Report of the Technical Advisory Workshop on Planning for the Medium-Long-Term IWC-POWER Programme

Tokyo, Japan, 6-10 September 2022

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1. INTRODUCTORY ITEMS

The Workshop was held at the Japanese Fisheries Agency Crew House, Tokyo, between 6-10 September 2022. The list of participants is given as Annex A.

1.1 Opening remarks and welcoming address

Matsuoka welcomed the participants to the Workshop, expressing his pleasure that a face-to-face meeting was possible and noting that the Scientific Committee had agreed that the complexity of developing the medium-term IWC-POWER programme meant that a face-to-face meeting was essential. Unfortunately, circumstances prevented Staniland, Palka and An from attending, but they sent their wishes for a successful meeting and noted their willingness to respond to requests and queries by email. All members of the Steering Group would be given the opportunity to review the draft report.

Fukui, Director for International Fisheries Coordination, Fisheries Agency of Japan, welcomed the participants on behalf of the Japanese Government. He stressed that the IWC-POWER programme, with its broad coverage of the North Pacific Ocean, and with participation of experts from a number of countries, has made a substantial contribution to the development of scientific knowledge and evidence for proper conservation and management of large whales in the North Pacific. Given its outstanding scientific significance and development, Japan is proud to have co-sponsored the IWC-POWER programme over the last 13 years, including this year. He reiterated the thanks of his Government to all who have worked for the IWC-POWER programme over many years. Although Japan is no longer a member of the IWC, it is pleased to continue the IWC-POWER programme under a co-operative relationship with the Committee. Japan looks forward to discussing the next phase of the IWC-POWER programme during this Workshop.

Although sorry that he was unable to attend in person, Staniland, Head of Science Conservation and Management at the IWC Secretariat, sent a written message of support. He thanked all who attended for their continued support in providing expert advice to help the planning and implementation of this important research programme. The international effort involved is one of the key strengths of the IWC-POWER programme that has provided priceless information on cetaceans for over 10 years. To date, researchers from Japan, the Republic of Korea, the USA, Russia, Mexico and the UK have all participated on cruises. The sightings data, biopsy samples and photo-ID photographs feed directly into the work of the Scientific Committee and underpin a great deal of the advice provided to the Commission. He stressed that the programme could not function without the generous support of the Japanese Government who provide the vessel, crew and some of the scientists. Without this financial and logistical support, the IWC-POWER programme would not be able to operate, and our understanding of cetacean populations in the North Pacific would be severely limited. He drew attention to the recent comments by the Scientific Committee (IWC, 2023, item 22.1) on the importance of the POWER programme:

> *'The Committee reiterates to the Commission the great value of the data contributed by the IWC-POWER cruises which have covered many regions of the North Pacific Ocean not surveyed in recent years. The programme addresses important information gaps for several species and has already contributed greatly to the ongoing assessment work of the Committee.'*

1.2 Election of Chair and rapporteurs

Matsuoka and Kitakado shared the Chair. Donovan and Goetz acted as rapporteurs.

1.3 Adoption of Agenda

The adopted agenda is shown as Annex B.

1.4 Review of available documents

The list of documents is given as Annex C.

2. REVIEW OF DISCUSSIONS BY THE SCIENTIFIC COMMITTEE AT SC68D

The IWC had agreed (see IWC, 2012, item 10) that the long-term IWC-POWER programme:

[1]Presented to the SC meeting as SC/69A/REP/03A.

'will provide information to allow determination of the status of populations (and thus stock structure is inherently important) of large whales that are found in North Pacific waters and provide the necessary scientific background for appropriate conservation and management actions. The programme will primarily contribute information on abundance and trends in abundance of populations of large whales and try to identify the causes of any trends should these occur. The programme will learn from both the successes and weaknesses of past national and international programmes and cruises, including the IDCR/SOWER programme.'

2.1 Short-term options (including information gaps)

The short-term (Phase 1) objective of the IWC-POWER programme has been to focus on the 'least studied' areas of the central and Eastern North Pacific, taking into account national programmes. Much of these areas have now been covered, with the notable exception of Russian waters. With respect to short-term options, the Committee this year recognised the difficulties experienced in obtaining a permit to operate in the Russian waters of the Bering Sea and approved the 'back-up' plans developed to cover waters south of the Aleutian Island Archipelago. It agreed that at least two more cruises are required to complete the initial programme but recognised that completion of un-surveyed areas of the Western Bering Sea area and East of Kamchatka depended on the international situation. The TAG considered these comments during discussions of the 2023 and 2024 cruises, given in SC/69A/REP/03B.

2.2 Medium and long-term (including information gaps)

The Committee endorsed the updated medium-term objectives provided in table 1 of IWC (2021). It agreed that planning for the next phase of the IWC-POWER programme should begin as soon as possible with the aim to complete it by 2024. In addition to the work undertaken in Phase 1, the Committee agreed that future cruises should have 'an emphasis on participation from all range states and also include consideration of more methodologically focused cruises in some years (e.g., use of a towed acoustic array, telemetry work, use of SeaGlider, etc.)'.

The Workshop considered these comments, particularly under Item 7.

3. OBJECTIVES OF THE WORKSHOP

The primary focus of the Workshop was to continue the planning for the next phase of IWC-POWER (medium to long-term) by:

- reviewing the general (Item 4) and species-specific outcomes (Item 5) to date of the almost complete Phase 1;
- reviewing progress on already identified analyses (and identifying any additional analyses) required to complete planning for the second phase by 2024 (see Table 1); and
- updating the medium-term objectives (see Table 2) and in the light of these provide a broad outline of what Phase 2 might look like to guide intersessional work (Item 7).

In addition, the Workshop developed plans for the 2023 Cruise and discussed options for the 2024 Cruise. Those discussions can be found in SC/69A/REP/03B.

4. GENERAL SURVEY APPROACHES USED TO DATE (2010-21)

The Workshop (hereafter TAG) welcomed the provision of Annex D that summarises the cruises undertaken to date and formed an important component of the discussions below.

4.1 Primary and secondary objectives of surveys related to field and analytical methods used given available resources

Phase 1 of IWC-POWER aimed to obtain baseline data for the distribution and abundance of cetaceans in the 'least studied' areas of the central and Eastern North Pacific with the focus on large whales but collecting data on other cetaceans and marine debris. During these surveys, data and samples were collected to assist in clarifying stock structure. This facilitates determination of appropriate management units (units-to-conserve) to allow the elucidation of status and the need (if any) for actions to reduce anthropogenic pressures that might negatively affect status. Given the lack of knowledge of the present situation in these areas, the initial aim was to cover them as quickly as possible given the resources available, such that the information obtained would guide the development of the medium-term strategy to allow the overall objective eventually to be met.

4.2 Distribution and abundance

4.2.1 Choice of survey areas and cruise track design

Fig. 1 shows the survey areas covered to date and those anticipated to be covered in Phase 1 of IWC-POWER. The choice of survey areas and strata was largely pragmatic, based on the number of days the vessel was available and transit times, but included consideration of historical distribution and densities of the high priority species, based on examination of whaling data and past information from Japanese scouting vessels (1965-82) (IWC, 2012, item 8.7.2). Some areas have been covered more than once, given the problems in obtaining permits to enter Russian waters. It should be noted that Bryde's whales were not initially considered a high priority species for IWC-POWER (IWC, 2012, table 3), but this was later revised on the Committee's advice. Areas south of 40°N were surveyed from 2013-16. The fundamental approach to

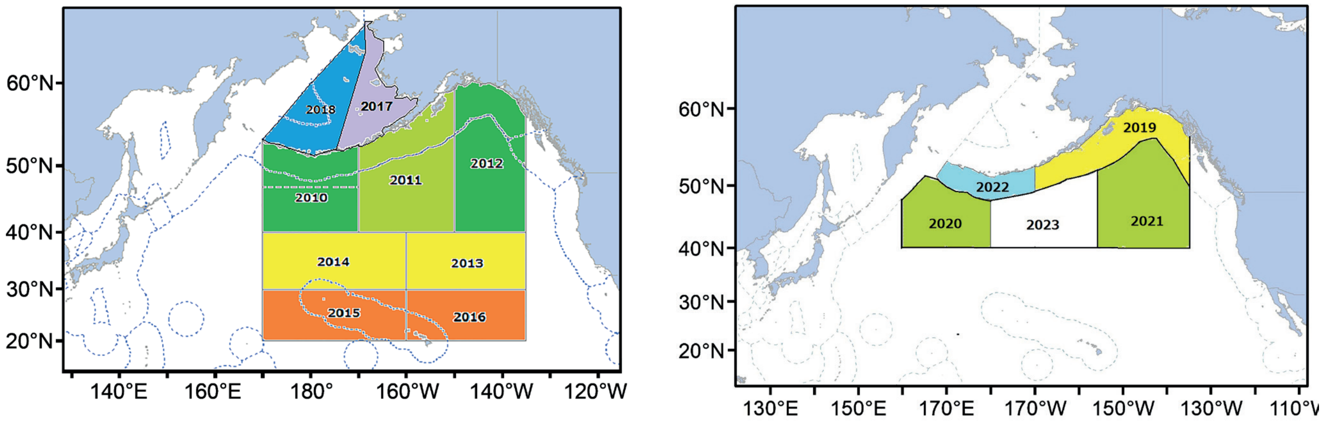


Fig. 1. Survey areas covered to date by year and those anticipated to be covered in Phase 1 of IWC-POWER.

obtain information on distribution and abundance was line-transect survey. Cruise design followed standard practice: i.e., equal coverage probability using programme DISTANCE and a random start point. Valuable information on the distribution/ occurrence of cetacean species in these poorly studied areas has been obtained from sightings data and this is summarised by species for the large whales under Item 5.

4.2.2 Survey methods for Distance sampling (including survey modes, distance and angle experiments) and analytical approaches (design-based and spatial approaches)

4.2.2.1 SURVEY MODE

From 2010-16, the surveys were carried out in 'NSP' mode (passing mode with abeam closing). This was believed to be the most appropriate given the priority species and the need to confirm species identity and group size, as well as to obtain biopsy samples and photographs. It later became apparent that the assumption that $g(0)$ is close to one for the larger whales might not be applicable. From 2017, the survey mode was therefore changed to alternating between NSP and double platform (IO) mode. This change usually took place around every 50 n.miles on effort and at the Cruise Leader's discretion, depending *inter alia* on the density of sightings (IO is not practical in high density areas). The full analysis of these data is not yet complete for all species for which there is a sufficient sample size. The results of these analyses will assist in determining the most appropriate survey mode strategy or strategies (it may vary by area/target species) for the next phase of IWC-POWER.

4.2.2.2 DISTANCE AND ANGLE EXPERIMENTS

DISTANCE based analyses require unbiassed and precise estimates of the position of sighted animals from the trackline (obtained by estimating the distance and angle to the sighting). It is therefore important that experiments are conducted to estimate the ability of the relevant crew and researchers to do this (ideally under a range of sightings conditions). All cruises to date have undertaken 'Distance and Angle Experiments'. Analysis of these data is almost complete. Kitakado reported that the initial results show that bias, potentially a serious problem, is not present, but that there is some variation in precision that will affect the CV of the estimates. The TAG looks forward to the final results of the analysis and **agrees** that:

- such experiments must be held for each future cruise where DISTANCE sampling is undertaken in accordance with IWC guidelines; and
- methods used to determine distance and angle at sea should continue to be reviewed in light of potential new methods and technology.

4.2.2.3 ESTIMATES

The line transect data provide an estimate of the number of animals present in the study area at the time of the survey. For baleen whales, the areas covered by IWC-POWER usually represent feeding areas. It should be noted that there may be more than one population of any particular species within the survey area. It is also important to consider the timing of the surveys if comparing across years for the same geographical area when interpreting differences. For example, the cruises in the period up to 2016 took place in July and August, whilst surveys since 2017 have taken place in August and September. This does not necessarily invalidate comparisons, but the possibility should still be considered.

To date, the primary analytical approach has been to produce standard design-based estimates of abundance (see WP10) as yet not corrected for $g(0)$ or taking into account additional variance. Estimates by species are considered where appropriate under Item 5.

The value of using spatial modelling approaches to estimate abundance and produce density maps is increasingly recognised. Where successful, this can reduce CVs and provide insights into those factors of importance in determining why animals are distributed within the study areas. This is especially important in the light of additional variance and potential changes in distribution (and thus abundance estimates in the same areas in different years) due to environmental changes and may directly affect our ability to estimate trends - a key component of the medium to long-term objectives of IWC-POWER. Completing the spatial modelling analyses for the existing IWC-POWER data is a high-priority item and key to assisting design of the next phase (including choice of survey areas and stratification). Spatial modelling approaches also provide a better approach to recalculating abundance estimates for different geographical boundaries as new information on stock structure is obtained.

