking entire schools, undoubtedly had major impacts upon the population which likely resonates today. Entire maternal lineages may have been extirpated, and it is likely that the widespread illegal hunting of females by both Japan and the former USSR created a depletion from which the population has not yet recovered.

5.2 Evaluate the possibility of initiating an assessment

SC/66b/IA13 considered the issue of conducting an assessment of North Pacific sperm whales within the California Current region. California Current population size was estimated at 1,997 (posterior median estimate; CV=0.57) in 2014 based upon preliminary analysis of seven surveys conducted in the US EEZ. The authors noted that assessments of North Pacific/California Current sperm whales were challenged by the complex social structure of females and the strong sexual segregation of the species. In addition, the broad and continuous geographic distribution, with no apparent hiatuses, makes adequate sampling and appropriate stratification particularly difficult (Mizroch and Rice, 2013). SC/66b/IA13 presented brief summaries of the many available data types, including genetics, acoustics, diet, tagging, and photo-identification. However, it was noted that the data are patchily distributed and data may be available in one area but not in others. Despite these challenges, the North Pacific/California Current provides a relatively well-studied area, covered in part by recent line-transect surveys. In addition, the history of whaling in the region has been reviewed and several studies have examined population abundance, trends and structure using modern methodologies. Many of the elements for a better assessment are in place for this region of the North Pacific.

The sub-committee thanked the authors for compiling the available data to allow the Committee to consider a future in-depth assessment of sperm whales within the California Current. It was noted that these animals probably do not represent a population unit given evidence of long-distance movements from *Discovery* marks. The possibility of undertaking assessments of sperm whales has been a topic of discussion for some time within an e-mail correspondence Steering Group (chaired by Brownell) under the sub-committee on Other Southern Hemisphere Whale Stocks.

The sub-committee **agreed** that the many uncertainties about sperm whales in this area were likely sufficiently large to preclude an in-depth assessment. Furthermore, these problems apply equally or more so for other areas, and in addition extensive falsification is now known to be involved with the Japanese sperm whale data in the IWC catch database for both the North Pacific and the Southern Hemisphere (Ivashchenko and Clapham, 2015; SC/66b/IA01). In light of all these problems, the sub-committee **agreed** to suspend discussion of sperm whale assessments for the foreseeable future. However, the review provided in SC/66b/IA13 serves as an example of an approach which might be useful within a different management context.

6. NORTH PACIFIC BLUE WHALES

6.1 Review new data

SC/66b/IA12 noted that blue whale populations worldwide have regionally-distinct songs, with two distinct songs in the North Pacific Ocean. The eastern North Pacific (ENP) song consists of two units, pulsed A call and tonal B call, while blue whale song in the central and western Pacific consists only of a distinct tonal call. Variability in tonal calls of blue whale songs provides a basis for evaluating possible population structure hypotheses. Variability at six sites in 2012 and 2013 were investigated. Three sites in the ENP: Gulf of Alaska, Washington coast, and Southern California Bight; and three in the central and western Pacific (CWP): Hawaii, Wake Atoll, and Tinian in the Mariana Islands Archipelago. In the eastern Pacific, the average B call in the Gulf of Alaska was higher in frequency than the average call in the Southern California Bight. In addition, the Gulf of Alaska calls had a substantial frequency downshift in the second part of the call, which was not present in the Southern California Bight calls. Calls off Washington were intermediate between the two other regions' calls in both parameters. Seasonally, blue whale B call occurrence in the Gulf of Alaska and the Southern California Bight was concurrent, with a peak in September. Off Washington, B call detections persisted at low levels through the fall and early winter. The variation in call frequencies and the co-occurrence of peak calling in distinct areas may suggest blue whales in the ENP form two distinct subpopulations. In the CWP, calls of two different frequencies and durations were recorded, but they co-occurred in time and space, making population delineation challenging. Additionally, analyses of the data that are still underway show that ENP and CWP calls overlap off Hawaii and Gulf of Alaska.

In discussion, it was noted by the authors that the available data cannot determine if there are two populations in the CWP since the two calls there are always detected together. It was also noted that if the difference in Gulf of Alaska compared to Southern California Bight indicate separate populations, this would have implications for the recent assessment of ENP blue whales (Monnahan and Branch, 2015): either the total abundance would be higher (since Gulf of Alaska was not included in the abundance estimates), or total catches would be lower (since Gulf of Alaska catches were included in the assessment). Neither scenario would change the conclusions of the assessment that ENP blue whales are nearly recovered.

The sub-committee welcomed these results, and noted the need for more hydroacoustic deployments, particularly in the Gulf of Alaska and in the western North Pacific off Japan to resolve uncertainty in stock structure.

6.2 Evaluating the possibility in initiating an assessment

SC/66b/IA15 presented a summary of catches, sighting surveys, acoustic detections and satellite tagging data for blue whales in the North Pacific. The ENP population is well studied, ranging from the Costa Rica Dome to the Gulf of Alaska, and is thought to be nearly recovered from historical whaling (Monnahan and Branch, 2015). Catches have been divided between the ENP and CWP using differences in call types, but no assessment of the CWP has yet been conducted, despite some reasons for concern. Notably, catches in the CWP were nearly twice as high as in the ENP. In addition, around and south of Japan, after whaling ended few sightings of blue whales have been made. In particular, the Japanese Scouting Vessel (JSV) data from 1965-87 sighted many blue whales in the North Pacific, mostly north of 40°N and 156°E to 129°W, but despite substantial search effort west of Kamchatka Peninsula, no blue whales had been sighted there. Blue whales around Japan were likely seriously depleted or even extirpated. More recent data from JARPN and JARPNII during 1994-2014 found 78 sightings (102 individuals, nine mother-calf pairs) of blue whales west of Kamchatka (145-156°E, Matsuoka *et al.* (2016), so it is possible the blue whales are shifting back into these waters. In summary, the data are available for an assessment of CWP blue whales: catches are listed in this paper, and abundance estimates could be obtained from the JARPN/JARPNII/POWER surveys, which cover most of the range of CWP blue whales. Given the high CWP catches, the uncertainty of stock structure in the CWP, and possible extirpation off Japan, an assessment of CWP stock status is urgently needed.

In discussion, it was noted that 15 individual blue whales from the 2010-14 IWC POWER photo-catalogue were compared to collections in the ENP and Mexican catalogues and no matches were found none. This adds evidence that the POWER survey encounters CWP blue whales and not ENP blue whales.

It was also noted that two CWP call types have been recorded south of the POWER survey and east of the JARPN II surveys in May-July, and around Hawaii in December-January. Additionally in Matsuoka *et al.* (2011) it was reported that blue whale were sighted (26 schools, 34 individuals) in June-July 2010 35-40°N and 157°E-170°W and 32°N-37°N and 145°E-180°E. Thus at least some CWP blue whales are south of the POWER survey area.

There was considerable discussion about blue whales off Japan. It was noted that there were no museum or stranded blue whale records during the past 100 years from Japan, Korea and Taiwan and that there were few records of blue whales in Japanese waters after World War II despite numerous surveys after the mid-1960s. In addition, Omura (1955) reported that blue whales off Japan were depleted because of overfishing. It also seems unlikely that oceanographic shifts were to blame for the absence of blue whales off Japan, since ENP blue whales are still present throughout their range. When locations of the catches from older catcher vessels were compared with the JARPN/JARPNII sightings, it was observed that the older catcher vessels did not venture more than 100 miles from the coast of Japan. Thus, as suggested by Reeves *et al.* (1998) and Clapham *et al.* (2008), this evidence can be interpreted to indicate the population has been extirpated and the blue whales off southeastern Kamchatka were a different population.

In regards to Japanese blue whale catches, the sub-committee recommended a review of old literature before modern whaling be conducted to check the 47 known net catches before 1900.

It was also **agreed** that an assessment would need to examine at least two stock structure hypotheses: one where the entire CWP is a single population; and another where there are two populations, with one including Japan, Korea and Taiwan, and the other encompassing the area east of 145°W (or thereabouts) where CWP calls are detected. Of key importance is the analysis of genetic samples from the area south of Kamchatka and elsewhere in the CWP area. The sub-committee therefore **recommended** analysing biopsy samples from POWER, JARPN and JARPNII and comparing these with genetic data from the ENP population. There are 11 genetic samples from JARPNII which are available to researchers by using the usual IWC Data Availability Agreement Procedure B process.

In summary, to resolve these issues, the sub-committee **recommended** the following was needed to inform an assessment of North Pacific blue whales**:** analyse genetic samples, encourage collection of acoustic data, in-depth review of information, and review the available catch data, especially around Japan. The assessment would look at two scenarios, one based on a whole CWP stock, and one separating the CWP into two populations.

To facilitate preparations for an in-depth assessment an intersessional working group was created (Annex V), chaired by Branch to review available data needed for an assessment of North Pacific blue whales.

7. NORTH PACIFIC HUMPBACK WHALES

7.1 Review new data

The first comprehensive photo-identification and genetic study of humpback whales throughout the North Pacific occurred in 2004-06 during the SPLASH project (Structure of Populations, Levels of Abundance and Status of Humpbacks). Photo-identification data from SPLASH have previously been analysed to estimate total abundance for the entire North Pacific as 21,808 (CV=0.04) (Barlow *et al.*, 2011). SC/66b/IA21 presents additional analyses of the SPLASH photo-identification data to provide regional estimates of abundance within all sampled winter and summer areas in the North Pacific, as well as estimate migration rates between these areas. A multi-strata mark recapture model was fit to the photo-identification data using a six-month time-step, with the four winter areas and the six summer areas defined to be the sample strata. The best model, as selected by AICc, had a capture probability that was different in each strata and each year, and included the non-Markov movement model. The strongest migratory connection was between the Kamchatka feeding area (*n*=1,111, CV=0.37) and the Asia breeding area (*n*=1,059, CV=0.08). The feeding areas in Alaska, as well as northern British Columbia, support the majority of the North Pacific population, including the Aleutian Islands and Bering Sea (*n*=2,427, CV=0.20), the Gulf of Alaska (2,089, CV=0.09), and southeastern Alaska and northern British Columbia (*n*=6,137, CV=0.07). Those feeding areas all have a strong migratory link (Psi; i.e. probability of movement from one strata to another > 0.86) to Hawaii (*n*=11,398, CV=0.04), with the link between southeastern Alaska/northern British Columbia and Hawaii (Psi=0.94, CV=0.17) particularly high. In return, nearly all Hawaiian whales migrate to Alaska and northern British Columbia. The migratory destination of whales that winter in Mexico (*n*=3,264, CV=0.06) is the most diverse, with whales going to all feeding areas except Kamchatka, with the highest proportion going to California and Oregon (Psi=0.74, CV=0.06). Nearly all Central American whales (*n*=411, CV=0.30) migrate to California and Oregon to feed (Psi=0.92, CV=0.06), but the California/Oregon feeding area (*n*=3,734, CV=0.11) represents primarily whales that migrate to Mexico (Psi=0.90, CV=0.16), with the remainder migrating to Central America (Psi=0.10, CV=0.45).

The sub-committee commended the enormous effort this project took, where hundreds of researchers collected thousands of photos and biopsies, which then involved several years to determine matching between the photos. The photos are currently publically available.

SC/66b/IA19 followed on from a simple and preliminary population model presented last year regarding North Pacific humpback whales (Ivashchenko *et al.*, 2015). Following suggestions from the Committee and others, the authors presented an updated and more complex assessment. Three scenarios were examined relating to the assignment of the historical catches in the Asia and California/Oregon regions. The data on current abundance and exchange rates were the same for all scenarios. The results were not notably sensitive to the choice of catch series, and population trajectories were produced for each feeding and breeding area. Estimates of pre-exploitation abundance for the total North Pacific ranged from 13,000 to 20,000, depending on the catch scenario used. The model was able to mimic the central tendency of the estimates of abundance for each feeding and breeding area. In addition, in the case of the Asian breeding grounds in Western North Pacific, including Okinawa and the Philippines, the model mimicked the trend inferred from the abundance estimates. However, the model was unable to mimic the change in abundance for the Hawaiian and Mexican breeding grounds and the Gulf of Alaska feeding ground. Two of the breeding stocks (Russia and Central America) are estimated to have been severally depleted but to be recovering or recovered. Unexpectedly, the reductions in the Hawaiian and Mexican breeding stocks were estimated to be limited, which is a key reason the model cannot mimic the trends in the abundance estimates for these breeding grounds.

The sub-committee noted that SC/66b/IA19 represented an excellent first step in developing a multi-stock assessment model for North Pacific humpback whales, and welcomed further development of the model for next year's meeting.

SC/66b/O02 reviewed recent survey work on humpback whales in the Mariana Islands (north of Guam and south of the Ogasawara Islands) in the western North Pacific. Humpbacks have been known from whaling operations in the region of the Mariana Islands since the middle of the 19th century, but their current range and status is poorly known. Since the middle 1970s, there were 19 incidental sighting reports of humpback whales around the southern portion of the Mariana Archipelago. In 2007, the Mariana Islands Sea Turtle and Cetacean Survey, a shipboard visual and passive acoustic line-transect survey, was conducted within the US Navy Mariana Islands Range Complex from January to April 2007. During the winters of 2015 (February-March) and 2016 (March) the Pacific Islands Fisheries Science Center's Cetacean Research Program partnered with the US Navy to conduct small-boat photo-identification and genetic monitoring surveys for humpback whales off Saipan. A total of nine different mother-calf pairs and four non-calf whales were encountered during the 2015-16 surveys. Three fluke photo-identification images and nine biopsy samples were collected from these 22 individuals. Comparisons of the three new fluke images to those of five humpback whales photographed off the Marianas in 2007 resulted in a match of a female with a calf in 2016. Comparisons with other WNP humpback whale catalogues from Ogasawara and Okinawa would be valuable to compare the Saipan photographs. In the near future the genetic analyses from the biopsy samples will be reported.

The sub-committee welcomed this new work on humpback whales in the Mariana Islands and look forward to receiving more details in the future on additional surveys and other results.

The sub-committee also **recommended** that the various humpback whale fluke catalogue holders get together and attempt to match photos and report back to the Committee. This information is necessary for the assessment of the North Pacific humpback whales.

7.2 Evaluate the possibility in initiating an assessment

The data and information relevant to an assessment for North Pacific humpback whales that are currently available are summarised in Appendix 6. After examining this list and reviewing the new information presented above, the sub-committee **agreed** that there was sufficient information available to consider initiation of an in-depth assessment of North Pacific humpback whales.

In many cases, the first step of an assessment is a meeting to develop abundance estimates, review the catch history, analyse genetic information, and development an assessment model. In this case many of the major results relevant to an assessment have already been published or are at least completed (e.g. SC/66b/IA21). In addition, an assessment model has already been presented at this meeting (SC/66b/IA19). Consequently, the sub-committee **agreed** that it would be possible to start the assessment as a pre-meeting prior to SC/67a next year. It was noted that though the assessment model presented this year included a compilation of an extensive catch history, the model would need to be updated to account for all the data and species-specific issues to be considered.

To facilitate completing the work needed for the assessment to commence next year an intersessional working group was formed with four main tasks (Annex V). Ivashchenko agreed to coordinate the development and testing of the assessment model in collaboration with Punt, Wade and Zerbini (modeler to be decided). She also agreed to work with Japanese and other relevant colleagues to assess whether additional catch data are available for whaling that occurred prior to 1900; this might include data from Taiwan, from Yankee whaling and from a native fishery in the Kamchatka/Aleutians Islands area. Additional information needed included: new estimates of abundance (after 2004-06, to which the SPLASH estimates relate); new data on population structure and movements; and information on human impacts, including entanglement and ship strikes. It will also be necessary to consider different hypotheses for population structure for the assessment model, such as (among others) changing feeding area boundaries, including the 'unknown' breeding area identified by SPLASH, and splitting the Mexican breeding grounds. Additional information on population structure might be available from further analyses of SPLASH samples and from consideration of alternate boundaries. This could include feeding grounds, e.g. inshore/offshore strata in the Gulf of Alaska, and breeding grounds, e.g. alternate latitudinal strata for Mainland Mexico/Central America, and information from mixed stock analyses of mtDNA haplotypes.

8. NORTH PACIFIC SURVEYS

8.1 Review of 2015 IWC-POWER sighting survey

SC/66b/IA09 reported on the 2015 IWC-Pacific Ocean Whale and Ecosystem Research (POWER) cruise. The 6th annual IWC-POWER (as a successor to the IWC/IDCR-SOWER cruises since 1978/79 in the Antarctic) was successfully conducted from 11 July to 22 August 2015 in the central North Pacific (north of 20°N, south of 30°N, between 170°E and 160°W) using the Japanese Research Vessel *Yushin-Maru No.3*. Original transect design had to be adapted in order to circumnavigate the Papahanaumokuakea Marine National Monument area in the middle of the survey area. The cruise was organised as a joint project between the IWC and Japan. The cruise plan was endorsed at the SC/66a meeting. Researchers from Japan, USA and UK participated in the survey. The cruise had five main objectives: (a) provide information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure; (b) provide information relevant to *Implementation Reviews* of whales in terms of both abundance and stock structure; (c) provide baseline information on distribution and abundance for a poorly known area for several large whale species/populations, including those that were known to have been depleted in the past, but whose status is unclear; (d) provide biopsy samples and photo-identification photos to contribute to discussions of stock structure for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear; and (e) provide essential information for the intersessional workshop to plan for a medium-long term international programme in the North Pacific. The sighting survey was conducted under the methods based on the guidelines of the Committee (IWC, 2012). The predetermined transect lines were completed within the anticipated schedule, where survey coverage was 95.6% of the research area. A total of 1,198.5 n.miles and 1,151.3 n.miles were surveyed in the Passing (NSP) and Independent Observer (IO) mode, respectively. Totals of 765.2 and 291.9 n.miles were also surveyed during transit to and from the research area. Bryde's (27 schools/32 individuals) and sperm (11/50) whales were the only large whale species recorded. Other cetacean species sighted were dwarf sperm (1/6) Cuvier's beaked (3/6), Longman's beaked (1/110) *Mesoplodon* (1/2), *Ziphiidae* (4/4), short-finned pilot (1/32), killer (1/4) whales; Risso's (1/3), bottlenose (4/36), rough toothed (2/54) spotted (3/162), striped (5/279) and Fraser's (2/233) dolphins. The Estimated Angle and Distance Training Exercises and Experiments were completed as in previous years. Photo-identification data for 29 Bryde's, three sperm and four killer whales were collected. Bryde's and sperm whales were the only sighted large whale species and were widely distributed within the research area. A total of 199 marine debris items was recorded. A total of 37 biopsy (skin and blubber) samples were successfully collected from one sperm, two killer and 34 Bryde's whales using the Larsen-gun system. Of the Bryde's whales, 22 samples (from 22 individuals) were collected from sub-area 1 (west of 180°E) and 12 samples from sub-area 2 (180°E-170°W). The 6th cruise of the POWER program provided important information on cetacean distribution in an area where limited recent surveys have been conducted.

On behalf of the sub-committee, Kato thanked the Cruise Leader, researchers, Captain and crew, and the Steering Committee for completing the 6th cruise of the IWC-POWER programme. The Government of the USA had granted permission for the vessel to survey in their waters, without which this survey would not have been possible. The Government of Japan generously provided the vessel and crew. Furthermore, the IWC Secretariat was thanked for providing support. In particular, the sub-committee thanked David Mattila from the Secretariat for the entanglement rescue seminar he gave to the crew members before departure. The sub-committee recognised the value of the data contributed by this and the other POWER cruises, collected in accordance with survey methods agreed by the Committee, covering many regions not surveyed in recent decades, and addressing an important information gap for several large whale species. The sub-committee looked forward to receiving abundance estimates arising from these data.

The sub-committee also welcomed news that the photo-identification data had been sent to the Secretariat for uploading into catalogues, and biopsy samples had been sent to the Southwest Fisheries Science Center for storage on behalf of the IWC. Issues concerning this survey programme will be investigated further at the upcoming POWER Technical Advisory Group (TAG) Workshop to inform the medium- and long-term planning.

In discussion of the 2015 POWER cruise it was recognised that despite the difficulties arising from the Papahanaumokuakea Monument in the middle of the study area, the survey design had been appropriately adapted and changes had not caused many difficulties or biases in the data. Furthermore, it was noted that the absence of sei whale sightings during the survey can be considered as an indication that the southern limit of summer sei whale distribution at 40°N. Sightings of five mother-calf pairs of Bryde's whales in the western part of the study area were highlighted. The estimated lengths of the calves at 7.5-8.5m indicated that these were not newborn calves and it was noted that the sightings were recorded outside of the breeding season. The sub-committee also noted that guidelines are being developed by the *ad hoc* Working Group on Guidelines for Photo-identification Databases, which will be incorporated as appropriate in future cruises.

8.2 Review of other North Pacific cruises

SC/66b/IA10 reported on a systematic large-scale vessel-based sighting survey that was conducted in 2015 by Japan to examine the distribution and abundance of large whales in the North Pacific. The research area was set between 35°N and 52°N and between 157°E and 170°E (sub-area 1 for North Pacific Bryde's whales). The research area was divided into an eastern and a western stratum at 163.30°E. The survey was conducted between 23 April and 6 June 2014. The research vessels *Yushin-Maru* and *Yushin-Maru No.2* were engaged in this survey. A total of 2,660.2 n.miles were searched in the survey area. Successful coverage of the tracklines was 87.8% for the eastern stratum and 87.4% for the western stratum. In total, seven large whale species, blue (10 schools/15 individuals), fin (19/25), sei (40/56), common minke (2/2), humpback (10/12), North Pacific right (2/3) and sperm whale (34/113) were sighted during the survey. Photo-identification data were collected from blue (12 individuals), humpback (9) and North Pacific right whales. Biopsy samples using a crossbow were successfully collected from blue whales (6 individuals), fin (3), common minke (1), humpback (5) and North Pacific right (2) whales.

The sub-committee welcomed this report and recognised the series of very productive surveys under this programme and looked forward to receiving abundance estimates arising from these data. The sub-committee also thanked Matsuoka for overseeing this survey on behalf of IWC.