Completing the analysis to determine the power of various strategies to detect trends under different scenarios is a high priority (e.g., with respect to different levels of increase or decrease in abundance, different time frames and/or survey frequency, different levels of survey effort and different levels of significance). Kitakado provided some valuable initial analyses. A number of informal suggestions were made to the author on improvements to be incorporated into the final analyses.

The TAG welcomed this work but **agrees** that, where possible, incorporation of a series of estimates into a population assessment model framework (e.g., see AWMP/RMP and in-depth assessment approaches) is the most appropriate way to examine status and management implications in light of uncertainty in both stock structure and abundance, rather than a traditional analysis of trends from two or more estimates that usually has low power where the estimates have CVs of more than 0.2, which is not uncommon, even without taking into account additional variance.

It is envisaged that the DISTANCE sampling approach will form the major component of the next phase of IWC-POWER.

4.2.3 Individual identification (photo and genetic)

While DISTANCE sampling approaches are standard for many species, for others, mark-recapture methods to obtain abundance estimates from individual identification data are an alternative or preferable. It is important to note that, whilst line-transect abundance estimates represent a snapshot of animals in the survey area at a certain time, mark-recapture estimates represent an estimate of the number of animals using an area over time (depending on certain assumptions). Mark-recapture estimates are particularly suited to species where obtaining sufficient sample sizes is possible, e.g., where large sampling effort is/has been possible, such as humpback and eastern North Pacific blue whales (see Items 5.3 and 5.6), or small populations where densities are too low to obtain reliable abundance estimates with realistic levels of effort under the IWC-POWER programme, e.g., eastern North Pacific right whales (see Item 5.2). In most cases, the value of data collected by IWC-POWER has been and will be to contribute samples/photos from offshore areas to existing individual identification catalogues. Collaboration will also form an important part of the medium-term strategy. The possibility of focused studies to collect such data in some small areas (e.g., targeted to North Pacific right or blue whales) in the medium-term plan is considered under Item 7.

It is envisaged that biopsy sampling and photo-ID using the current methods will continue to be an important component of IWC-POWER.

4.2.4 Acoustics

Acoustic techniques have not been used to estimate abundance in the IWC-POWER programme to date. Even in principle, regarding large whales species, it has only been used successfully to estimate the abundance of sperm whales using towed arrays of hydrophones (e.g., Lewis *et al*., 2019). With current resources, this is unlikely to form part of the IWC-POWER programme, but the possibility should be kept under review.

Acoustics (directional sonobuoys) have been used successfully to improve detection of right whales to obtain biopsy samples and photo-ID data to assist in mark-recapture estimation (e.g., the 2017 cruise; a similar approach was used for blue whales under IWC-SOWER). This is considered further for the medium-term programme (see Item 7.1).

4.2.5 Telemetry

In 2021, a feasibility experiment (total cruise time spent just under six hours) to investigate the use of telemetry to elucidate the diving behaviour of fin and sei whales was undertaken with the objective of using these data to investigate availability bias in order to correct abundance estimates (WP15). This was voluntarily undertaken by Japan with the equipment prepared by ICR. A type of Low-Impact Minimally Percutaneous External electronics Tag (LIMPET), SPLASH10-F-333 (Wildlife Computers), was used in the experiment. Tagging and biopsy experiments were conducted at the same time. The tags were attached to two fin and three sei whales. Success rates were 33.3% (n=6) and 75.0% (n=4) for fin and sei whales respectively. The field experiment was successful and dive sequence data were obtained from two fin and three sei whales via satellite. It was noted that improvements in the data transmission settings were needed. The same goes for Mote (Wildlife Computers, US), a stationary listening station that can continuously log telemetry data from satellite tags on animals within the reception range.

The TAG welcomed this initiative (see Item 4.3.3). The value of telemetry in the next phase of the IWC-POWER programme is considered under the relevant agenda items below.

4.3 Stock structure and movements

4.3.1 Population structure related genetic analyses from biopsy samples

The genetic component of the IWC-POWER cruise (reviewed in WP8) has proved to be extremely successful and has already made important to contributions to the Committee (e.g., the RMP *Implementation Review* for Bryde's whales and ongoing *Comprehensive Assessment* of sei whales). Details are provided by species along with information on when analyses are expected to be completed under Item 5. In general, analyses have focussed so far on mtDNA and microsatellites (14-17 loci). For certain species (see Item 5), there is a move to include SNPs (single nucleotide polymorphisms) that are more powerful and do not require cross-laboratory calibration.

It is envisaged that biopsy sampling and genetic analyses will continue to be an important component of IWC-POWER.

4.3.2 Movements from individual identification (photo and genetic)

'Recaptures' of individually identified animals cannot only be used to estimate abundance but also provide information on movements. The likelihood of recaptures clearly increases where data are shared between all researchers across the Pacific, ideally in the form of single catalogues. As noted under Item 4.2.3, the major contribution of the IWC-POWER programme has been and will be to contribute samples/photos from offshore areas to existing individual identification catalogues. Collaboration will also form an important part of the medium-term strategy.

It is envisaged that biopsy sampling and photo-ID to identify individuals will continue to be an important component of IWC-POWER.

4.3.3 Telemetry

Telemetry can provide valuable information on long-term movements of whales that can in turn provide valuable information on potential mixing of populations and location of breeding grounds. To date, the IWC-POWER programme has only undertaken a feasibility study to use telemetry to investigate short-term diving behaviour (WP10; see Item 4.2.5). The use of telemetry for long-term movements in the next phase of the IWC-POWER programme is considered under Item 7.

4.4 Marine debris

The IWC-POWER cruises have collected information on marine debris since 2010, using a strategy to minimise any disruption of the primary aim of collecting data on cetaceans (i.e., collecting such data only for the first 15 minutes of each hour). The data from 2010-16 have been analysed in light of previous comments by the Committee and the TAG which looks forward to its publication in the near future. It is envisaged that such studies be continued in the next phase of the programme.

4.5 Other (e.g., related to environment)

During Phase 1 of IWC-POWER, it had been agreed that it was not practical to undertake the collection of any more oceanographic information from the vessel other than that which could easily be obtained without the need to stop the vessel (primarily sea-surface temperature). However, the TAG **agrees** on the importance of oceanographic data to the IWC-POWER programme (e.g., with respect to spatial modelling). It **agrees** that a number of external data sources (e.g., satellite data and ocean models) can provide information and that these should be explored, recognising that care is needed to determine that it can be obtained at a suitable scale. While it is a low priority and the actual feasibility of the installation needs to be examined, the possibility of collecting data by an echosounder to qualitatively understand the distribution of prey species of cetaceans would be considered. This is considered further under Item 7.

5. REVIEW OF RESULTS AND AVAILABLE INFORMATION BY SPECIES

5.1 Fin whales (high priority)

5.1.1 Distribution and stock structure

Figs 2 and 3 show the distribution of sightings and biopsy samples for the cruises from 2010-22. Fin whales are widely distributed throughout the surveyed areas north of 40°N. This is broadly in accord with past summer catch data. The distribution of sightings suggest that fin whales are probably found to the west and east of the surveyed areas as they were in the past. The western waters are partly covered by Japanese national surveys, but it is clear that, for a full picture, it will be necessary to obtain information from Russian waters. Unfortunately, proposed IWC-POWER cruises to Russian waters have not received permits from the Russian Federation (see discussion at SC69D). There is a suggestion that, due to warmer waters as a result of climate change, fin whale distribution might extend further north into the northern Bering and Chukchi Seas. The 2024 cruise will likely extend north into part of the Chukchi Sea.

The spatial modelling referred to under Item 5.1.2 will greatly assist in developing density maps and planning for the next phase of IWC-POWER.

The biopsy samples (*n*=142) are well distributed throughout the surveyed area. The Workshop was informed that the Southwest Fisheries Science Centre (SWFSC) in La Jolla, California, is developing methods to genotype SNP loci and that some IWC-POWER samples will be used in later genotyping. The ICR is planning lab work for mtDNA control region sequencing and microsatellite DNA (16 loci) genotyping for a stock structure study that will incorporate IWC-POWER samples and

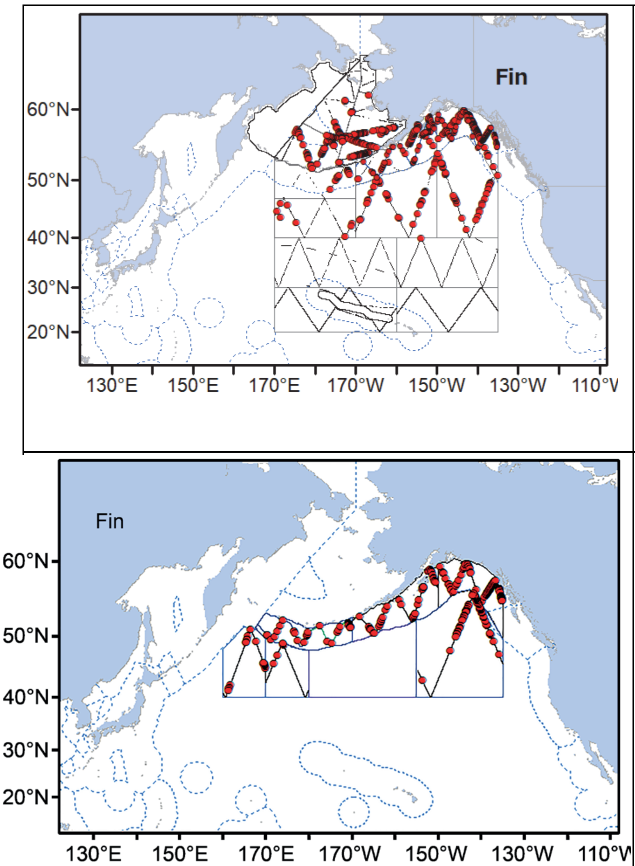


Fig. 2. Summary of sightings of fin whales for the cruises from 2010-18 (top) and 2019-22 (bottom). Dotted blue lines: EEZs.

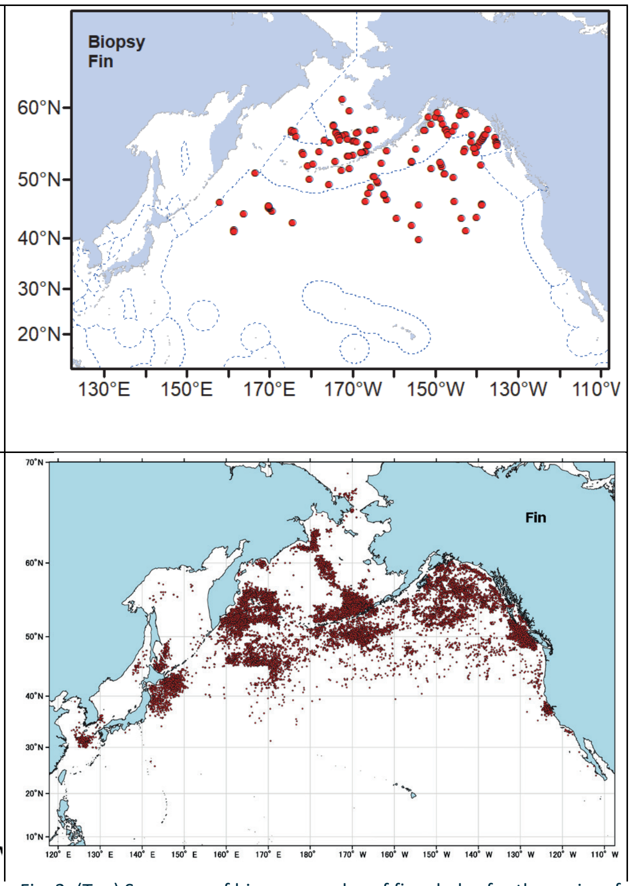


Fig. 3. (Top) Summary of biopsy samples of fin whales for the cruises from 2010-22, including samples collected during transit. Dotted blue lines: EEZs. For comparison with Figs. 2 and 3 (top), the bottom section shows distribution of historic catches throughout the year - not just during IWC-POWER surveys.

western North Pacific samples from other sources. Genetic analyses of stock structure are ongoing. Completion of these analyses will greatly assist any future *Comprehensive Assessment* of North Pacific fin whales.

5.1.2 Abundance

The TAG received preliminary design-based estimates of fin whale abundance up to 2018 (WP10). These are uncorrected for *g*(0) or additional variance. To provide context only in terms of the next phase of IWC-POWER, the uncorrected estimates for the Bering Sea (2017-18) are around 14,000 (CV about 0.25), and, for the rest of the surveyed areas south of the Aleutian Islands (2010-12), around 29,000 (CV around 0.21). These preliminary estimates should not be cited and cannot be considered agreed estimates.