In discussion it was noted that the North Pacific right whales sighted were not observed feeding. These observations are in line with results from the SPLASH project and suggest that right whales are migrating at this time of the year. The value of the collected data was pointed out. Spatial analyses of the data are intended to also include data from the following survey and so will only be conducted thereafter.

SC/66b/IA17 reported on a systematic large-scale vessel-based sighting survey that was conducted in 2015 by Russia in the northern Okhotsk Sea (a part of sub-area 12 NE for the common minke whale RMP *Implementation*). The objective of the survey was to obtain information on distribution and abundance of whales and dolphins. The research area was between 50°N and 57°N and 137°E and 157°E. This area had not been surveyed during the past 25 years. The research vessel *Vladimir Safonov* was engaged in this survey and six Russian and one Japanese scientist participated in the cruise. The survey was conducted between 7 August and 12 September 2015. The area covered by the cruise was separated into two blocks, the southern block designated for training of the sighting survey methods and the northern block B designated as the research area. Normal closing mode including photo-identification for large cetaceans and passing mode for small cetaceans were primarily used. The survey was conducted at visibilities better than 1.5 n.miles and wind speeds below 7.5m/s. The vessel speed did not exceed 10 knots. A total of 745 n.miles was searched in the survey area. Successful coverage of 97% of the pre-determined track lines was achieved. In the training area, 301 n.miles were searched and 1,294 n.miles during transit. In total five large whale species, fin (38 schools/87 individuals), humpback (1/2), North Pacific right (4/5), common minke (11/11) and sperm (1/1) whales were sighted during the survey. Other cetacean species sighted were killer whales (9 schools/19 individuals), Dall's (175/626) and harbour (4/10) porpoises. Photo-identification data were collected from one humpback whale. Trials for collecting photo-id data from right and killer whales were unsuccessful. Distribution patterns of recorded species were similar to previous surveys in the Okhotsk Sea. Fin whales were distributed widely in the research area, but slightly more abundant in the shallow waters. North Pacific right whales were found throughout the research area. Minke whales were most abundant in coastal waters. Killer whales were abundant in shallow waters. Dall's porpoise was the most frequently sighted cetacean species. Humpback whales were found close to the entrance of the Shelikhov Gulf. Data from this survey will be analysed together with data from the 2016 survey. Results will be presented to the Committee in 2017.

The sub-committee welcomed this report and recognised the value of this program that is surveying an area which has not been surveyed for 20 years. The sub-committee looked forward to receiving abundance estimates arising from these data and also thanked Tomio Miyashita for overseeing this survey on behalf of IWC.

In discussion, it was noted that (compared to data from 20 years ago) lower than expected minke whale numbers had been observed. The north-eastern corner of the Okhotsk Sea, which is known as an important minke whale habitat, had not been included in the survey due to logistical constraints. This area will be included in the upcoming survey in 2016. Moreover, the absence of gray whale sightings was noted. This was mainly attributed to shallow shelf areas not having been surveyed.

The plan is to analyse these data using spatial modelling and to seek advice from Japanese colleagues to evaluate the option of pooling data with the Japanese data. Japan confirmed plans for collaboration and joint data analyses with data from surveys dating back to 1989. Japan thanked Russia for surveying the waters of the Okhotsk Sea.

8.3 Review planning meeting report for 2016 cruise

Donovan introduced the report of the TAG (Technical Advisory Group) to the IWC-POWER (SC/66b/Rep01), who had met at the Japanese Fisheries Agency crew house, Tokyo, Japan from 7-9 October 2015. Its primary objective was to review the available information from the first five cruises and to develop a plan to design a medium-term programme to meet the Commission's agreed long-term objectives relating to status, trends and causes of any trends.

Species distribution maps for the first six years of surveys were developed and reviewed in conjunction with other information from non-POWER surveys to identify where the final surveys for the short-term programme should take place. Information on the efficiency of taking biopsy samples over the six years was examined, which will prove valuable in planning for the medium-term. Median times ranged from 20-25 minutes for Bryde's, sei and fin whales to around 45 minutes for blue, humpback and killer whales.

There was some focus on aspects of visual survey methods including: how to treat unidentified whales (including a recommendation for further work with respect to sei and Bryde's whales), the possibility of $g(0)$ being <1 for sei and Bryde's whales and agreement to undertake Independent Observer mode during the next survey(s) to ascertain this. The TAG was pleased that improved angle and distance measurements had been undertaken on the 2015 cruise and some additional suggestions in terms of logistics and analysis were made. The importance of spatial/habitat modelling work and the associated need to consider information on potential explanatory variables was emphasised and a number of suggestions for further work identified. A plan for a broad scale spatial modelling approach was developed.

Collaboration with other groups was also stressed with respect to cetacean studies as well as marine debris and the collection of non-cetacean data (e.g. sea turtles) and ways to achieve this were identified.

The importance of combined visual/acoustic survey approaches for estimating sperm whale abundance was recognised and it was agreed that this could usefully be taken forward at the 2016 Scientific Committee meeting. Information from experts that telemetry work was feasible from a large vessel such as that being used at present was welcomed and this will be taken forward in the context of the medium-term programme.

There was also recognition of the importance of developing a new fully functional relational database to enable efficient storage of the several kinds of data collected and to facilitate analyses of the data (including a more effective mapping option). This should also be integrated with any onboard data collection system. A strategy for developing this system was agreed.

The sub-committee thanked Japan for hosting the workshop and underlined the value of these successful collaborative efforts. In discussion it was emphasised that the photo-identification work conducted during the POWER cruises is remarkably successful, producing a large number of photo-identification matches from different catalogues of humpback, killer and blue whales every year. It was noted that all photo-identification and biopsy sampling data are available upon request and recalled that requests should follow the data request protocols.

Much of the waters of the Bering Sea projected to be covered in 2017-19 are within the EEZs of the Russian Federation or the USA, so permits are needed when the ship enters national waters. The sub-committee **strongly expressed** how important it was to survey the Russian waters to understand the abundance and distribution of the many cetacean species there which are not frequently surveyed. It is expected one Russian scientist will participate in the cruises conducted in Russian waters. The Russian scientists present were interested in collaborating and stated they would provide what support they could to assist in obtaining the permits. Details will be discussed during the Tokyo POWER Planning Meeting in October 2016, where a Russian scientist will participate. It was underlined that permits for both US and Russian territorial waters should be requested in a timely manner.

Donovan introduced the Report of the Planning Meeting for the IWC-POWER Cruise for 2016 (SC/66b/Rep02) which was held at the Japanese Fisheries Agency crew house, Tokyo, from 9-10 October 2015. The Planning Meeting finalised details for the forthcoming IWC-POWER cruise to be held from 1 July-30 August 2016 including transit from and to Japan, using a research vessel, which will be the same type as in the previous cruises (e.g. the *Yushin-Maru No. 3*), kindly provided by Japan. This will be the seventh cruise under the successful international IWC-POWER programme. The proposed plan will cover waters from 170°W to 160°W between 20°N and 30°N; some 32 days will be available in the research area. The cruise will *inter alia* provide: (a) information for the proposed *Implementation Review* of Bryde's whales in terms of both abundance and stock structure; (b) baseline information on distribution, stock structure and abundance for a poorly known area for cetaceans, including those that were known to have been depleted in the past but whose status is unclear; (c) essential information for the development of the medium-long term international programme in the North Pacific in order to meet the Commission's long-term objectives.

Data collection will focus upon abundance estimation using line-transect data (including additional emphasis on the use of 'Independent Observer' mode to investigate whether $g(0)$, the number of whales seen on the trackline, which prior data suggest is <1 for Bryde's whales, can be estimated with sufficient accuracy and precision to allow unbiased estimates of abundance to be developed – assuming that $g(0)$ is 1 leads to negatively biased estimates), biopsy sampling and photo-identification studies. The possibility of collecting data on microplastics is being investigated. Data on marine debris are routinely collected.

A number of tasks to be completed prior to the cruise were identified including application for permits, final choice of researchers (Koji Matsuoka of Japan has been nominated as Cruise Leader), updating of Guidelines for Researchers and obtaining necessary equipment including biopsy darts and improved equipment for angle and distance experiments. Appropriate deadlines and responsible persons were identified.

8.4 Review plans for 2017 and 2018 POWER cruises

SC/66b/IA06 outlined the line transect sighting survey cruise plans for the 2017 and 2018 IWC-POWER as part of the short term research programme. It is assumed that the research vessel, *Yushin-Maru No.3* (*YS3*), will be available for both cruises. It is proposed that the 2017 and 2018 cruises will be conducted in the Bering Sea, where the POWER cruises have not yet been conducted. Photo-identification and biopsy experiments are also planned. The cruise will take place mainly in July and August. The duration of the survey will be approximately 60 days involving 14 days in transit and 46 days in the research area. The outcome of the survey would also contribute to the Intersessional Workshop to Plan for a Medium-Long Term IWC-POWER International Programme in the North Pacific. The data and the report of this survey would be submitted to the Committee meeting soon after the cruise.

The sub-committee welcomed the plan, and thanked the Government of Japan for its generous offer of providing a vessel for this survey. The Steering Group for IWC North Pacific Planning appointed last year was re-established, convened by Kato. Matsuoka was assigned responsibility for IWC oversight.

Discussion focussed on survey strata design. It was noted that the strata did not include coastal areas and boundaries were not aligned with coastlines in order to ensure US and Russian territorial waters were not included in planned strata. The gulf in the northwestern part of the study area was mainly excluded from the survey area because of shallow water depths. However, the authors will consult bathymetric charts again and evaluate feasibility of extending the survey into shallower waters.

It was suggested, to distribute the survey effort less uniformly between the survey strata, more effort be allocated to poorly known parts of the survey area. Most of survey block 1 and the northern part of block 2, the shelf waters of the Bering Sea, have been covered by US sighting and acoustic surveys quite well, while the deep water basin of the Bering Sea in Block 3 has hardly ever been surveyed. The deep water basin of the Bering Sea is a potential habitat for Baird's beaked whales, especially the rare small 'black' form of *Berardius* (Morin *et al.*, 2017). Decisions on the coverage will be finalised at the Tokyo planning meeting.

It was noted that both blocks 2 and 3 comprise of some Russian EEZ waters. It is intended to survey block 1 first, in order to have more time for obtaining permits for the other two blocks. The sub-committee considered re-stratifying the survey area in a way such that the Russian EEZ waters were contained in one block only, thus allowing an additional year to receive a Russian permit. The sub-committee **strongly recommended** the POWER cruise include Russian waters and so the Russian permit be applied for as soon as possible. The sub-committee also **recommended** the IWC Secretariat send a letter of support to the appropriate authorities within the Russian Federation to encourage collaboration and request the necessary permits. Moreover, it was suggested to explore whether there had been any precedents for permits for Japanese ships operating in Russian waters, in order to aid in required procedures. Decisions on the final survey design will be made during the Tokyo planning meeting in October.

SC/66b/O01 presented a proposal for inclusion of passive acoustic monitoring using sonobuoys in the upcoming POWER surveys of the Bering Sea. Such monitoring can be conducted without disruption of other survey activities, and represents a means to significantly extend coverage of cetaceans in the study area. In addition, it would potentially allow the survey to find critically endangered North Pacific right whales (the highest priority species in this region) for photo-identification and biopsy sampling. Acoustic recorders and sonobuoys obtained from the US Navy could be provided for the POWER surveys at no additional cost. Operations would require room for one additional person on board and some space for sonobuoys on deck.

The sub-committee welcomed this proposal and emphasised the great additional value acoustic monitoring would contribute to the POWER surveys in the Bering Sea. The POWER steering group was **recommended** to look at required logistics and facilitate implementation of acoustic surveys.

Because of the questions surrounding obtaining Russian permits, it was **agreed** that acoustic monitoring should be commenced in US waters only, where no problems with obtaining permits are expected.

Matsuoka introduced the report of the small group planning the 2017 and 2018 IWC-POWER cruises (Appendix 7). The small group undertook preliminary planning for the cruises in accordance with the suggestions by the Technical Advisory Group (TAG) of POWER (SC/66b/Rep01) and a proposed plan (SC/66b/IA06). The details of the cruises will be finalised at the Tokyo planning meeting, which is planned for 15-18 September 2016. In addition, preliminary planning of the 2019 cruise will also be undertaken at this meeting. It was noted that passive acoustic monitoring is planned to be conducted on at least the 2017 cruise, as proposed in SC/66b/O01, in addition to the usual distance and angle estimation, photo-identification, and biopsying. Passive acoustic monitoring will be conducted without affecting normal survey activities (e.g. sighting survey).

In discussion, the sub-committee agreed that passive acoustic monitoring would add valuable information and **recommended** including it into the survey. The sub-committee also **agreed** that initial consideration on research area and cruise track design for the 2017-19 cruises will be undertaken intersessionally and results reported at the Tokyo planning meeting. It was confirmed that a meeting room at the Japanese Fisheries Agency crew house, Tokyo will again be available for the upcoming 2016 meeting as well as for a special editorial workshop for the IDCR-SOWER commemorative volume (19-20 September 2016) (see also Item 3.1).

8.5 Review plans for other North Pacific cruises

SC/66b/IA07 presented a plan for a systematic vessel-based dedicated sighting survey in the North Pacific 2016 by Japan as a part of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPNII). The main objective of this cruise is to examine the distribution and estimate the abundance of sei whales for management and conservation purposes. The survey will be conducted using the research vessels *Yushin Maru* and *Yushin-Maru No.2* between 29 July and 6 September 2016, and take place in the area between 35°N-43°N and 140°E-150°E (a part of sub-areas 7CS, 7CN, 7WR and 7E for minke whales). For the objective of abundance estimation, distance and angle estimation experiments will be conducted. Biopsy skin samples of blue, fin, sei, Bryde's, humpback and North Pacific right whales will be collected. Photo-identification experiments on blue, North Pacific right and humpback whales will also be conducted. The report of the sighting survey will be submitted to the 2017 Scientific Committee meeting.

The sub-committee **endorses** this proposal, and Matsuoka was appointed to provide IWC oversight.

It was noted that the proposed direction of travel in the offshore survey blocks could be following the seasonal migrations of minke whales. Consequently an alternative design minimising transit times between survey strata was suggested. However, the sub-committee was told that the proposed design was chosen due to logistics and to maximise the time in the survey area.

SC/66b/IA11 presented a plan for a systematic vessel based dedicated sighting survey in the northern Okhotsk Sea in 2016 by Russia. The research vessel *Vladimir Safonov* will conduct a sighting survey using primarily normal closing mode. Six Russian and one Japanese scientist will be involved. The research period will take 35 days; total survey distance covered will be about 2,000 n.miles. The research area will include two survey blocks. Block A comprises the entire Shelikhov Gulf. Block B comprises the coastal waters of the northern Okhotsk Sea north of 57°N. Photo-identification data will be collected from large cetaceans. The sighting data of both cruises from 2015 and 2016 will be analysed using distance analysis techniques. The data in block B will contribute to the evaluation of process error. Cruise results will be submitted to the next Scientific Committee meeting in 2017.

In discussion it was reported that the survey area had been chosen because no information on cetaceans was available from the area. The northern Okhotsk Sea had never been targeted by a dedicated cetacean survey before the commencement of surveys as part of the newly established cooperation with Japan. Concern was raised with regard to the quality of photo-identification data to be obtained from the cruise, because small boats are not available and better cameras are needed. It was suggested to consider re-locating the transit back from the survey area in order to travel along the coast of Kamchatka which is a habitat where there was a good chance of encountering North Pacific right whales. Though opportunistic collection of sighting data is intended during transit, logistic restraints may not allow rerouting of the transit, but possibilities will be explored.

The sub-committee **endorsed** this proposal and Miyashita was appointed to provide IWC oversight.

8.6 Mid- and long-term recommendations for the IWC-POWER cruises

The sub-committee **endorsed** the mid- and long-term recommendations for the IWC-POWER cruises that were discussed at the TAG meeting and under Item 8.3. At this time, it was not necessary to update the recommendations until more data are collected and analysed.

9. DATABASES

9.1 Update of IWC-DESS database

Validation of the sightings data from the 2013 and 2014 POWER cruises is now complete. Hughes expressed her appreciation to Matsuoka for his assistance in this work. Data from the 2015 cruise has been received by the IWC and the validation process has just begun.

Limited progress was made towards developing the design of a new IWC integrated relational database that links the various types of data that are collected for and archived within the IWC: sighting, effort, and weather line transect related data; photographs; biopsies; processed genetic data; and processed passive acoustic data. It is also envisioned that these data would be linked to the various catalogues of both photos and genetic information, linked to the catch data, and linked to spatially explicit physical and biological environmental-type data collected from outside sources that could be used in spatial models of the sightings and catch data. The sub-committee noted other features of the database system should include the ability to produce maps of these data; utilise code mapping tables that translate inputted data from various sources to standardise variables and codes; output data in a format that could be used as input to analytical tools, such as the DISTANCE software (used to analyse line transect data); and output data in a flat file format so it could be sent to other data users. They also noted it was important to include web access, which could be used to both input and export data.

To further the development of the design of the database system, the sub-committee **recommended** an intersessional Working Group to detail the variables already archived, consider other needed variables, and explore the general designs of databases used by other whale researchers and other large international organisations such as FAO or CCAMLR (Annex V).

10. REVIEW OTHER ABUNDANCE SURVEYS

SC/66b/O05 presents a plan for a cetacean line-transect sighting survey to be conducted by COMHAFAT in coastal waters of Mauritania to Guinea-Bissau during a 15-day cruise within the time period November 2016 to February 2017. The research vessel, *General Lansana Conte* of Guinea (198 tons) will be used. Researchers from COMHAFAT member states will conduct the survey, though scientists from non-member states may be involved if COMHAFAT and vessel capacity allow for it. Cetacean searching will be conducted using standard closing mode line transect methods under good weather condition (Beaufort wind scale of 3 or less and greater than 2 n.miles in visibility). Results will be reported to the Scientific Committee.

The sub-committee welcomed this survey proposal and considered it a well-designed project. It was determined that IWC oversight was not necessary for this survey. The sub-committee looked forward to the results of this survey, in addition to the results of other similar surveys recently conducted by the COMHAFAT.

11. OTHER

SC/66b/IA02 reported results of an investigation into the accuracy of Soviet factory ship noon position data as reported to the IWC. It has generally been assumed that noon positions were accurate, despite that nation's extensive illegal whaling, as previously discussed by the Committee, for example in IWC (2016b) and Ivashchenko *et al.* (2013). Comparison of available track data from Soviet whaling industry reports with information submitted to IWC shows that the officially reported data provide a reasonably accurate idea of general whaling effort, with minor discrepancies attributable to differences in precision or to geo-referencing. However, the Soviet report tracks sometimes include unreported excursions for the purpose of illegal whaling, and these were omitted from the data sent to IWC. The paper provided a list of available data with which to compare tracks. In conclusion the authors noted that some caution should be used when using Soviet noon positions in any analysis.

In discussion, the Russian scientists present stated that at this time they could not comment on the accuracy of this information. In order to clarify this issue and provide a more considered review, they proposed that the authors send their data (including sources, and information on where the original data are stored) for official examination by appropriate Russian governmental authorities (i.e. to the Ministry of Natural Resources, which is the ministry responsible for the participation of Russia in the IWC). They also proposed that to facilitate discussion in the future, any papers that refer to analyses regarding USSR falsifications are provided to the Russian authorities in sufficient time ahead of a meeting to allow review by the Russian Federation, so that their view can be presented at the same meeting as the analysis.

The sub-committee noted this proposal and **agreed** that where it was possible, notification of papers could facilitate discussions. The authors of SC/66b/IA02 noted that the true catch data obtained from Soviet whaling industry reports and other Russian sources had been accepted as the data of record by IWC and incorporated into the catch database. In addition, they volunteered to provide a list of Soviet whaling industry reports to a Russian representative, and stated that they had been informed by a previous Russian Commissioner (Ilyashenko) that copies of these reports exist in the Fisheries Ministry archives in Moscow.

12. UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

The draft list of abundance estimates was examined and a few minor changes were sent to Allison (see Annex S).

13. WORK PLAN AND BUDGET REQUESTS

The sub-committee examined it progress at the end of this meeting and **agreed** to concentrate efforts for the next two years on only a few in-depth assessments that are in different stages of development (Tables 2 and 3). Progress is expected intersessionally through the work of several working and steering groups (Annex V). The sub-committee also developed budget proposals to facilitate progress on three topics, the in-depth assessment of North Pacific sei whales and humpback whales and the collection of new data from the North Pacific during IWC-POWER cruises (Table 4). The sub-committee **recommended** these proposals be funded to ensure progress is made towards two in-depth assessments and the collection of North Pacific data, particularly in areas infrequently surveyed.

14. ADOPTION OF REPORT

The report was adopted on 15 June 2016 at 23:03, subject to final editorial changes. The sub-committee thanked the Chair. The Chair thanked all of the rapporteurs, in particular

Table 2

Summary of the work plan intersessional during 2016/17 and the 2017 Annual Meeting (SC/67a).

Item	Intersessional 2016/17	2017 Annual Meeting (SC/67a)
Document Indo-Pacific Antarctic minke whale assessment	Working group to draft a report summarising previously available results for the completed assessment.	Review document.
IDCR/SOWER volume	Complete papers and reviews.	Review final papers.
NEWREP-A program	-	Review cruise reports, plans for future cruises, and research results.
In-depth assessment of N Pacific sei whales	Continue progress towards assessment by completing ToR of a Steering group overseeing various tasks.	Review new analyses of input data, continue development of assessment model.
Prepare for in-depth assessment of N Pacific blue whales in the central western population	Continue compilation of data that could be used in assessment; conduct recommended analyses to improve knowledge on stock definition and abundance.	Review new research results and available historical data.
Initiate in-depth assessment of N Pacific humpback whales	Complete ToR of intersessional working group that is preparing for the assessment.	Initiate in-depth assessment during a pre-meeting.
IWC-POWER program	Conduct Tokyo planning meeting for the 2017 cruise, and conduct cruise.	Review cruise reports, research results and plans for the 2018 and 2019 cruises.
Other abundance cruises	-	Review cruise reports, cruise plans, and cruise results for surveys not covered in other sub-groups.
Develop IWC-DESS database	Complete ToR of intersessional working group that is preparing information to develop a scope for a tender to develop the database.	Review progress and develop work plan.