Analysis of the data to estimate *g*(0) is underway and additional variance will be investigated by comparing estimates from the early period (2010-12) with those for similar areas in the later period (i.e., 2019-22), recognising that the survey periods for these later cruises were later in the year (August-September rather than July-August). The TAG **recommends** that corrected fin whale design-based and spatial estimates for the whole period are developed as a high priority.

5.1.3 Outstanding issues relative to new surveys

The IWC-POWER data are invaluable for providing the first direct abundance estimates of fin whales for this part of the North Pacific. As noted under Item 5.1.1, the importance of obtaining estimates from Russian waters cannot be overstated. While recognising the current political situation, the TAG strongly **encourages** the IWC and relevant range states to continue to seek permission to finish Phase 1 of IWC-POWER and enable proper planning for Phase 2 with respect to this species.

5.2 North Pacific Right whales (High priority)

5.2.1 Distribution and stock structure

There have been few sightings of this species, even with the use of directional hydrophones to assist in detections (Fig. 4). The sighting in the northern Bering Sea was unusual. Distribution is clearly limited in the eastern North Pacific within the IWC-POWER area.

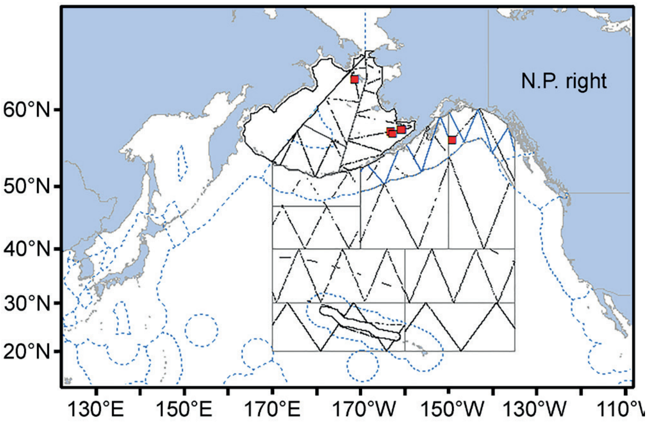


Fig. 4. Summary of sightings of North Pacific right whales for cruises from 2010-18. No sightings were made during the 2019-22 cruises.

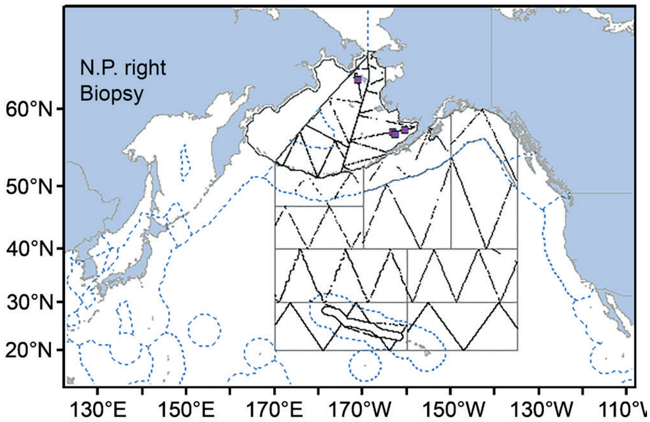


Fig. 5. Summary of biopsy samples of North Pacific right whales for cruises from 2010-21.

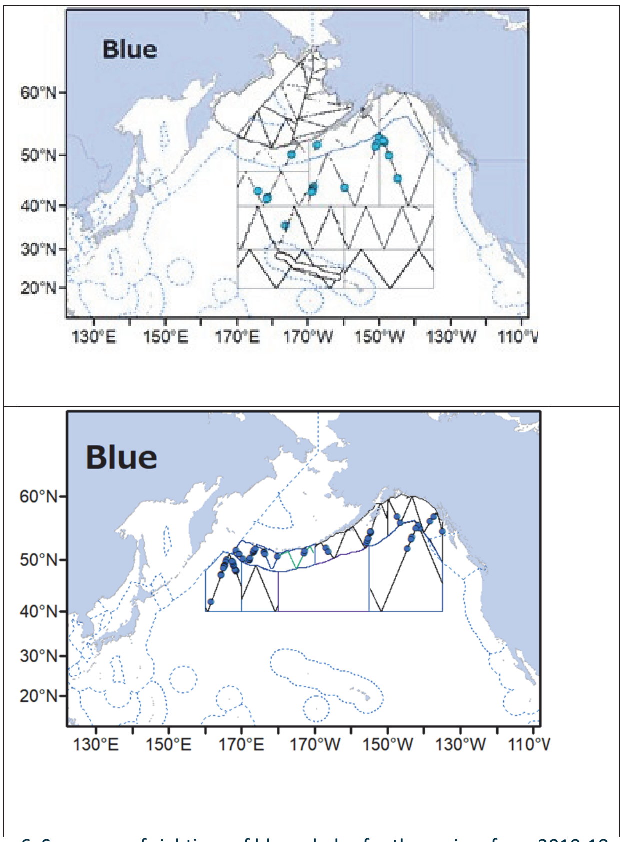


Fig. 6. Summary of sightings of blue whales for the cruises from 2010-18 (top) and 2019-22 (bottom). Dotted blue lines: EEZs.

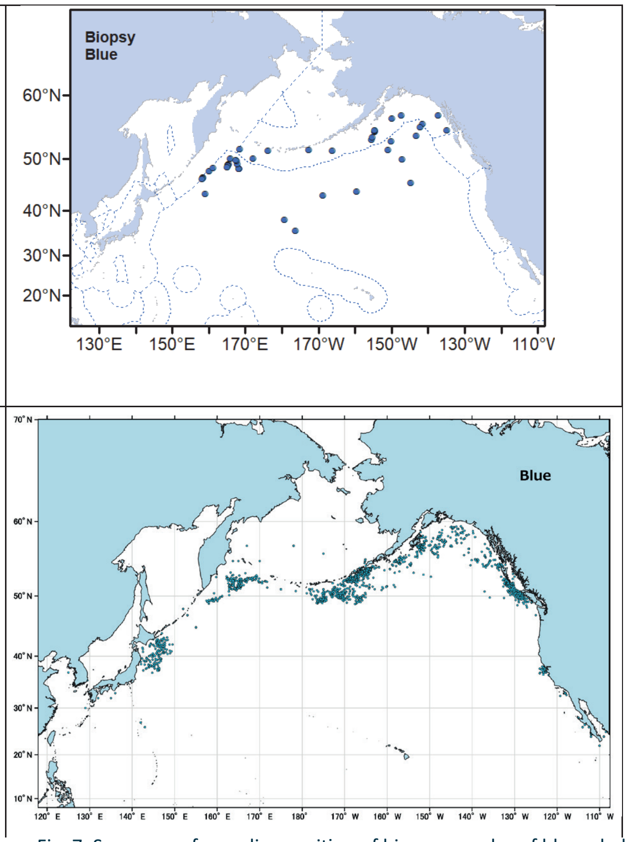


Fig. 7. Summary of sampling position of biopsy samples of blue whales collected for cruises from surveys 2010-22, including samples collected during transit. Dotted blue line: EEZs. For comparison with Figs. 6 and 7 (top), the bottom section shows distribution of historic catches throughout the year - not just at time of IWC-POWER surveys.

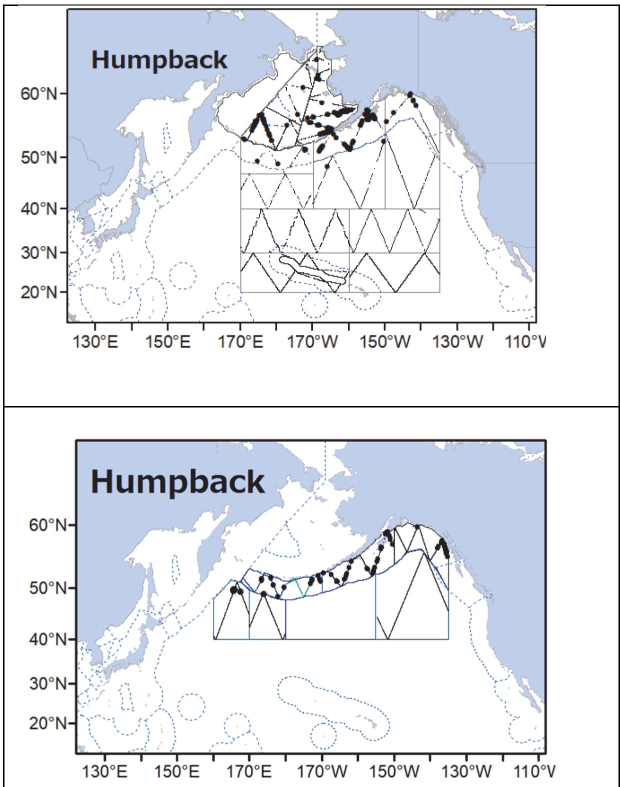


Fig. 8. Summary of sightings of humpback whales for the cruises from 2010-18 (top) and 2019-22 (bottom). Dotted blue lines: EEZs.

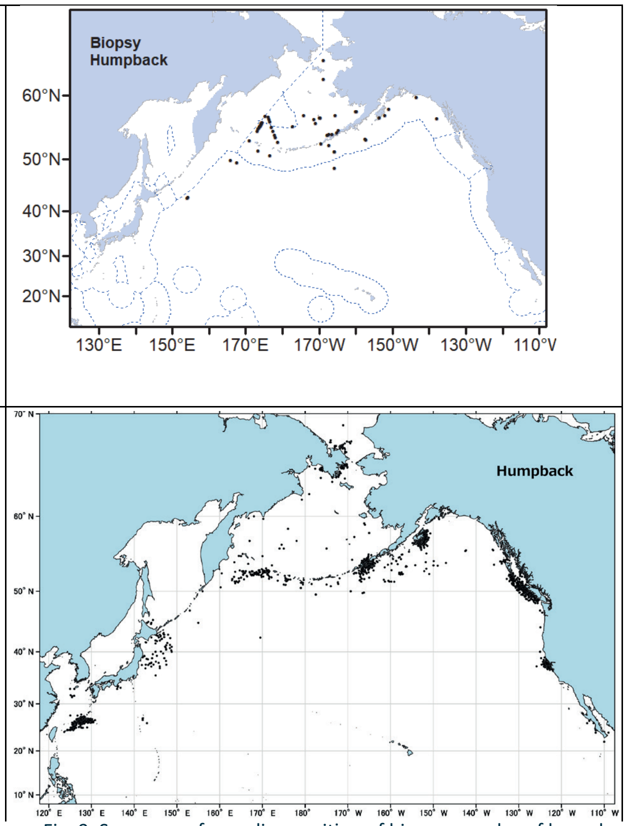


Fig. 9. Summary of sampling position of biopsy samples of humpback whales collected from surveys 2010-22, including samples collected during transit. Dotted blue line: EEZs. For comparison with Figs. 8 and 9 (top), the bottom section shows distribution of historic catches throughout the year - not just at time of IWC-POWER surveys.

High priority was given to obtaining biopsy samples (*n*=6) from any animals seen. These IWC-POWER samples have been incorporated into a larger scale study of North Pacific right whales. Pastene *et al.* (2020) analysed genetic data generated from these samples, in combination with all other available genetic data of this species, as part of a collaborative genetic study between the SWFSC and the ICR to focus on stock structure. Two markers were examined for samples from the eastern and western North Pacific (mtDNA, *n*=30, each for east and west; microsatellites, *n*=19, only west).

These mtDNA results were consistent with the pattern of catch and sighting data which showed higher densities on both sides of the North Pacific, but little in between, as suggested by Clapham *et al.* (2004). These findings support the hypothesis of different populations occurring in the eastern and western sides of the North Pacific. An alternative but less likely interpretation of these results indicates a single interbreeding population in the North Pacific that exhibits mtDNA structuring as a result of matrilineally driven seasonal site fidelity. Available and future genetic samples should be analysed for stock differentiation based on nuclear markers, microsatellite DNA and/or SNPs.

5.2.2 Abundance
There are insufficient sightings data to develop a reliable DISTANCE sampling-based abundance estimate from IWC-POWER cruises. Low abundance levels also make it unlikely that this approach will be successful in the future. The contribution of IWC-POWER to obtaining abundance estimates lies in providing individual identification data to existing catalogues to allow for mark-recapture abundance estimates to be derived. The use of acoustics to assist in the detection of North Pacific right whales to increase sample size for individual identification is recommended.

5.2.3 Outstanding issues relating to new survey
The major issue for the future is to determine strategies that will facilitate increased sample sizes to enable mark-recapture estimates to be developed in conjunction with other projects in the North Pacific.