Table 3

Summary of the work plan intersessional during 2017/18 and the 2018 Annual Meeting (SC/67b).

Item	Intersessional 2017/18	2018 Annual Meeting (SC/67b)
Document Indo-Pacific Antarctic minke whale assessment	Finalise document and submit for publication.	-
IDCR/SOWER volume	Finalise papers, peer reviews and publish.	-
NEWREP-A program	-	Review cruise reports, plans for future cruises, and research results.
In-depth assessment of N Pacific sei whales	Continue progress towards assessment.	Finalise assessment.
In-depth assessment of N Pacific blue whales in the central western population	Finalise required data and conduct initial assessment.	Review initial assessment and refine assessment model.
In-depth assessment of N Pacific humpback whales	Complete recommendations resulting from initial assessment.	Review results.
IWC-POWER program	Conduct Tokyo Planning meeting for the 2018 cruise, and conduct cruise, consider refining medium- and long-term recommendations for the IWC-POWER cruises.	Review cruise reports, research results, and plans for the 2019 cruises; develop plans for analysis of the time series of data.
Other abundance cruises	-	Review cruise reports, cruise plans, and cruise results for surveys not covered in other sub-groups.
Develop IWC-DESS database	Continue progress toward developing the database.	Review progress and develop work plan.

Table 4

Summary of budget requests for the 2017-18 period. For explanation and details of each project see text.

Title	Relevance to which sub-committee(s)?	2017 (£)	2018 (£)
Assessment modelling for an in-depth assessment of North Pacific sei whales	IA	2,500	2,500
IWC-POWER cruise	IA, RMP	38,000	38,000
Pre-meeting for an in-depth assessment of North Pacific humpback whales	IA	8,040	0
Total request			

Cooke who produced a draft report in short time. In addition, the Chair thanked the participants for their flexibility (for example, starting to review a section of draft text at 22:00) and for their co-operation and willingness to consider others even in the light of a lively debate.

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Appendix 1

AGENDA

1. Introductory items
    - 1.1 Election of Chair
    - 1.2 Appointment of rapporteurs
    - 1.3 Adoption of Agenda
    - 1.4 Documents available
2. Antarctic minke whales
    - 2.1 Progress on ways to report on the Indo-Pacific in-depth assessment
    - 2.2 Evaluate the possibility in initiating an in-depth assessment focusing on South Atlantic and Antarctic Peninsula
    - 2.3 Consideration of factors that drive Antarctic minke whale distribution
    - 2.4 Distributions of baleen and toothed whales in the Antarctic relative to spatial and environmental covariates
    - 2.5 Statistical catch at age models
3. Antarctic surveys
    - 3.1 Review progress on IDCR/SOWER volume
    - 3.2 Review of 2015/16 NEWREP-A cruise
    - 3.3 Review planning of 2016/17 NEWREP-A cruise
    - 3.4 Review information from other cruises
4. In-depth assessment of North Pacific sei whales
    - 4.1 Abundance and distribution
        - 4.1.1 New surveys
        - 4.1.2 Recent and past surveys
    - 4.2 Catch history
        - 4.2.1 Sei/Bryde's distinction in Japanese coastal whaling data
        - 4.2.2 Individual catch records for 1938-52
        - 4.2.3 Revisions to USSR catch data
        - 4.2.4 Marking data
    - 4.3 Stock structure hypotheses
    - 4.4 Stock assessment model formulation
    - 4.5 Work plan
5. Sperm whales
    - 5.1 Review new data
    - 5.2 Evaluate the possibility in initiating an assessment
6. North Pacific blue whales
    - 6.1 Review new data
    - 6.2 Evaluate the possibility in initiating an assessment
7. North Pacific humpback whales
    - 7.1 Review new data
    - 7.2 Evaluate the possibility in initiating an assessment
8. North Pacific surveys
    - 8.1 Review of 2015 IWC-POWER sighting survey
    - 8.2 Review of other North Pacific cruises
    - 8.3 Review planning meeting report for 2016 cruise
    - 8.4 Review plans for 2017 and 2018 POWER cruises
    - 8.5 Review plans for other North Pacific cruises
    - 8.6 Mid- and long-term recommendations for the IWC-POWER cruises
9. Databases
    - 9.1 Update of IWC-DESS database
    - 9.2 Update on progress with IWC photographic database
10. Review other abundance surveys
11. Other
12. Updated list of accepted abundance estimates
13. Work plan and budget requests
14. Adoption of report

Appendix 2

SIGHTINGS DATASETS FOR USE IN THE NORTH PACIFIC SEI WHALE IN-DEPTH ASSESSMENT[1]

Table 1

Datasets to be used in the North Pacific sei whale in-depth assessment. NR=Not required.

Survey area	Programme	Range of years	Range of months	In IWC database	Analysis	Cruise report or summary report	Sei whales sighted
1. Surveys already analysed (note: years 2000, 2001 and 2010 missing from JARPN/JARPNII analyses)							
Alaskan coastal areas and the pelagic North Pacific N of 40°N	IWC-POWER cruises	2010-12	Jul.-Aug.	Yes	Hakamada *et al.* (2011), Hakamada *et al.* (2012), Hakamada and Matsuoka (2015)	IWC-POWER cruise reports: Matsuoka *et al.* (2011; 2012; 2014; 2013; 2015a).	Many sightings in pelagic areas (2010-12); few sightings in US EEZ (only in 2010).
North Pacific	Japanese scouting vessels (commercial/ chartered)	1964-90	May-Oct.	Yes	5° square summaries (1965-90)	Wada (1975; 1976; 1977; 1978; 1979; 1980; 1981); Miyashita *et al.* (1995).	Many (esp. in early years).
Western North Pacific 150°-170°E, 35-50°N excl. Russian EEZ	JARPN II (offshore)	2000-15	May-Aug.	Yes	Line transect: Hakamada *et al.* (2009) (2002-07); Hakamada and Matsuoka (2016) (2008/09/11/12). Spatial modelling: Konishi *et al.* (2009) (2000-07); Murase *et al.* (2016) (2002-13)	Kiwada *et al.* (2009); Matsuoka *et al.* (2016).	Many in most years
Western North Pacific	JARPN	1994-99	May-Sep.	Yes	Matsuoka *et al.* (2000) (1994-99)	Fujise *et al.* (2000)	-
US west coast	SWFSC	1991, 1996, 2001, 2008	Summer/ autumn	No	Barlow (2010)	Carretta *et al.* (2015)	Few
2. Surveys with significant sei whale sightings in at least some years, awaiting analysis							
Western North Pacific excl. Russian EEZ	NRIFSF (Far Seas Fisheries Research Inst.)	1983-2015	Variable, May-Sep.	No	-	Anon. (1984; 1985; 1986; 1987; 1988; 1989; 1990; 1991; 1992; 1993; 1994; 1995); Kato (1996; 1997; 1998; 1999; 2001; 2002; 2003); Kato and Iwasaki (1998); Kato and Miyashita (2004; 2005); Miyashita (2006); Miyashita *et al.* (2008; 2009; 2007; 2010; 2011); Matsuoka *et al.* (2015b); SC/66b/IA10	Many in some cruises
Kuril/Kamchatka incl. Russian EEZ	NRIFSF	2005	Aug.	No	-	Miyashita (2006).	9 sei whales
US west coast	SWFSC	2014	-	No	-	J. Barlow (pers. commn.)	11 sei whales
3. Surveys with zero or very few sei whale sightings: no analysis required, but used to bound distribution							
Alaskan coastal areas and the pelagic North Pacific S of 40°N	IWC-POWER cruises	2013-16	Jul.-Aug.	Yes	NR	SC/66b/Rep01; SC/66b/IA09	Only 1 sei whale
Alaskan waters, Bering Sea and Arctic	NMML	1999-2012	Spring, summer and autumn	No	NR	Zerbini *et al.* (2006); Friday *et al.* (2012; 2013)	A few Bering Sea and a few in Aleutians Mizroch *et al.* (2015)
Aleutian Islands	SWFSC	1994	Aug.	No	NR	Forney and Brownell (unpubl. data).	None
Gulf of Alaska	NMML	1980	Jun.-Jul.	No	NR	Rice and Wolman (1982).	None
Canadian Pacific		2002-12	Year-round	No	NR	Ford *et al.* (2010), plus unpublished data through 2012 (Ford, pers. comm.).	Only 1 sei whale
Hawaiian waters	PIFSC	2002 and 2010	Summer and autumn	No	NR	Carretta *et al.* (2015)	Very few
Okhotsk Sea	-	-	-	-	NR	Yoshida *et al.* (2011)	Only 1 sei whale
Okhotsk Sea	TINRO	2015	Aug.-Sep.	No	NR	SC/66b/IA17	None
Sea of Japan	NRIFSF	2001-10	May-Aug.	No	NR	Kato and Miyashita (2005); Miyashita and Kato (2006); Miyashita *et al.* (2007); Miyashita *et al.* (2008); Miyashita *et al.* (2009); Miyashita *et al.* (2010).	None

[1]This is an update of the table in *J. Cetacean Res. Manage. (Suppl.)* 17: 124 [2016].

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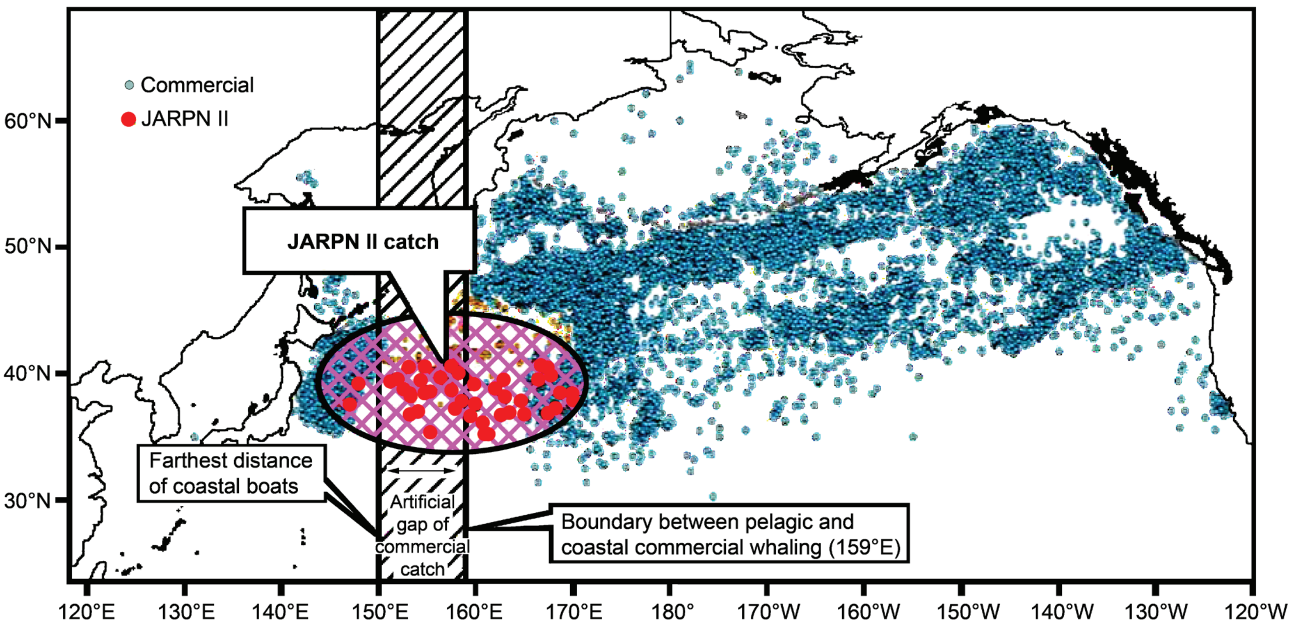
Appendix 3

COMMERCIAL CATCH POSITIONS OF SEI WHALES AND JARPNII (2002-06) IN SUMMER (JUNE TO AUGUST) RECORDED IN THE IWC CATCH DATABASE (VERSION 4)



Appendix 4

SIMPLIFIED STOCK BOUNDARIES FOR THE FIVE-STOCK HYPOTHESIS FOR NORTH PACIFIC SEI WHALES

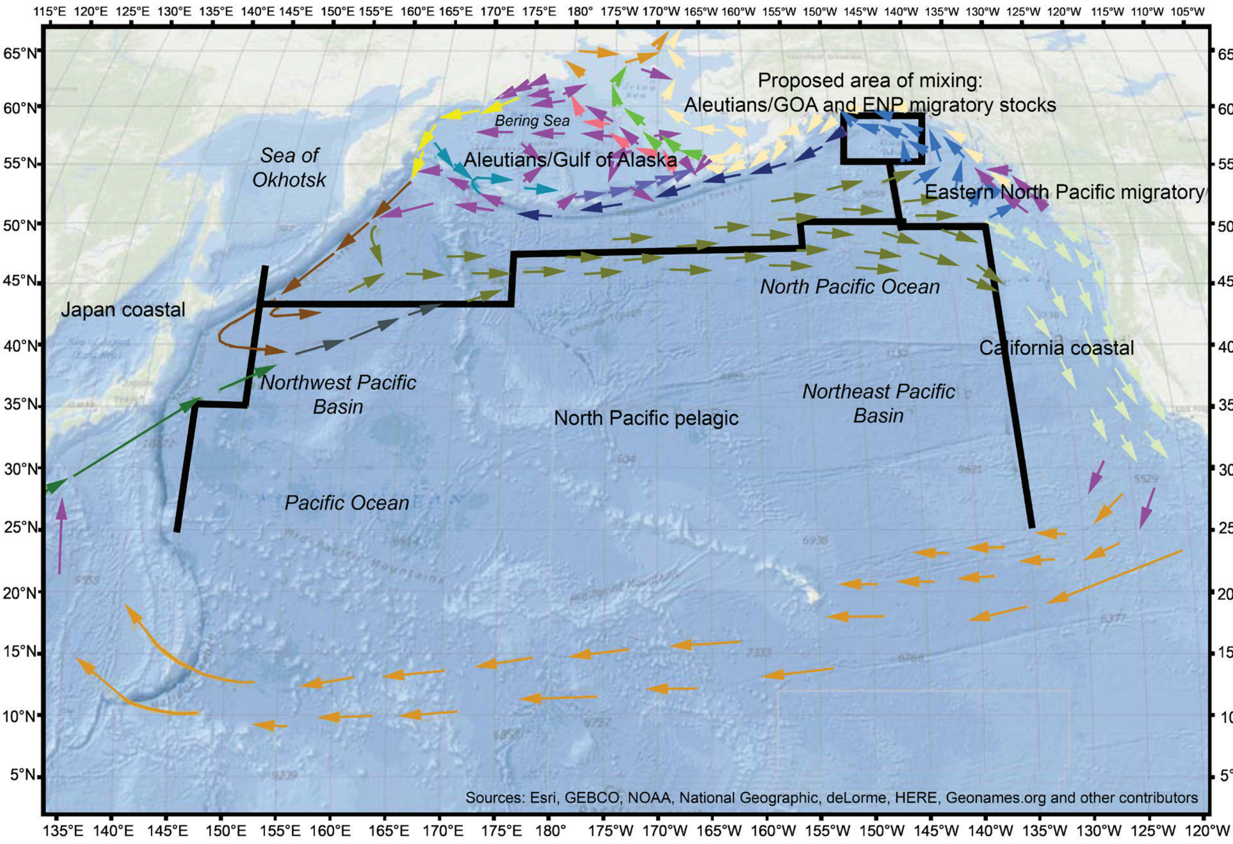


Fig. 1. Catches of sei whales in the North Pacific. Note. USSR pelagic catches not included.

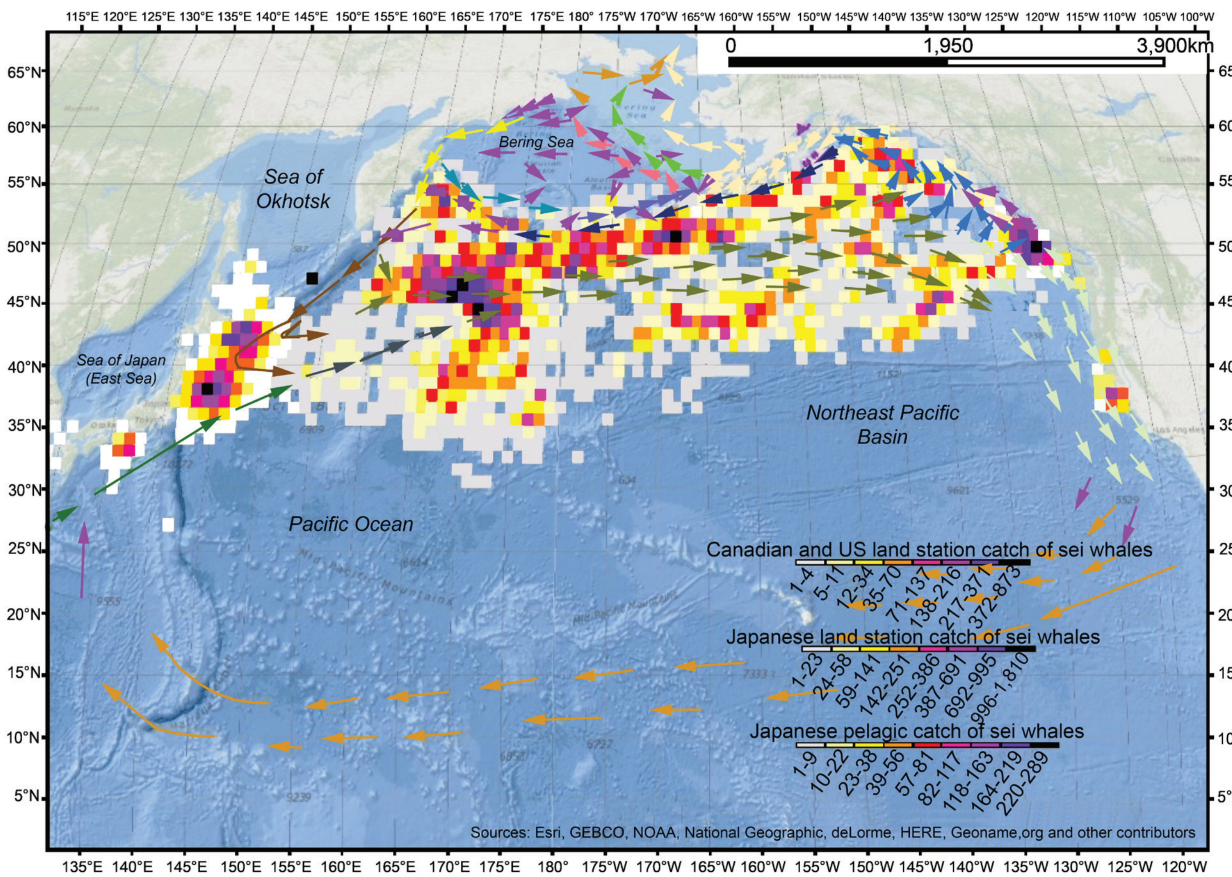


Fig. 2. US land station catch of sei whales from 1947-71 (n=388). Canadian land station catch of sei whales from 1948-67 (n=2,850). Japanese pelagic catch of sei whales from 1952-2011 (n=30,214). Japanese land station catch from 1929-75 (n=18,914).

Appendix 5

A PROPOSED AGE- AND SEX-STRUCTURED MODEL FOR NORTH PACIFIC SEI WHALES

INTRODUCTION

A sex- and age-structured population dynamics model that can represent the stock hypotheses identified during the 2015 meeting of the Scientific Committee is outlined. This model allows for multiple breeding stocks, each of which may be located on multiple feeding and wintering grounds. The values for the parameters of the model can be estimated by fitting it to data on trends in relative and absolute abundance, in addition to tagging data.

MODEL STRUCTURE

The model distinguishes 'breeding stocks' and 'feeding grounds'. Breeding stocks are demographically and genetically independent whereas multiple stocks may be found on each feeding ground. There is no dispersal between breeding stocks. The year is divided into two seasons, nominally 'summer' and 'winter' to account for within-year recaptures from the lower latitudes to the higher latitudes.

Each breeding stock is found in a set of sub-areas, each of which may have catches, and indices of relative or absolute abundance.

BASIC POPULATION DYNAMICS

The population dynamics are based on a two-season version (w=winter; s=summer) of the standard age- and sex-structured model used by the IWC Scientific Committee, with the 'start of the year' defined as the start of winter, i.e.:

$$\begin{aligned} N^{\mathrm{w,m/f},i}_{t+1,0} &= 0.5B^{i}_{t+1} && \text{if } a = 0 \\ N^{\mathrm{w,m/f},i}_{t+1,a} &= (N^{\mathrm{s,m/f},i}_{t,a-1} - C^{\mathrm{s,m/f},i}_{t,a-1})(S_{a-1})^{1/2} && \text{if } 1 \le a \le x-1 \\ N^{\mathrm{w,m/f},i}_{t+1,x} &= (N^{\mathrm{s,m/f},i}_{t,x-1} - C^{\mathrm{s,m/f},i}_{t,x-1})(S_{x-1})^{1/2} + (N^{\mathrm{s,m/f},i}_{t,x} - C^{\mathrm{s,m/f},i}_{t,x})(S_{x})^{1/2} && \text{if } a = x \end{aligned} \tag{1.1a}$$

$$N^{\mathrm{s,m/f},i}_{t,a} = (N^{\mathrm{w,m/f},i}_{t,a} - C^{\mathrm{w,m/f},i}_{t,a})(S_{a})^{1/2} \tag{1.1b}$$

where:

$N^{\mathrm{w},m/f,i}_{t,a}$ is the number of males/females of age a in breeding stock i at the start of the winter season of year t;

$N^{\mathrm{s},m/f,i}_{t,a}$ is the number of males/females of age a in breeding stock i at the start of the summer season of year t;

$C^{s,m/f,i,f}_{t,a}$ is the catch of males/females of age a in breeding stock i during season s of year t (whaling is assumed to take place in a pulse at the start of each season); and

S_a is the annual survival rate of animals of age a (assumed to be the same for males and females):

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } 1 < 0 \end{cases} \tag{1.2}$$

S_0 is the calf survival rate; S_{1+} is the survival rate for animals aged 1 and older; $B^{\mathrm{i}}_{\mathrm{t}}$ is the number of births to breeding stock i during year t; and x is the maximum (lumped) age-class (all animals in this and the x-1 class are assumed to be recruited and to have reached the age of first parturition). x is taken to be 15 (this value must be above the ages at full recruitment and full maturity.