5.3 Blue whales (high priority)
5.3.1 Distribution and stock structure
Blue whales have been observed throughout the IWC-POWER study area, primarily north of 40°N, as far as the Aleutian chain. Recent surveys, and data from other sources, including Japanese national surveys, show that the western edge of

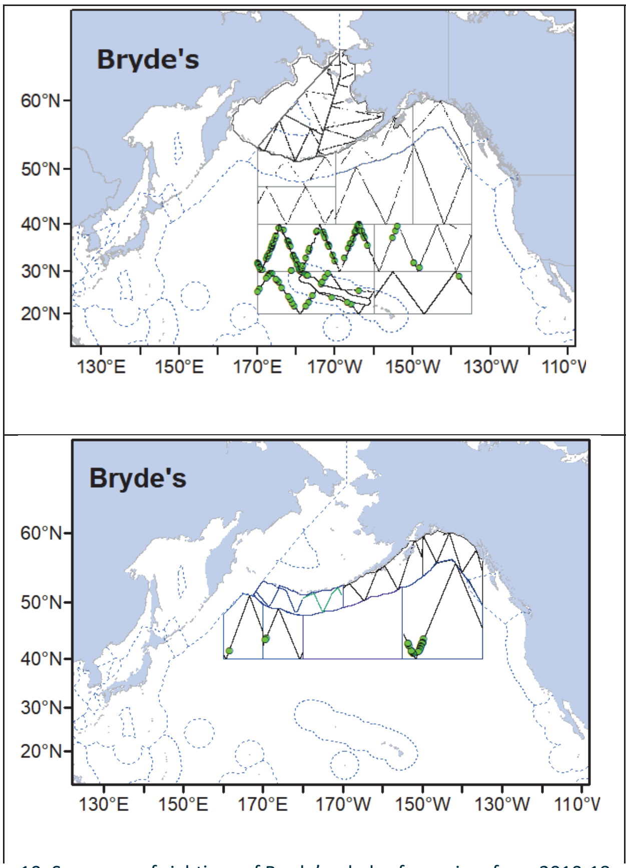


Fig. 10. Summary of sightings of Bryde's whales for cruises from 2010-18 (top) and 2019-22 (bottom). Dotted blue lines: EEZs.

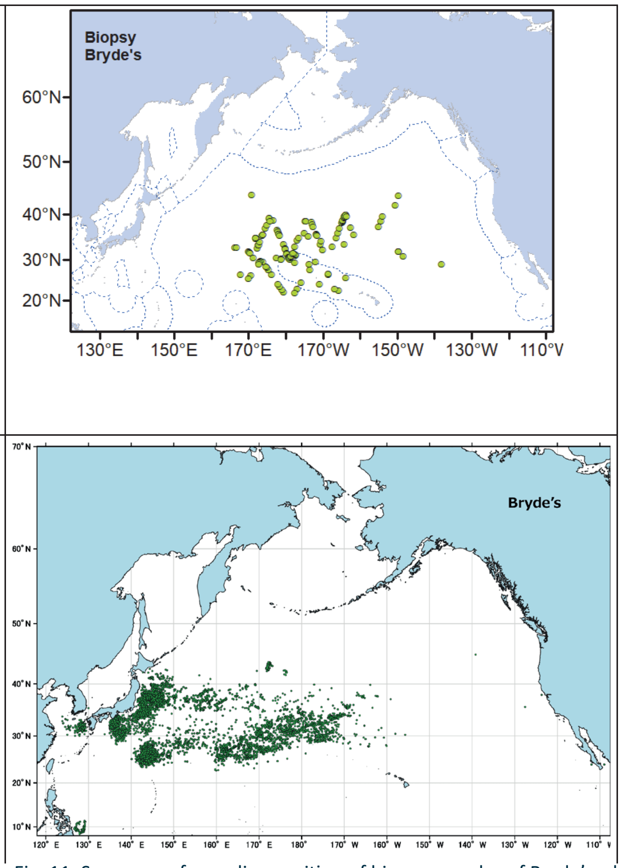


Fig. 11. Summary of sampling position of biopsy samples of Bryde's whales collected from surveys 2010-22, including samples collected during in transit. Dotted blue line: EEZs. For comparison with Figs. 10 and 11 (top), the bottom section shows distribution of historic catches throughout the year - not just at time of IWC-POWER surveys.

the study area does not represent the western boundary for blue whales. The total number of IWC-POWER blue whale biopsy samples is 47 (including samples taken during transit). Even though the sample size is small, the samples are widely distributed throughout the IWC-POWER research area north of 40°N (Fig. 7).

The Workshop was informed that SWFSC generated mitogenome sequences for the IWC-POWER samples up to 2017 (n=9) for use in a project to evaluate the global subspecies taxonomy of blue whales (table 3 of IWC, 2021). With respect to stock structure and a future *Comprehensive Assessment* of North Pacific blue whales, the Workshop was informed that ICR is further planning mtDNA and microsatellite laboratory work for a study to incorporate samples from the western North Pacific (IWC, 2021).

5.3.2 Abundance

Only data for the 2010-12 surveys have been analysed to date. The sample size was small, with 15 primary sightings, and the preliminary design-based estimate (uncorrected for $g(0)$ or additional variance) of around 1,100 with a CV of 0.38 is only provided to add context for development of the next phase of IWC-POWER. It should **not** be cited or considered an agreed estimate. The TAG **agrees** that an analysis of all blue whale data after completion of the 2023 survey should be promptly undertaken. Consideration should be given to obtaining mark-recapture abundance estimates from photo-ID efforts throughout the North Pacific.

5.3.3 Outstanding issues relative to new survey

The IWC-POWER sightings and biopsy data have provided the first systematic recent information on this species in these waters relating to abundance and stock structure. Photo-ID efforts are promising. Full analyses of the available information from IWC-POWER and other sources on these topics should be undertaken in the next two to three years in order to enable an appropriate strategy and priority for Phase 2 (see Table 7).

5.4 Humpback whales (medium priority)

5.4.1 Distribution and stock structure

Humpback whales were widely distributed throughout the surveyed areas north of 50°N (Fig. 8). The total number of IWC-POWER humpback whale biopsy samples is 62 and they are widely distributed longitudinally in the IWC-POWER research area north of 50°N (Fig. 9). These samples have not yet been analysed.

5.4.2 Abundance

Preliminary abundance estimates were provided in WP10. Attention was drawn to differences in detection functions between the Gulf of Alaska and the Bering Sea. It was agreed this should be investigated further before final estimates are presented to the Committee. It was noted that, while IWC-POWER line-transect estimates can provide information to the ongoing *Comprehensive Assessment* of North Pacific humpback whales, mark-recapture estimates are the primary source of the abundance estimates used. IWC-POWER photographs make an important contribution to that effort.

5.5 Bryde's whales (eastern North Pacific) (medium priority)

5.5.1 Distribution and stock structure

Bryde's whales were primarily found south of 40°N. Within the surveyed areas, they were most abundant between around 170°E and 160°W - but the former clearly did not represent a distribution boundary as witnessed by Japanese surveys.

The total number of IWC-POWER Bryde's whale biopsy samples is 139. These are widely distributed in the IWC-POWER research area, south of 40°N (Fig. 11). The IWC-POWER samples have played a major role in the Implementation Review of this species in the western North Pacific, in conjunction with samples from Japanese whaling. They were the predominant samples to the east of 180°E. The results of this work have been extensively discussed by the Committee.

5.5.2 Abundance

The Committee has used abundance estimates from the IWC-POWER surveys as an important part of the *Implementation Review*.

5.5.3 Outstanding issues relative to new survey

In future, primary biopsy sampling effort should be spent in areas east of 150°W in order to further examine the two stocks proposed for the western and central North Pacific. There is also a need to investigate the relationship between Bryde's whale stocks in the North Pacific with a genetically differentiated stock in the Gulf of California.

Additional analyses based on kinship could be valuable to assist interpretation of the current results of the heterogeneity test and Bayesian analyses. The development and use of additional genetic markers (e.g., SNPs) are recommended to further examine the available genetic samples.

Given the other high-priority species and the distribution of Bryde's whales, the TAG suggests that a targeted survey(s) should be considered later in the programme (e.g., after 2029) in light of further analysis of the existing data. Telemetry studies will be considered for long-term movements (relevant to distribution, movements within the surveyed area and identification of breeding areas) and diving behaviour (to investigate availability bias in line-transect estimates).

Previous recommendations for work to evaluate the use of photo-ID data for this species should be carried out to determine its value for Phase 2.

5.6 Sei whales (medium priority)

5.6.1 Distribution and stock structure

As expected, Sei whales were found throughout the surveyed areas between 50°N and 60°N.

The total number of IWC-POWER sei whale biopsy samples is 126. These are widely distributed in the IWC-POWER research area, north of 40°N (Fig. 13). These samples are playing a major role in the ongoing *Comprehensive Assessment* of sei whales along with samples from Japanese cruises. The Committee has decided to proceed with two hypotheses on stock structure, one that considers a single stock in the North Pacific, the other that considers five stocks. The first is based on the interpretation of genetic and non-genetic analyses, while the second is based on the interpretation of mark-recapture data. Based on the results of the genetic analyses, the Committee has agreed that the pelagic region of the North Pacific comprises a single stock of sei whales.

IWC-POWER biopsy samples were important for the analyses described above because they covered the eastern North Pacific, an area where the number of historical samples was small and dated. The additional samples from IWC-POWER allowed an increase in the number of samples (increase in the power of the analysis) and allowed the testing for temporal genetic differences in the eastern North Pacific (Kanda *et al.*, 2015). The use of techniques such as SNPs may assist where there are few samples, such as the coastal areas (and see Item 5.6.3).

5.6.2 Abundance

The Committee continues to use abundance estimates from the IWC-POWER surveys as part of the *Comprehensive Assessment* of sei whales.

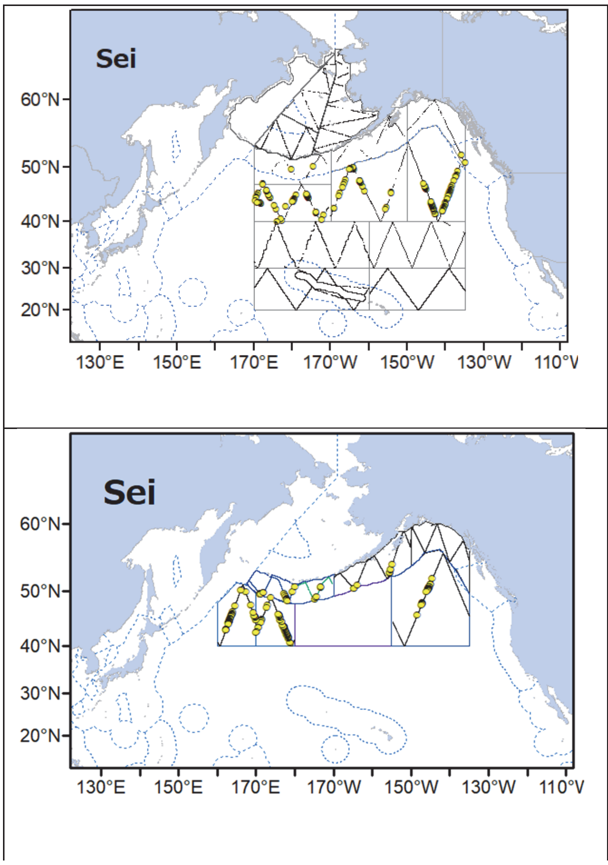


Fig. 12. Summary of sightings of sei whales for cruises from 2010-18 (top) and 2019-22 (bottom). Dotted blue lines: EEZs.]

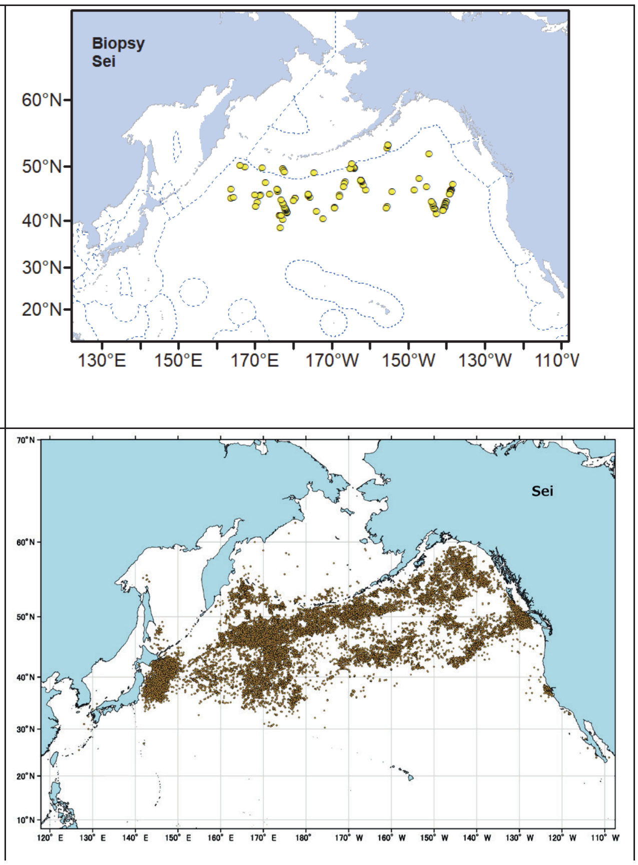


Fig. 13. Summary of sampling position of biopsy samples of sei whales collected from surveys 2010-22, including samples collected during transit. Dotted blue line: EEZs. For comparison with Figs. 12 and 13 (top), the bottom section shows distribution of historic catches throughout the year - not just at time of IWC-POWER surveys.]

5.6.3 Outstanding issues relative to new survey

Results of the *Comprehensive Assessment* will help focus future IWC-POWER medium-term strategy and priorities for this species.

The TAG noted that the stock structure hypotheses with five stocks would benefit from samples both from the coastal area (e.g., the Aleutians) and from where there were considerable catches in the past. However, the IWC-POWER surveys have seen few animals here which means the possibility of obtaining biopsy samples is low. The value of targeted telemetry seems more practical for Phase 2.

5.6.4 Other

Previous recommendations for work to evaluate the use of photo-ID data for this species should be carried out to determine its value for Phase 2.

5.7 Sperm whales (medium priority)

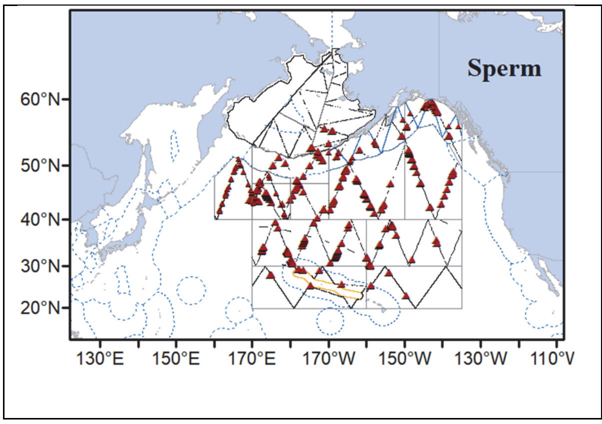
5.7.1 Distribution and stock structure

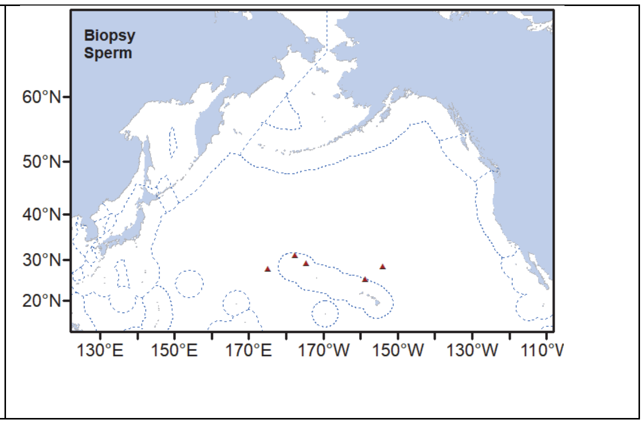
Sperm whales are seen commonly throughout the area, apart from the Bering Sea.

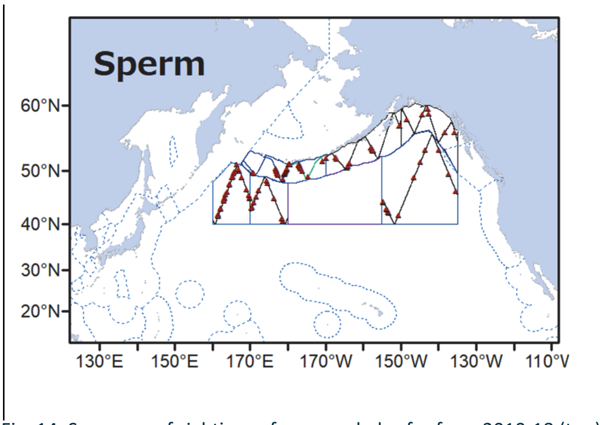
Collection of biopsy samples is a low priority. The total number of IWC-POWER sperm whale biopsy samples is six. These were obtained south of 30°N (Fig. 15). These samples have not yet been analysed and would only be of value in conjunction with other studies.

5.7.2 Abundance

Obtaining abundance estimates for sperm whales from visual surveys is problematic in part due to long dive times. If certain assumptions are made, they can provide a suitable index of abundance. Uncorrected abundance estimates provide minimum estimates and initial line-transect abundance estimates from IWC-POWER (still being finalised) suggest tens of thousands of sperm whales in the North Pacific.







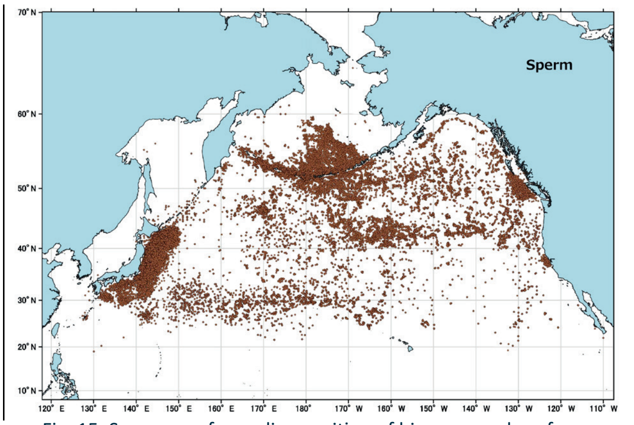


Fig. 14. Summary of sightings of sperm whales for from 2010-18 (top) and 2019-22 (bottom). Dotted blue lines: EEZs.

Fig. 15. Summary of sampling position of biopsy samples of sperm whales collected from surveys 2010-22, including samples collected during transit. Dotted blue line: EEZs. For comparison with Figs. 14 and 15 (top), the bottom section shows distribution of historic catches throughout the year - not just at time of IWC-POWER surveys.

5.7.3 Outstanding issues relative to new survey

The TAG noted that the possibility of using towed acoustic arrays to obtain abundance estimates in some targeted years in the longer term could be considered under IWC-POWER, depending on availability of equipment, suitable vessels and practicality in light of other priorities. Future surveys will contribute to indices of relative abundance.

5.8 Common minke whales (eastern North Pacific) (low priority)

5.8.1 Distribution and stock structure

The TAG noted that, while common minke whales were reported, conditions were not optimal for common minke whales sightings that are a low priority for the IWC-POWER programme. The sightings data therefore do not provide a reliable indication of overall distribution. They are not a target for biopsy sampling.

5.8.2 Abundance

While abundance estimates can be calculated from the IWC-POWER data, the TAG agreed that they are not reliable given the sub-optimal sighting conditions.

5.8.3 Outstanding issues relative to new survey

The TAG agreed that common minke whales remain a low priority for the IWC-POWER programme. However, if the Okhotsk Sea can be covered at some time in the future for high priority species (e.g., right whales), then it would be appropriate to consider modifying present 'acceptable' conditions to allow the estimation of abundance for this species. It would also be valuable to collect biopsy samples for any future *In-depth Assessment*.

5.9 Other species

In light of precious recommendations, the TAG agreed that it was important to examine the distribution and abundance of the other species recorded during IWC-POWER at a future meeting. Once available, these estimates will inform future IWC-POWER discussions.

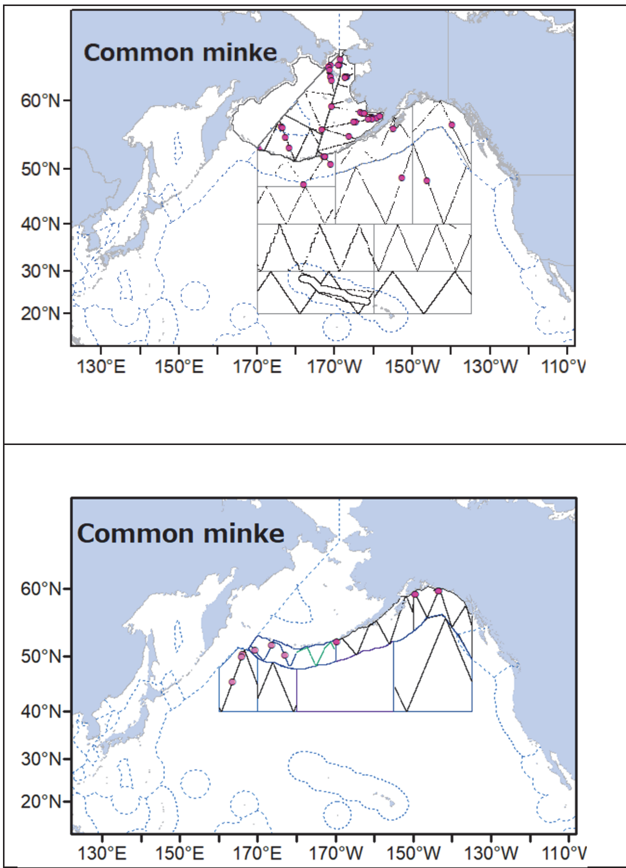


Fig. 16. Summary of sightings of common minke whales from 2010-18 (top) and 2019-22 (bottom). Dotted blue lines: EEZs.

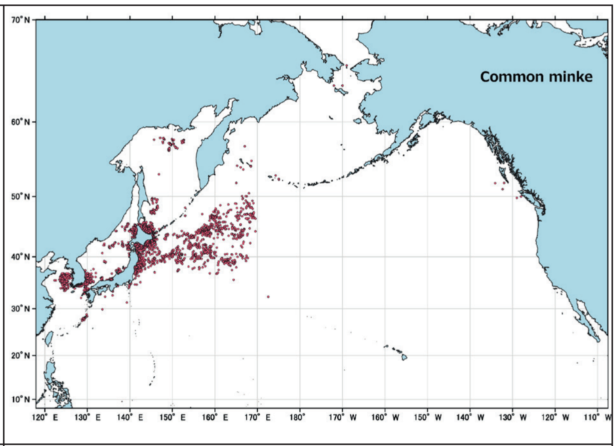


Fig. 17. For comparison, Fig. 17 shows the distribution of historic catches throughout the year - not just at time of IWC-POWER surveys.

6. REVIEW OF OTHER (I.E. NON IWC-POWER) PAST AND ONGOING SURVEY ACTIVITIES AND AVAILABILITY OF DATA

The TAG noted the enhanced value of collaborative analyses with surveys and other efforts occurring outside the IWC-POWER cruises. This is already the case for a number of Committee initiatives, such as *Implementation Reviews* and *Comprehensive Assessments*. It was **agreed** that, prior to the 2023 TAG meetings, the Steering Group should develop a list of relevant activities for discussion.

7. INITIAL PLAN FOR ACHIEVING MEDIUM TO LONG-TERM OBJECTIVES AND PRIORITIES BASED ON LESSONS LEARNED UNDER ITEMS 4 AND 5

7.1 Update on objectives (e.g., stock structure, abundance, trends) and priority species

In light of discussions above, the TAG spent considerable time updating the medium-long term objectives and **recommends** these to the Committee (see Table 1).

7.2 In light of objectives and previous experience, consideration of whether new survey areas should be considered, and if so where (e.g., areas further north including Beaufort and Chukchi Seas, areas further south and east including breeding areas in winter), while taking into account other likely research programmes

The TAG **agreed** that this item should be further considered at next year's meeting in light of the results of analyses recommended and discussions by the Committee about the updated medium- long-term priorities developed under Item 7.1. The discussion of appropriate regions will involve integration of scientific priorities, resources and the geopolitical situation. From a scientific perspective, there is merit in covering the Okhotsk Sea (right and common minke whales), the Beaufort and Chukchi Seas (especially fin, humpback and gray whales) and investigating potential changes in density and distribution of various species in light of changes to climate. The ability to detect these changes, should they occur (within and/or outside the present IWC-POWER area), is important to address at next year's meeting via power analyses (updated WP19), given the vessel resources likely to be available.

Table 1

Suggestions for updated medium-term priorities based on results from Phase 1. *Refers to likelihood of obtaining an abundance estimate in at least some areas. **Refers to likelihood of obtaining biopsy and/or photo-ID data from encountered schools. N.B. Consideration of the effect of possible distribution changes due to climate change will be a general priority for most species (e.g., by extending the surveyed areas to the north). See Item 5 for more details and recommendations by species.