BIRTHS AND DENSITY-DEPENDENCE

The number of births at the start of year t for breeding stock i, $B^{\mathrm{i}}_{\mathrm{t}}$, is given by:

$$B^{i}_{t} = b^{i}_{t}\, N^{\mathrm{f},i}_{t} \tag{2.1}$$

where $N^{\mathrm{f},i}_{t}$ is the number of mature females in breeding stock i at the start of the winter season of year t:

$$N^{\mathrm{f},i}_{t} = \sum_{a=a_m}^{x} N^{\mathrm{w,f},i}_{t,a} \tag{2.2}$$

α_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition); b^i_t is the probability of birth/calf survival for mature females:

$$b^i_t = \max(0, b_K\{1 + A^i(1 - (N^{1+,\mathrm{w},i}_t / K^{1+,\mathrm{w},i})^{z^i}\}) \tag{2.3}$$

b_K is the average number of live births per year per mature female at carrying capacity; and A^i is the resilience parameter for breeding stock i, and z^i is the degree of compensation for breeding stock i. The number of 1+ animals at the start of season s of year t and at carrying capacity are given by:

$$N^{1+,s,i}_t = \sum_A N^{1+,s,i,A}_t = \sum_A X^{A,s,i} \sum_{a=1}^{x} (N^{s,\mathrm{m},i}_{t,a} + N^{s,\mathrm{f},i}_{t,a}) \tag{2.4}$$

$K^{1+,s,i,A}_t$ is the carrying capacity for breeding stock i and feeding ground A at the start of season s:

$$K^{1+,s,i} = \sum_A K^{1+,s,i,A} = \sum_A X^{A,s,i} \sum_{a=1}^{x} (N^{s,m,i}_{-\infty,a} + N^{s,\mathrm{f},i}_{-\infty,a}) \tag{2.5}$$

$X^{A,S,i}$ is the proportion of animals of breeding stock i that are found in feeding ground A during season s.

CATCHES

The catch by breeding stock is determined by apportioning the catches by feeding ground, taking account of mixing (i.e. exposure to harvesting) matrices, according to:

$$C^{s,\mathrm{m/f},i}_{t,a} = \sum_A X^{A,s,i} N^{s,\mathrm{m/f},i}_{t,a} (1 - e^{-\alpha^A_a F^{s,\mathrm{m/f},A}_t}) \tag{3.1}$$

where α^A_a is the relative vulnerability of animals of age a to harvest by the fleets that operate in sub-area A. The values for the fishing mortality rates are selected so that the observed and predicted values for $C^{s,\mathrm{m/f},A}_t$, the number of males/females caught in feeding ground A during season s of year t, are matched exactly.

$$C^{s,\mathrm{m/f},A}_t = \sum_i X^{A,s,i} \sum_a N^{s,\mathrm{m/f},i}_{t,a} (1 - e^{-\alpha^A_a F^{s,\mathrm{m/f},A}_t}) \tag{3.2}$$

INITIALISING THE PARAMETER VECTOR

The numbers at age in the pristine population are given by:

$$\begin{aligned} N^{\mathrm{w,m/f},i}_{-\infty,a} &= 0.5\, N^i_{-\infty,0} \prod_{a'=0}^{a-1} S_{a'} && \text{if } a < x \\ N^{\mathrm{w,m/f},i}_{-\infty,x} &= 0.5\, N^i_{-\infty,0} \prod_{a'=0}^{x-1} S_{a'} / (1 - S_x) && \text{if } a = x \end{aligned} \tag{4.1}$$

The value for $N^i_{-\infty,0}$ is determined from the value for the pre-exploitation size of the 1+ component of breeding stock i using the equation:

$$N^i_{-\infty,0} = K^{1+,\mathrm{w},i} / \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1 - S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \tag{4.2}$$

LIKELIHOOD FUNCTION

Under the assumption that the estimates of abundance for a sub-area are log-normally distributed, the negative of the logarithm of the likelihood function is given by:

$$-\ell n L_1 = \ell n \sqrt{\mathrm{Det}[V]} + 0.5 \sum_k (\ell\,\mathrm{n}\, \underline{N}^{A,obs} - \ell\,\mathrm{n}\, \underline{N}^A)[V^{-1}](\ell\,\mathrm{n}\, \underline{N}^{A,obs} - \ell\,\mathrm{n}\, \underline{N}^A)^T \tag{5.1}$$

where $N^{A,\mathrm{obs}}_t$ is survey estimate of abundance for sub-area A during year t; and V is the sum of the variance-covariance matrix for the abundance estimates plus an additional variance term (assumed to be independent of year).

The tagging data are incorporated in the likelihood function by tracking the number of tags in each breeding stock that were tagged in each year, i.e.:

$$\tilde{N}^{\mathrm{w,m/f},i,s',A'}_{t+1,a,t'} = \begin{cases} (\tilde{N}^{\mathrm{s,m/f},i,s',A'}_{t,a-1,t'}(1-\sum_A X^{A,s,i}(1-e^{-\alpha^A_{a-1}F^{\mathrm{s,m/f},A}_t})) + \chi^{\mathrm{s,m/f},A'}_{t',a-1} T^{\mathrm{s},A'}_{t'} e^{-\alpha^{A'}_{a-1}F^{\mathrm{s,m/f},A'}_{t'}} (S_a)^{1/2} \\ (\tilde{N}^{\mathrm{s,m/f},i,s',A'}_{t,x,t'}(S_x)^{1/2} + \tilde{N}^{\mathrm{s,m/f},i,s',A'}_{t,x-1,t'}(S_{x-1})^{1/2})(1-\sum_A X^{A,s,i}(1-e^{-\alpha^A_x F^{\mathrm{s,m/f},A}_t})) + \\ \qquad (\chi^{\mathrm{s,m/f,i},A'}_{t',\mathrm{x}}(S_x)^{1/2} + \chi^{\mathrm{s,m/f,i},A'}_{t',x-1}(S_{x-1})^{1/2}) T^{\mathrm{s},A'}_{t'} e^{-\alpha^{A'}_x F^{\mathrm{s,m/f},A'}_{t'}} \end{cases} \tag{5.2a}$$

$$\tilde{N}^{\mathrm{s,m/f},i,s',A'}_{t,a,t'} = (\tilde{N}^{\mathrm{w,m/f},i,s',A'}_{t,a,t'}(1-\sum_A X^{A,s,i}(1-e^{-\alpha^A_a F^{\mathrm{w,m/f},A}_t})) + \chi^{\mathrm{w,m/f},A'}_{t',a} T^{\mathrm{w},A'}_{t'} e^{-\alpha^{A'}_a F^{\mathrm{w,m/f},A'}_{t'}} (S_a)^{1/2} \tag{5.2b}$$

where $\tilde{N}^{s,\mathrm{m/f},i,s',A'}_{t,a,t'}$ is the number of tagged males / females of age a in breeding stock i at the start season s of year t that were tagged during seasons s' of year t' in sub-area A'; $T^{s,A}_t$ is the number of animals that were tagged in sub-area A during season s of year t; $\chi^{s,\mathrm{m/f},i,A}_{t,a}$ is the proportion of animals in sub-area A at the start of seasons s of year t that are males/females of age a from breeding stock i, i.e.:

$$\chi^{s,\mathrm{m/f},i,A}_{t,a} = \frac{X^{A,s,i} N^{s,\mathrm{m/f},i}_{t,a}}{\sum_{a'}\sum_{\mathrm{m/f}}\sum_{i'} X^{A,s,i'} N^{s,\mathrm{m/f},i'}_{t,a'}} \tag{5.3}$$

The model estimate of the number of recaptures of animals originally tagged in sub-area A' during season s' of year t' that were recaptured in sub-area A during season s of year t (excluding within-season recaptures), $\hat{R}^{s,s',A,A'}_{t,t'}$, is given by:

$$\hat{R}^{s,s',A,A'}_{t,t'} = \sum_i \sum_{m/\mathrm{f}} \sum_a X^{A,s,i} \tilde{N}^{s,\mathrm{m/f},i,s'A'}_{t,a,t'} (1-e^{-\alpha^A_a F^{s,\mathrm{m/f},A}_t}) \tag{5.4}$$

The log-likelihood for the tagging data, under the assumption of a negative binomial recapture process is given by:

$$\ell n L_2 = \sum_s \sum_{s'} \sum_{t'} \sum_{t>t'} \sum_{A'} \sum_A \ell n \left\{ \left(\frac{\Gamma(\theta + R^{s,s',A,A'}_{t,t'})}{\Gamma(R^{s,s',A,A'}_{t,t'}+1)\Gamma(\theta)} \right) \left(\frac{\theta}{\hat{R}^{s,s',A,A'}_{t,t'}+\theta} \right)^{\theta} \left(\frac{\hat{R}^{s,s',A,A'}_{t,t'}}{\hat{R}^{s,s',A,A'}_{t,t'}+\theta} \right)^{R^{s,s',A,A'}_{t,t'}} \right\} \tag{5.5}$$

where $R^{s,s',A,A'}_{t,t'}$ is observed the number of recaptures of animals originally tagged in sub-area A' during season s' of year t' that were recaptured in sub-area A during season s of year t, and θ is the overdispersion parameter.

Appendix 6

A BRIEF SUMMARY OF INFORMATION AVAILABLE FOR NORTH PACIFIC HUMPACK WHALES, AND A PROPOSAL FOR AN IN-DEPTH ASSESSMENT

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INTRODUCTION

North Pacific (NP) humpback whales have never been the focus of an in-depth assessment by the International Whaling Commission (IWC) in large part because all populations were seriously depleted when they were given protected status fifty years ago. In addition, the catch records were incomplete. Recently, the catch record for NP humpbacks has been updated to include new information on extensive illegal takes by the USSR (Ivashchenko *et al.*, 2013). In addition, there is now considerable new information on the current abundance and population structure of NP humpbacks derived from the multi-national photo-identification and genetic study known as Structure Levels of Abundance and Status of Humpback Whales (SPLASH) (Baker *et al.*, 1998; Barlow *et al.*, 2011; Calambokidis *et al.*, 2008). Here we briefly summarise information available for NP humpback whales, with a focus on new data.

CATCH RECORD

The IWC database contains detailed records for the majority of humpback whale catches made in the NP during the 20th century. Ivashchenko *et al.* (2013) has updated the catch record for NP humpbacks to include new information on extensive illegal takes by the USSR. With these additional catches, the 20th century catch record is thought to be reasonably complete, with the total number of humpbacks caught in the NP during this time estimated to be 29,103 whales. Catch records before 1900 are incomplete (Omura, 1986; Reeves and Smith, 2006), so any estimate of the overall total catch for humpback whales in this ocean will vary depending upon the assumptions one makes with regarded to missing information.