Initial priority and feasibility	Rationale and comments
Blue whale (high) High direct* High opportunistic**	• Depletion level in the west is unknown but may be high given past catches. • Population in the east is estimated to have recovered to 62-99% of its unexploited level (Monahan *et al*., 2015) with abundance at about 2-3,000 based on mark-recapture estimates from long-term studies south and east of IWC-POWER survey area. • Initial line-transect abundance estimates from IWC-POWER (still being finalised) suggest around one thousand animals in the surveyed area. • Results of genetic analyses (43 IWC-POWER samples in addition to samples from other programmes) will inform population structure and management units. Consideration of other data sources (e.g., 'songs' - see Monnahan, 2014) should be undertaken, including analysis of existing sonobuoy data collected under IWC-POWER. • Given the size of the line-transect abundance estimate, the probability of obtaining mark-recapture estimates using data from the northern waters and in co-operation with the existing data from Japan and the USA is high if focussed cruises (or parts of cruises) are undertaken in specific areas in the east and west to collect photo-ID and biopsy samples. Opportunistic studies on other cruises should continue. • Continued collaboration with existing photo-ID work e.g., US and Japanese national programmes are important. The possibility of a single catalogue should be investigated as a priority. • Telemetry studies will be considered for long-term movements (relevant to distribution, movements within the surveyed area and identification of breeding areas) and diving behaviour (to investigate availability bias in line-transect estimates, although the primary method for obtaining abundance estimates is likely to be mark-recapture).
Fin whale (high) High direct* High opportunistic**	• Depletion level was believed to be high based on catch history at start of IWC-POWER. North Pacific fin whales are now a potential Comprehensive Assessment candidate which will enable the present depletion level to be established. • Initial line-transect abundance estimates from IWC-POWER (still being finalised) suggest tens of thousands of fin whales in the North Pacific. • Results of genetic analyses (142 IWC-POWER samples) will make an important contribution to understanding stock structure and management units in the North Pacific. These are expected within two years. This will also help to develop both future survey strategy and Comprehensive Assessment. Including data from the USA, Japan and Korea is important. • Co-ordination with national programmes in Japan, Korea and the USA should continue and be strengthened. Work in Russian Federation waters is very important, provided appropriate permits can be obtained. • Telemetry studies will be considered for long-term movements (relevant to distribution, movements within the surveyed area and identification of breeding areas) and diving behaviour (to investigate availability bias in line-transect estimates).
Right whale (high) High direct* High opportunistic**	• Highly depleted based on catch history - especially in the east (data from US studies and IWC-POWER). • Absolute numbers in the east are well below 100. Valuable IWC-POWER data should be incorporated. Focused studies in the east should continue. • Numbers in the west are considerably higher. Obtaining abundance from line-transect surveys is feasible, but this would require permits to operate in Russian waters, including those close to the coast which is unlikely to be granted. Focused studies to obtain photo-ID and biopsy samples in international waters in the west (e.g., international waters to the south and east of Kamchatka) should be undertaken. Collaboration with Japan and the US is important and the possibility of a single catalogue should be investigated as a priority. • Telemetry studies will be considered for long-term movements (relevant to distribution, movements within the surveyed area and identification of breeding areas) provided that safeguards are in place (*c.f.* the telemetry programme for western gray whales off Sakhalin).
Sei whale (medium) High direct* High opportunistic**	• Depletion level being investigated as part of the ongoing *Comprehensive Assessment*. • Initial abundance estimates from Japan and IWC-POWER (still being finalised) are in tens of thousands. • Analysis of genetic and other data has led to two stock structure hypotheses: a single stock or five stock-hypotheses with a single pelagic stock in the areas covered by IWC-POWER and Japan and five postulated coastal stocks. • Results of the *Comprehensive Assessment* will help focus future IWC-POWER medium-term strategy and priority for this species. • While obtaining biopsy samples from the postulated coastal stocks will be valuable, a targeted strategy to obtain these is not feasible given the very low densities in such areas covered by IWC-POWER to date. • Telemetry studies will be considered for long-term movements (relevant to distribution, movements within the surveyed area and identification of breeding areas) and diving behaviour (to investigate availability bias in line-transect estimates).
Humpback whale (medium) High direct* High opportunistic**	• Good information is already available from SPLASH and national programmes which suggests overall high abundance (genetic and photo-ID mark-recapture) - hence medium priority. • IWC-POWER has contributed valuable data/samples to existing genetic and photo-ID databases. This should continue. • Ongoing *Comprehensive Assessment* will assess status and potential depletion of populations in the North Pacific. • Abundance estimates from IWC-POWER (still being finalised) can provide interesting 'snapshot' estimates to compare with the primary mark-recapture estimates by population/feeding aggregations. • Results of the *Comprehensive Assessment* will assist when developing medium-term strategy and priority for this species by population within IWC-POWER. • Telemetry studies will be considered for diving behaviour (to investigate availability bias in line-transect estimates).

Initial priority and feasibility	Rationale and comments
Sperm whale (medium) Medium direct* Low opportunistic**	• Depletion level unknown but possibly high given catch history • Lack of good information on population structure and status, though good distributional data from IWC-POWER. • Obtaining abundance estimates from visual surveys can be problematic due to long dive times, but if certain assumptions are made, they can provide a suitable index of abundance. Uncorrected abundance estimates provide minimum estimates. Initial line-transect abundance estimates from IWC-POWER (still being finalised) suggest tens of thousands of sperm whales in the North Pacific. • Obtaining biopsy samples and photo-ID has proved to be difficult under IWC-POWER and priority is therefore low given the high population size. • Possibility of using towed acoustic arrays in some years in the longer term could be considered depending on availability of equipment, suitable vessels and practicality in light of other priorities.
Bryde's whale (medium) High direct* High opportunistic**	• Suggest low priority for first six or so years of next phase of IWC-POWER because: - Recently completed IR shows good population status and apparently low level of threats; - Removing from target species allows a great reduction in size of priority research area to north of 40°N. • A targeted survey(s) is to be considered from 2029 in light of existing data. • Telemetry studies will be considered for long-term movements (relevant to distribution, movements within the surveyed area and identification of breeding areas) and diving behaviour (to investigate availability bias in line-transect estimates).
Common minke whale (low) Suggest only opportunistic	• Depletion level probably low in east/central based on catch history; in west dealt with by national programmes. • From the outset of IWC-POWER, it was agreed that common minke whales were a low priority - thereby allowing acceptable sighting conditions to be set at higher sea states than optimal for minke whales to increase effort for the larger whales species. • However, if Okhotsk Sea can be covered for high priority species (e.g., right whales), then would provide valuable information, incl. biopsy samples. • If permission granted by Russian Federation, consider modifying present 'acceptable' conditions as, at present high range, they are unsuitable for estimating abundance for this species.
Gray whale (low) Low direct* High opportunistic**	• There are ASW hunts but the primary data sources to evaluate these are from other visual, genetic and photo-ID programmes (e.g., USA, Mexico, Sakhalin Island) - hence medium priority. These are evaluated under the AWMP and a series of range-wide workshops. • Main IWC-POWER contribution is obtaining biopsy/photo-ID in areas outside these programmes for comparison with existing information on population structure. Important areas are feeding grounds, especially the western Chukchi Sea which would require permission to operate in Russian waters. • Sharing of data with the other programmes primarily responsible for providing information on the assessment of gray whales should continue.
Bowhead whale (very low) Low direct* High opportunistic**	• There are ASW hunts but the primary data sources to evaluate these are from the USA national programme. This is evaluated under the AWMP. • The IWC-POWER cruises in northern waters may encounter bowhead whales. If so, they should record the sightings data, but no effort need be expended on photo-ID or biopsy sampling as stock structure and abundance is well-known. An important area is the western Chukchi Sea, but this would require permission to operate in Russian waters.

7.3 In light of objectives and previous experience, consideration of whether experimental cruises are needed to test new technology or methodological approaches

There was insufficient time to address this is detail, but suggestions above relating to telemetry, acoustics, use of sea drones and glider should be considered further next year.

7.4 Field methods by objectives, taking into account feasibility and priority species in light of analytical approaches

The TAG referred to discussions above relating to the updated priorities. It noted that the primary research methods used to date (distance sampling, biopsy sampling and photo-ID were likely to remain the primary methods for the next phase) along with consideration of newer techniques, such as telemetry or targeted surveys using acoustics.

8. PROPOSAL FOR NEXT THREE TO FIVE SEASONS' WORK

The TAG **agreed** that this will be an important topic for next year's meeting in light of the additional analyses of existing data and discussions of updated priorities at SC69A.

9. OTHER GENERAL MATTERS

9.1 Participation of other range states in IWC-POWER and coordination with other research activities

The Committee has long supported the IWC-POWER programme. Despite limited IWC funds, thanks to the generosity of Japan, systematic surveys and data collection has taken place in areas that have not been covered for decades, if ever. Many of these areas had been subject to intense whaling in the past. The TAG noted that Japan remains a co-owner of the IWC-POWER data and refers to the data access protocol for IWC-POWER, IWC-SOWER and IDCR data (SC Handbook).

Table 2

Workplan.

Item	Activity	Responsible persons (lead in **bold** type)	Time
Data			
1	Complete validation of IWC-POWER sightings and effort data for the period up to 2022 cruise. Submit GPS and shape files.	**Matsuoka** and Hughes	Ongoing
3	Complete importation and classification of 2022 IWC-POWER photographs into IWC photographic database	Taylor, **Matsuoka** and Staniland	Ongoing
Analyses			
1	Complete review of angle/distance experiments, following the guidance provided in IWC (2019, item 6.2.1) and IWC (2021), then publish.	**Kitakado** and Team	Ongoing. Final draft expected at 2023 TAG
2	Develop updated abundance estimates (design-based) for humpback, blue, fin, sei and Bryde's whales, following advice provided in IWC (2020), and later (incorporating estimates from item 4 below if available).	**Matsuoka, Kitakado** and scientists from TUMSAT/ICR	Ongoing. Some accepted by ASI. Updated drafts for others at 2023 TAG
3	Develop updated abundance estimates (model-based) for humpback, blue, fin, sei and Bryde's whales, following advice provided in IWC (2020), and later (incorporating estimates from item 4 below if available.	**Kitakado, Matsuoka** and scientists from TUMSAT/ICR	Ongoing. Updated draft expected at 2023 TAG
4	Provide updated estimates of *g*(0) for species where considered possible (including fin, sei and humpback) following advice provided in IWC (2020), and later.	**Hakamada** and scientists from TUMSAT/ICR	Ongoing. Final draft expected at 2023 TAG
5	Develop abundance estimates for small cetacean species (killer, etc.)	Matsuoka, Kitakado and others	Ongoing. Updated draft expected at 2023 TAG
6	Continue simulation work to investigate spatial modelling approaches following advice provided in IWC (2020), and later.	**Kitakado** and Palka	Ongoing. Updated draft expected at 2023 TAG
7	Continue work on power analyses following advice provided in IWC (2020), and later.	**Kitakado** and Palka	Ongoing. Updated draft expected at 2023 TAG
Future			
1	Develop a Factsheet covering IWC-POWER up to 2023, focusing on achievements and the next phase.	**Staniland** and Steering Group	Present at SC68C

Phase 1 of IWC-POWER has set an important baseline for meeting the long-term objectives of understanding stock structure, estimating trends in several populations and determining where conservation priorities exist. The ability to detect trends in a reasonable timeframe is largely dependent on the effort that is available. The TAG **reiterates** previous recommendations that the Committee:

- **encourages** all member governments and range states to support the IWC-POWER, either financially or in-kind - in particular, this might be achieved by co-ordinating existing research field work with IWC-POWER; and
- **encourages** the IWC to increase efforts to advertise its willingness to share IWC-POWER data for integrated analyses (e.g., marine debris, biopsy and photo-ID data), especially where analyses of such data alone will only provide limited information.

9.3 Permits and related matters

The TAG **reiterates** the importance of governments and scientists to continue to work proactively to obtain necessary research permits associated with IWC-POWER work, including permission to operate in national waters and the CITES process for biopsy samples.

9.4 Workplan

See Table 2 for the workplan.

10. ADOPTION OF THE REPORT

The Chair thanked the participants for their hard work and the Government of Japan for its support both in this meeting and for the cruise. The participants thanked the Chair for his hard work and leadership. The report was adopted by correspondence.