POPULATION STRUCTURE

A current understanding of humpback whale population structure in the NP has been developed through the use of photo-identification (Calambokidis *et al.*, 1997; Urbán R *et al.*, 2000), genetics (Baker *et al.*, 1998), and a small amount of satellite tagging. The current most complete picture of humpback whale population structure in the NP comes from the SPLASH study. For this study, Baker *et al.* (2013) reported DNA profiles, including mtDNA control region haplotypes, sex identification and 10 microsatellite genotypes for 2,193 samples representing 1,805 individuals. The regional frequencies of mtDNA haplotypes and micro-satellite alleles were used for analyses of differentiation among and between feeding and breeding grounds based on *a priori* stratification. On the basis of the *a priori* regional strata used in SPLASH, Baker *et al.* (2013) found genetic evidence of six winter/breeding populations, including one with an unknown breeding ground in the western North Pacific:

(1) Asia, including Okinawa and the Philippines;
(2) western Pacific, with location unknown but mixing in Ogasawara;
(3) windward Hawaiian Islands;
(4) mainland Mexico;
(5) offshore Mexico (Revillagigedo Islands); and
(6) central America.

Photo-identification and genotypes matching also provided the most complete look at movements between winter/breeding and summer areas, as well as any movements between winter/breeding areas (Calambokidis *et al.*, 2008; Baker *et al.*, pers. comm.). From the photo-identification records, SC/66b/IA21 uses a multi-strata model to estimate the probability of movement between winter/breeding areas and summer/feeding areas from the SPLASH study.

With regard to population structure, satellite tagging has provided little information that was not already known from photo-ID, other than the novel movement of a tagged humpback from the eastern Bering Sea to the Russian coast (Kennedy *et al.*, 2014).

ABUNDANCE

Prior to the SPLASH project, regional estimates of abundance for humpback whales had been made for many of the winter areas including Mexico (Urbán *et al.*, 1999), Hawaii, and Asia (Calambokidis *et al.*, 1997), but abundance had not been estimated previously for central America. Similarly, prior to SPLASH, summer feeding/area abundance estimates had been made for some areas where photo-identification studies have taken place for many years, including California/Oregon, southeastern Alaska, the Shumagin Islands, Alaska, or where line-transect studies have been conducted, such as the southeastern Bering Sea shelf. However, comprehensive estimates were lacking for many of these regions, and some areas, such as Russia, had never been previously surveyed for abundance. The SPLASH study has provided photo-identification data from most of the range of the humpback whale in the NP. Barlow *et al.* (2011) uses the SPLASH data aggregated across areas to estimate the abundance of the total NP population as 21,808 (CV=0.04). SC/66b/IA21 uses a multi-strata model to conduct an integrated analysis that provides abundance estimates for four winter/breeding areas as well as six defined summer/feeding areas, including the first estimates for Russia and for central America.

In the interest of conciseness, references to other regional abundance estimates are not listed here. SC/66b/IA19 provides a preliminary list of abundance estimates suitable for population modelling in its table 1, but it will be important to review other available estimates for possible inclusion.

ADDITIONAL NEW INFORMATION ON DISTRIBUTION

Subsequent to the SPLASH project, a survey in 2007 documented humpback whales from a number of locations in the northwestern Hawaiian Islands at relatively low densities (Johnston *et al.*, 2007). Some humpback whales, including mother/calf pairs, have also been found in the Marianas Islands (Brownell, pers. comm.). Both of these locations are plausible migratory destinations for whales from the Aleutian Islands and Bering Sea, which had a lower detection rate in winter areas during SPLASH, suggesting that there is an unknown winter/breeding area (Calambokidis *et al.*, 2008). Recent surveys (2009-12) have also had sightings and acoustic detections of humpbacks in the Chukchi Sea, north of the Bering Strait, both in Russia along the northern side of the Chukotka Peninsula, and also on the US side especially near Point Hope (Clarke *et al.*, 2013). SPLASH surveys covered the Bering Strait portion of the Chukotka Peninsula, but there was insufficient ship-time to go to the northern side of the peninsula, and no survey effort occurred in the US portion of the Chukchi Sea.

INITIAL ASSESSMENT MODELING

SC/66a/IA16 presents an initial assessment of the aggregated NP population. SC/66b/IA19 presents the first assessment of NP humpback whales modelling four separate breeding populations, with feeding-area catches allocated to breeding populations. This is not intended to be a final assessment, but has provided a good starting point for conducting an in-depth assessment.

CONCLUSION

With the completion of the corrected catch database, and availability of abundance and movement data from the SPLASH project, we suggest that we are in a position to undertake an in-depth assessment. We propose this in-depth assessment be initiated at the 2017 Scientific Committee meeting. Work on an in-depth assessment could be conducted either as an intersessional workshop or pre-meeting before next year's Scientific Committee; alternatively, it could be organised as a separate Working Group within the full Scientific Committee meeting, as was the case for the Comprehensive Assessment of North Atlantic humpback whales some years ago.

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Appendix 7

REPORT OF THE SMALL GROUP PLANNING THE 2017 AND 2018 IWC PACIFIC OCEAN WHALES AND ECOSYSTEM RESEARCH (POWER)

Members: Matsuoka (Chair), Baba, Bannister, Clapham, Diallo, Donovan, Hirayama, Ivashchenko, Kato, Kim, H.W., Kitakado, Miyashita, Mizroch, Morita, Murase, Okazoe, Palka, Yasokawa, Zharikov.

1. ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEUR

Matsuoka was appointed as Chair. Murase acted as rapporteur with assistance from Palka.

2. TERMS OF REFERENCE

The Terms of Reference for the group were:

To undertake preliminary planning of the IWC Pacific Ocean Whales and Ecosystem Research (POWER) for the 2017 and 2018 cruises. The plan will be developed in accordance with the suggestions by the Technical Advisory Group (TAG) of POWER (SC/66b/Rep01) and a proposed plan (SC/66b/IA06).

3. ADOPTION OF AGENDA AND AVAILABLE DOCUMENTS

This report follows the adopted agenda. Relevant documents include: SC/66b/Rep01-Rep02, SC/66b/IA06 and SC/66b/O01.

4. CRUISE LOGISTICS

4.1 Length of cruises

The group was informed that the Fisheries Agency of Japan would seek a budget for a research vessel and crew for the cruises in 2017 and 2018, as in previous years. The cruises are scheduled for July and August 2017 and 2018. The total duration of each cruise will be approximately 60 days, including transit periods. The meeting emphasised the importance of these surveys for the management of large whales in the North Pacific and noted that a sufficient budget and survey effort would be necessary to achieve the goal. Details of itinerary of the cruises will be finalised at the Tokyo planning meeting.

4.2 Availability of vessel

The group was informed that the research vessel, *Yushin-Maru No. 3*, would be available for the cruises in 2017 and 2018. It was noted that logistically and financially it would be beneficial to load gear from a US port, such as Dutch Harbor, Alaska. However, there was concern that this ship cannot enter non-Japanese ports. The group strongly requested the Government of Japan to allow the ship to enter a US port to load equipment. This matter will be addressed again in the Tokyo planning meeting.

Enquires were made to determine if other countries could collaborate by contributing additional cruises in the Bering Sea. Zharikov indicated that they were not planning marine mammal research cruises in the Bering Sea because they were conducting surveys in the Sea of Okhotsk (SC/66b/IA11). He would provide further updates at the Tokyo planning meeting. Clapham noted that they were not planning any dedicated marine mammal surveys for 2017 and 2018 in the Bering Sea. However, he would investigate to see if there were platforms of opportunity, such as oceanographic survey vessels, that could be used to deploy sonobuoys from. He agreed that he would investigate this matter and report the results at Tokyo planning meeting.

4.3 Number of international researchers

The *Yushin-Maru No. 3* will be able to accommodate at most four researchers, which includes the cruise leader. It was **agreed** that Matsuoka would be cruise leader for these cruises. An appropriate researcher from the US would participate in the 2017 cruise that is expected to be within US waters. Such participation from the US is required to take biopsy samples within the US EEZ. Additional researchers could be from any country. The steering group established by the Committee will nominate the researchers at the Tokyo Planning Meeting. Since there is a possibility to collect passive acoustic data using sonobouys on at least the 2017 cruise, an additional researcher would be required. Noting this matter, the working group requested that the Government of Japan investigate the possibility of increasing the number of researchers to five and report the findings to the Tokyo Planning Meeting.

4.4 Research area and cruise track design

Although a tentative research area and cruise track design were presented in SC/66b/Rep01 and SC/66b/IA06, redesign might be necessary for the 2017-19 cruises to account for the logistical constraints due to entry permits into the US and Russian waters and the different whale habitats as discussed within the full IA sub-committee. Details regarding the definition of the research strata and cruise tracks will be finalised at the Tokyo planning meeting.

4.5 Experiments

Planned experiments include the usual distance and angle estimation, photo-identification, and biopsying. In addition, passive acoustic monitoring would be conducted as proposed in SC/66b/O01. Details of these experiments will be finalised at the Tokyo planning meeting. With regard to photo-identification, Mizroch agreed to submit a summary of the status of the 2010-15 POWER cruise photo-identification catalogues before the Tokyo planning meeting.

4.6 Necessary permits

The planned research area for the 2017 cruise is within the US EEZ, which requires three different kinds of permits, and all are supposed to be obtained through cooperation between US and Japanese Governments. Tentative planned research areas of the 2018 and 2019 could include both the US and Russian EEZ. Recognising that obtaining the necessary permits from the Russian Government requires a long lead time, it was agreed that Okazoe would work with Zharikov intersessionally to identify details of the procedure to get necessary permits and report the results at the Tokyo planning meeting. In addition, the group reiterated the previous recommendation on sending a letter from IWC Secretariat to the appropriate authorities in the Russian Federation to stress the importance of this research.

4.7 Other

None was raised.

5. PLANNING MEETING

5.1 Terms of Reference

The terms of reference for the planning meeting are to undertake planning of the POWER for the 2017 and 2018 cruises and preliminary planning of the 2019 cruise. The plan will be developed in accordance with the suggestions by the TAG of POWER (SC/66b/Rep01) and a proposed plan (SC/66b/IA06).

5.2 Date and venue of the planning meeting

The planning meeting will be held in a meeting room at the Japanese Fisheries Agency crew house, Tokyo from 15 to 18 September 2016. It was suggested that technical issues could be considered on the first day of the Tokyo planning meeting because the TAG meeting will not be held this year. Then the second and third day could be meeting with the ship's crew to discuss the logistic issues. Finally, the last day could be allocated for report writing. The venue for report writing will be determined and announced by co-organisers.

5.3 Possible participants

The participants of the planning meeting will be Bannister, Brownell, Clapham, Donovan, Kato, Kelly, Kim (H.W.), Miyasita and Okazoe, Zharikov and some of the ship's crew. Matsuoka and Kato will act as co-organisers of the Tokyo planning meeting.

6. BUDGET REQUEST

The plans given above assume the availability of the same level of Japanese funding for a research vessel and crew as for the previous cruises. Clapham noted that NOAA would provide all equipment and costs necessary for passive acoustic survey except for the cost associated with shipments. Budget for the 2017 and 2018 cruises (including the planning meetings) to IWC of £38,000 and £38,000 is requested.

7. OTHER BUSINESS

It was noted that another meeting, a special editorial Workshop for the IDCR-SOWER commemorative volume is also planned immediately after the Tokyo planning meeting (19-20 September 2016). The venue will be determined and announced by the co-organisers.