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Annex A

List of Participants

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Iain Staniland	Head of Science, IWC
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Tatsuya Isoda	Secretariat, ICR
Midori Ota	Interpreter 1
Saemi Baba	Interpreter 2

Annex B

Agenda

1. Introductory items
   - 1.1 Opening remarks and welcoming address
   - 1.2 Election of Chair and rapporteurs
   - 1.3 Adoption of Agenda
   - 1.4 Review of available documents
2. Review of planning discussion at SC (SC/64/Rep1 and SC/65a/Annex G)[2]
   - 2.1 Short term options (incl. information gaps)
   - 2.2 Medium and long-term (incl. information gaps)
3. Objectives of this workshop
4. General survey approaches used to date (2010-21)[3]
   - 4.1 Primary and secondary objectives of surveys related to field and analytical methods used given available resources
   - 4.2 Distribution and abundance
     - 4.2.1 Choice of survey areas and cruise track design
     - 4.2.2 Survey methods for Distance sampling (including survey modes, distance and angle experiments) and analytical approaches (design-based and spatial approaches)
     - 4.2.3 Individual identification (photo and genetic)
     - 4.2.4 Acoustics
   - 4.3 Stock structure and movements
     - 4.3.1 Population structure related genetic analyses from biopsy samples
     - 4.3.2 Movements from individual identification (photo and genetic)
     - 4.3.3 Telemetry
   - 4.4 Marine debris
   - 4.5 Other (e.g., related to environment)
5. Review of results and available information by species
   - 5.1 Fin whales
     - 5.1.1 Distribution and stock structure
     - 5.1.2 Abundance
     - 5.1.3 Outstanding issues relative to new survey
     - 5.1.4 Other
   - 5.2 North Pacific Right whales
     - 5.2.1 Distribution and stock structure
     - 5.2.2 Abundance
     - 5.2.3 Outstanding issues relative to new survey
     - 5.2.4 Other
   - 5.3 Humpback whales
     - 5.3.1 Distribution and stock structure
     - 5.3.2 Abundance
     - 5.3.3 Outstanding issues relative to new survey
     - 5.3.4 Other
   - 5.4 Common minke whales
     - 5.4.1 Distribution and stock structure
     - 5.4.2 Abundance
     - 5.4.3 Outstanding issues relative to new survey
     - 5.4.4 Other
   - 5.5 Bryde's whales

[2]Including implications of the present political situation and work in waters of the Russian Federation.

[3]Species specific considerations appear under Item 5.

- 5.5.1 Distribution and stock structure
- 5.5.2 Abundance
- 5.5.3 Outstanding issues relative to new survey
- 5.5.4 Other

5.6 Blue whales
- 5.6.1 Distribution and stock structure
- 5.6.2 Abundance
- 5.6.3 Outstanding issues relative to new survey
- 5.6.4 Other

5.7 Sei whales
- 5.7.1 Distribution and stock structure
- 5.7.2 Abundance
- 5.7.3 Outstanding issues relative to new survey
- 5.7.4 Other

5.8 Sperm whales
- 5.8.1 Distribution and stock structure
- 5.8.2 Abundance
- 5.8.3 Outstanding issues relative to new survey
- 5.8.4 Other

5.9 Other

6. Review of other (i.e., non IWC-POWER) past and ongoing survey activities and availability of data
7. Initial plan for achieving medium to long-term objectives and priorities based upon lessons learned under Items 4 and 5

7.1 Update on objectives (e.g., stock structure, abundance, trends) and priority species

7.2 In light of objectives and previous experience, consideration of whether new survey areas should be considered and if so where (e.g., areas further north including Beaufort and Chukchi Seas, areas further south and east including breeding areas in winter) taking into account other likely research programmes

7.3 In light of objectives and previous experience, consideration of whether experimental cruises are needed to test new technology or methodological approaches

7.4 Field methods by objectives and taking into account feasibility and priority species in light of analytical approaches
- 7.4.1 Changes in abundance and distribution
  - 7.4.1.1 Research area choice and cruise design
  - 7.4.1.2 Survey methods and analytical approaches including consideration of new technology (e.g., dive time correction via telemetry and or drones, portable echosounder, new environmental data to assist in spatial modelling)
- 7.4.2 Population structure and movements
  - 7.4.2.1. Field protocols and priority species (biopsy, photo-ID, acoustics)
- 7.4.3 Other

8. Proposal for next three-five season's work
9. Other general matters

9.1 Participation of other range states in IWC-POWER

9.2 Co-ordination with other research activities

9.3. Permits and related matters

9.4 Data Ownership and Data Archive

9.5 Publication

9.6 Other

10. Other

Annex C

Documents

POWER WP

01. Report of the Meeting of the IWC-POWER Technical Advisory Group (TAG): January 2020 (SC/68B/Rep/01).
02. Report of the Meeting of the IWC-POWER Technical Advisory Group (TAG) and 2021 Planning Meeting: November 2020 (SC/68C/Rep/01).
03. Report of the Steering Group of the IWC-POWER Programme to SC68C (SC/68C/ASI/17).
04. Report of the IWC-POWER Planning Meeting for 2022: Virtual meeting, 9-10 December 2021 (SC/68D/Rep/03).
05. Report of SC/68D.
06. Overview of sighting surveys conducted on IWC-POWER cruises from 2010 to 2021.
07. An overview of the sighting studies on abundance based on IWC-POWER surveys.
08. An overview of the genetic studies on stock structure based on biopsy samples obtained by the IWC-POWER program and preliminary suggestions for sampling and analyses in the future.
09. Review of distance and angle experiment conducted in the IWC-POWER cruises.
10. Abundance estimates on design base analyses using 2010-18 IWC-POWER sighting data.
11. Abundance estimation of floating marine debris in the North Pacific using 2010-16 IWC-POWER data.
12. Results of the passive acoustic component of the IWC-POWER cruises, 2017-19.
13. Summary of Photo-ID.
14. Cruise report of the 2021 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER).
15. Results of the feasibility experiment of dive behaviour tagging for fin and sei whales during 2021 POWER survey in the eastern North Pacific.
16. NP sighting survey data (draft).
17. Proposal for the middle-term survey after 2023 IWC-POWER (draft).

Annex D

Overview of sighting surveys conducted on IWC-POWER cruises 2010-21

Matsuoka and Yoshimura

The IWC-POWER research cruises are an important component of the IWC's work, and the successor to the Southern Ocean programme (SOWER) which ran in the Antarctic for over 30 years and surveyed the complete circumpolar area south of 60°S three times. The IWC-POWER cruise has been organised as a joint project between the IWC and Japan since 2010. The cruise plan was endorsed at the each of IWC and Committee meeting. As its name suggests, the cruises focus on the (North) Pacific Ocean, with particularly focus on under-studied areas, some of which have not been surveyed for 40 years. The programme is now entering its 13th year. Scientists from Japan, the Republic of Korea, the USA, Mexico and the UK have participated in the fieldwork. In addition, scientists from Australia and Europe are members of a specialist IWC-POWER steering group. The survey was conducted using methods based on the Committee's guidelines. The acoustic survey was included from the 2017 Cruise to monitor the presence of marine mammals, with particular focus on locating North Pacific right whales.

Table 1

Summary of IWC-POWER surveys 2010-21.

No.	Year	Period	No. days	Research area	High Seas or Foreign EEZ	Vessel	Home Port	Port of call	International researchers	Survey mode	US biopsy permit	Acoustic	Remarks
1	2010	Jul.-Aug.	60	South of Aleutian Is., North of 40°N, 170°E-170°W	USA	KK1	Kushiro, Kushiro	-	Japan (2), USA (1), Korea (1)	NSP	-	-	-
2	2011	Jul.-Aug.	60	South of Gulf of Alaska, North of 40°N, 170°W-170°W	USA	YS3	Shimonoseki, Hakodate	-	Japan (1), USA (1)	NSP	-	-	Changed home port due to Great East Japan earthquake
3	2012	Jul.-Aug.	60	South of Gulf of Alaska, North of 40°N, 150°W-135°W	USA, Canada	YS3	Shiogama, Shiogama	-	Japan (2), USA (1), Korea (1)	NSP	-	-	-
4	2013	Jul.-Aug.	60	Subtropics, 40°N-30°N, 160°W-135°W	High Sea	YS3	Shiogama, Shiogama	-	Japan (2), USA (1), Korea (1), Mexico (1)	NSP	-	-	-
5	2014	Jul.-Aug.	60	Subtropics, 40°N-30°N, 170°W-160°W	High Sea, USA	YS3	Shiogama, Shiogama	-	Japan (2), USA (1), UK (1)	NSP	Yes	-	-
6	2015	Jul.-Aug.	60	Subtropics, 30°N-20°N, 170°W-160°W	High Sea, USA	YS3	Shiogama, Shiogama	-	Japan (2), USA (1), UK (1)	NSP	Yes	-	-
7	2016	Jul.-Aug.	60	Subtropics, 30°N-20°N, 160°W-135°W	High Sea, USA	YS3	Shiogama, Shiogama	-	Japan (2), USA (1), Korea (1)	NSP	Yes	-	-
8	2017	Aug.-Sep.	76	Bering (Eastern)	USA	YS2	Shiogama, Shiogama	Dutch Harbor (x2)	Japan (2), USA (1), UK (1)	NSP, IO	Yes	Yes	-
9	2018	Aug.-Sep.	76	Bering (Western)	USA	YS2	Shiogama, Shiogama	Dutch Harbor (x2)	Japan (2), USA (2)	NSP, IO	Yes	Yes	-
10	2019	Aug.-Sep.	85	South of Gulf of Alaska (US EEZ), 170°W-135°W	USA, Canada	YS2	Shiogama, Shiogama	Dutch Harbor (x2)	Japan (2), USA (2)	NSP, IO	Yes	Yes	Biopsy sampled in US EEZ. Original plan was Bering (western)
11	2020	Aug.-Sep.	60	Western NP, North of 40°N, 160°E-180°	High Sea	YS2	Shiogama, Shiogama	-	Japan (3)	NSP, IO	-	-	Due to Covid-19, foreign port calls and international researchers could not board
12	2021	Aug.-Sep.	60	Eastern NP, North of 40°N, 155°W-135°W	High Sea	YS2	Shiogama, Shiogama	-	Japan (2), USA (1)	NSP, IO	-	-	Due to Covid-19, no foreign port calls. Original plan was Bering (Western)
13	2022	Aug.-Sep.	60	South of Aleutian Is. (US EEZ), 167°E-170°W	USA	YS2	Shiogama, Shiogama	Dutch Harbor (x2)	Japan (2), USA (2)	NSP, IO	Yes	Yes	Biopsy samples in US EEZ. Original plan was eastern Kamchatka

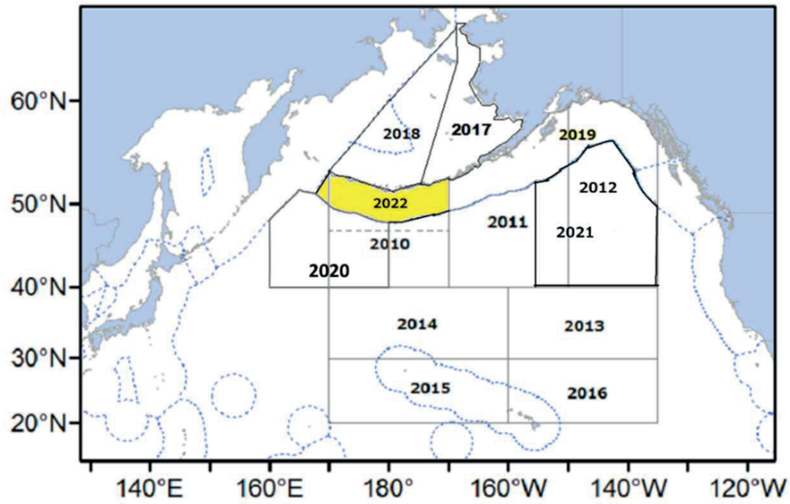

Fig. 1. The High Sea and foreign EEZ in the North Pacific (dotted blue line) and research area of IWC-POWER 2010-21.
Yellow: 2021 research area.

Objectives

The programme had five main objectives: (a) obtain information for *In-depth Assessments* of North Pacific sei, humpback and gray whales, in terms of abundance, distribution and stock structure; (b) obtain information on the critically endangered North Pacific right whale population in the eastern Pacific; (c) complete coverage of the northern range of fin whales following on from the IWC-POWER cruises in 2010-12; (d) obtain baseline information on distribution, stock structure and abundance in a poorly known area for several large whale species/populations, including those known to have been depleted in the past but whose status is unclear; (e) obtain 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.

Research vessel, crew, international researchers and searching distance

During the 13-year history of the programme to 2021, a total search distance on primary effort of 34,932.1 n.miles (64,694km) has been achieved during 837 ship-days in the North Pacific (Table 1). Three research vessels were used (Tables 1 and 5). A total of 169 crewmembers have been engaged and 48 international researchers from four North Pacific range nations selected by the IWC have been involved. The cruise leaders have usually participated for many years. There was an additional researcher (acoustic expert) onboard the 2017, 2018, 2019 and 2022 cruises. The acoustic researcher did not take part in sighting activities.

Sightings

A total of 76 blue whale (92 individuals), 929 fin whale (1,432 individuals), 400 sei whale (654 individuals), 272 Bryde's whale (318 individuals), 62 common minke whale (62 individuals), 534 humpback whale (917 individuals), 13 NP right whale (21 individuals) and 614 sperm whale (972 individuals) school sightings were recorded (Table 2).

Experiment

A total of 3,648 trials were conducted for distance and angle experiment (Table 2). A total of 1,233 photo-ID photographs (individuals) were taken (Table 3). A total of 560 biopsy samples (individuals) were collected (Table 4 and Fig. 6). A total of 2,730 marine debris were recorded (Table 6).

Satellite-linked dive behaviour tags were experimentally deployed during the 2021 IWC-POWER survey. The tags were attached to two fin and three sei whales. Success rates for each species were 33.3% (n=6) for fin and 75.0% (n=4) for sei whales (see WP15).

For acoustic research, because these areas include habitat for the critically endangered eastern North Pacific right whale (*Eubalaena japonica*, hereafter 'right whale'), passive acoustics (via sonobuoys) were included to acoustically monitor marine mammals, with particular emphasis on detecting and locating vocalising right whales. Over the course of three years, a total of 722 buoys were deployed, of which 648 were successful, for a combined total of over 2,362 hours of acoustic monitoring. The most frequently detected species were fin whales, on 332 total buoys (51.2%), sperm whales (228, 35.1%) and killer whales (181, 27.9%), followed by humpback whales (94, 14.5%), right whales (75, 11.5%), blue whales (54, 8.3%), gray whales (14, 2.1%) and sei whales (4, 0.6%) (see WP12).

Table 2

Summary of the searching effort (n.miles) and major sightings, including the transit survey between Japan and research area during 2010-21 IWC-POWER surveys.

Year	2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021		Total	
Searching effort (n.miles)	1,986.3		3,097.7		2,676.6		4,342.2		3,761.1		4,305.6		3,443.8		1,989.9		2,470.7		2,556.1		2,424.3		1,877.8		34,932.1	
Species	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.
Blue whale	5	5	10	10	4	4	0	0	1	1	0	0	1	1	0	0	8	12	19	21	22	31	6	7	76	92
Fin whale	28	55	82	141	149	210	3	3	0	0	0	0	0	0	145	198	148	220	266	458	29	32	79	115	929	1,432
Like fin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	20	22	25	20	30	2	2	9	9	70	86
Sei whale	62	118	58	95	87	164	4	4	1	1	0	0	1	1	0	0	5	7	26	43	131	181	25	40	400	654
Like sei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	2	2	2	3	12	12	16	23	32	40
Bryde's whale	0	0	0	0	0	0	54	64	118	140	46	52	28	32	0	0	0	0	0	0	6	8	20	22	272	318
Like bryde's	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	1	1	0	0	24	26
Like sei/bryde's	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	1	1	0	0	24	26
Common minke whale	8	8	2	2	2	2	1	1	0	0	0	0	0	0	23	23	17	17	6	6	3	3	0	0	62	62
Like minke	1	1	2	2	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0	0	0	1	1	8	8
Humpback whale	5	8	76	133	21	33	0	0	0	0	0	0	0	0	136	165	116	168	173	402	7	8	0	0	534	917
Like humpback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	12	3	3	7	15	0	0	0	0	19	30
North Pacific right whale	0	0	0	0	1	1	0	0	0	0	0	0	0	0	7	15	5	5	0	0	0	0	0	0	13	21
Like right	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0	0	0	0	0	0	0	0	2	2
Gray whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	22	28	90	6	15	0	0	0	0	49	127
Like gray	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	4	0	0	0	0	0	0	1	4
Sperm whale	75	92	95	119	50	57	67	99	78	155	32	93	32	115	25	33	35	36	50	61	56	90	19	22	614	972
Like sperm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	1	0	0	0	0	0	0	1	1
Baird's beaked whale	1	20	0	0	1	6	0	0	0	0	0	0	0	0	0	0	2	24	2	37	0	0	1	3	7	90
Cuvier’s beaked whale	0	0	0	0	1	4	2	6	6	13	5	9	2	5	0	0	0	0	3	5	1	5	0	0	20	47
Longman's beaked whale	0	0	0	0	0	0	0	0	0	0	1	110	0	0	0	0	0	0	0	0	0	0	0	0	1	110
Stejneger’s beaked whale	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Mesoplodon spp.	3	6	7	26	3	9	9	22	8	19	3	4	2	3	0	0	0	0	0	0	4	9	0	0	39	98
Zhiphiidae	4	9	14	23	23	44	36	71	39	86	8	10	7	11	2	3	0	0	6	8	4	8	4	8	147	281
Killer whale	10	102	7	70	17	99	0	0	1	3	1	4	0	0	32	134	20	136	55	269	18	71	1	4	162	892
Unid. large cetacean	42	68	70	106	59	93	39	43	11	11	3	3	0	0	0	0	0	0	0	0	1	1	0	0	225	325
Unid. cetacean	6	16	3	3	1	1	11	66	10	11	2	2	7	7	6	6	4	4	0	0	4	10	5	5	59	131

Table 3

Summary of angle and distance experiment undertaken (number of trials).

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Barrel distance	36	42	42	42	36	60	72	84	84	96	84	72	750
Barrel angle	36	42	42	42	36	60	72	84	84	96	84	72	750
IOP distance	-	-	-	-	-	60	72	84	84	96	72	84	552
IOP angle	-	-	-	-	-	60	72	84	84	96	72	84	552
Upper distance	36	24	37	37	24	40	60	60	48	60	48	48	522
Upper angle	36	24	37	37	24	40	60	60	48	60	48	48	522
Total	**144**	**132**	**158**	**158**	**120**	**320**	**408**	**456**	**432**	**504**	**408**	**408**	**3,648**

Table 4

Summary of photo-ID work undertaken, including transit survey between Japan and the research area (number of individuals photographed). Number of killer whales in 2018 cruise may change after confirmed photos.

Photo-ID	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Blue whale	3	9	4	0	1	0	1	0	8	16	26	7	75
Fin whale	0	25	59	3	0	0	0	79	69	51	1	31	318
Sei whale	0	27	51	2	0	0	1	0	0	0	0	15	96
Bryde's whale	0	0	0	6	73	49	12	0	0	0	0	13	153
Common minke whale	0	0	0	0	0	0	0	0	4	0	0	0	4
Humpback whale	5	48	26	0	0	0	0	48	39	30	3	0	199
North Pacific right whale	0	0	1	0	0	0	0	12	3	0	0	0	16
Gray whale	0	0	0	0	0	0	0	16	41	6	0	0	63
Sperm whale	0	0	1	0	4	22	2	0	4	0	0	0	33
Killer whale	45	18	50	0	3	4	0	84	33	19	17	3	276
Total	**53**	**127**	**192**	**11**	**81**	**75**	**16**	**239**	**201**	**122**	**47**	**69**	**1,233**

Table 5

Summary of biopsy work undertaken, including transit survey between Japan and the research area (number of individuals sampled).

Biopsy sample (ind.)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Blue whale	1	4	2	0	1	0	1	0	6	12	13	3	43
Fin whale	2	12	12	1	0	0	0	28	24	45	9	9	142
Sei whale	13	31	36	1	0	0	1	0	0	4	36	4	126
Bryde's whale	0	0	0	6	78	34	16	0	0	0	3	2	139
Common minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0
Humpback whale	0	1	0	0	0	0	0	18	29	12	2	0	62
North Pacific right whale	0	0	0	0	0	0	0	3	3	0	0	0	6
Gray whale	0	0	0	0	0	0	0	9	7	2	0	0	18
Sperm whale	0	0	0	0	0	1	5	0	0	0	0	0	6
Killer whale	2	0	1	0	1	2	0	2	7	0	2	1	18
Total	**18**	**48**	**51**	**8**	**80**	**37**	**23**	**60**	**76**	**75**	**65**	**19**	**560**

Table 6

Key characteristics of the three vessels used to date.

	Kaiko-Maru (2010)	*Yushin-Maru No.3* (2011-16)	*Yushin-Maru No.2* (2017-21)
Call sign	JGDW	7JCH	JPPV
Length overall (m)	61.9	69.61	69.61
Molded breadth (m)	11.0	10.8	11.5
Gross tonnage (GT)	860.25	742	747
Barrel height (m)	19.5	19.5	19.5
IO barrel height (m)	14.5	13.5	13.5
Upper bridge height (m)	9.0	11.5	11.5
Bow height (m)	6.5	6.5	6.5
Engine power (PS/kW)	1471	5,280/3,900	5,303/3,900

Table 7

Number of marine debris items during cruises. Marine debris were recorded during whale observations, restricted to the first 15 minutes of every hour (on effort). In other time zones, it may be recorded as long as it does not interfere with the whale sighting survey (off effort).

Year	On effort	Off effort	All	Photo
2010	15	18	33	0
2011	34	98	132	12
2012	57	173	230	13
2013	1,021	487	1,508	29
2014	118	129	247	91
2015	173	26	199	32
2016	150	3	153	?
2017	12	0	12	0
2018	11	8	19	21
2019	41	1	42	7
2020	67	0	67	0
2021	88	0	88	3
Total	**1,787**	**943**	**2,730**	**208**

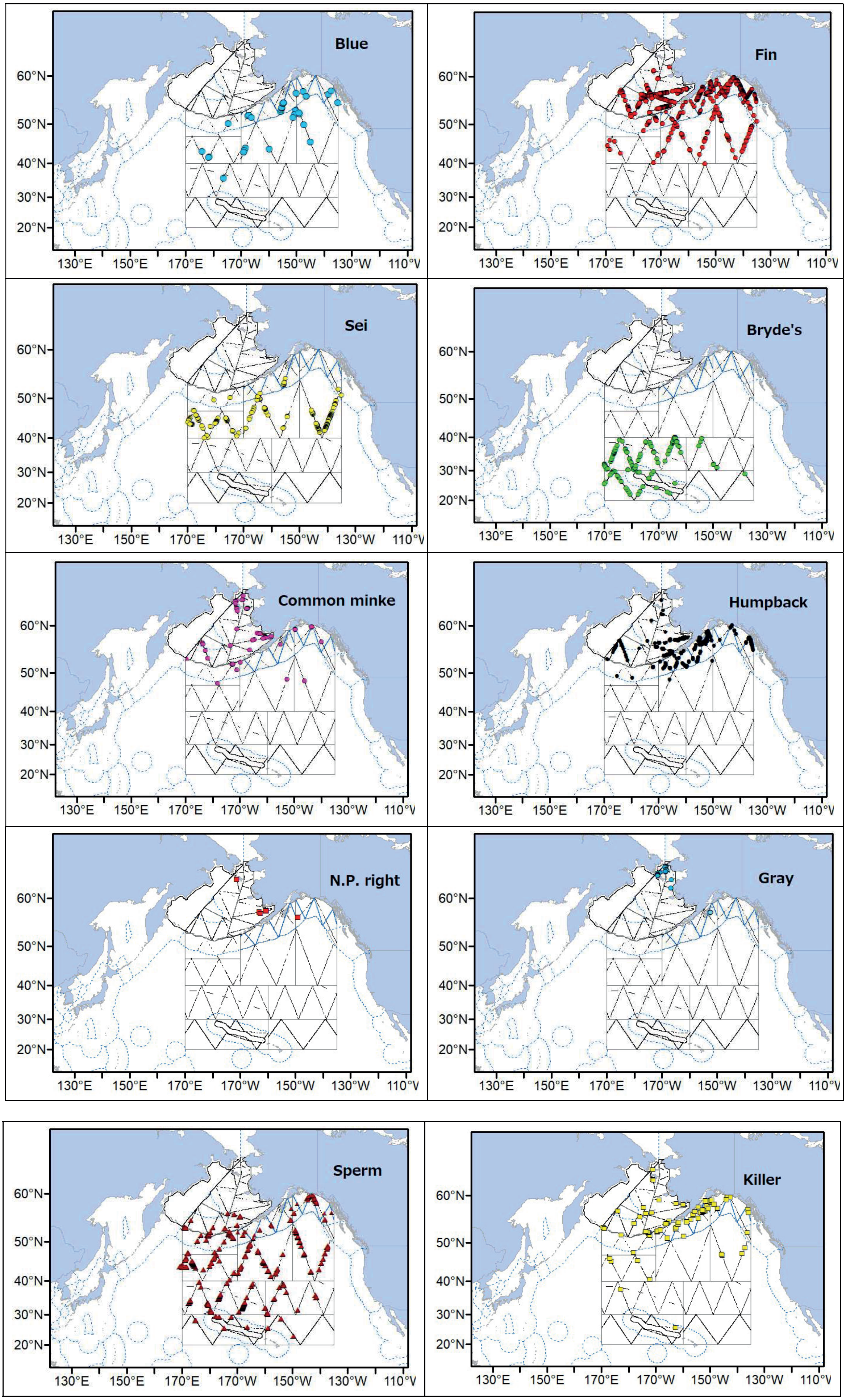

Fig. 2. Sighting position in the research area by species, all years combined.

Fig. 3. Bering Sea and depth of the water.

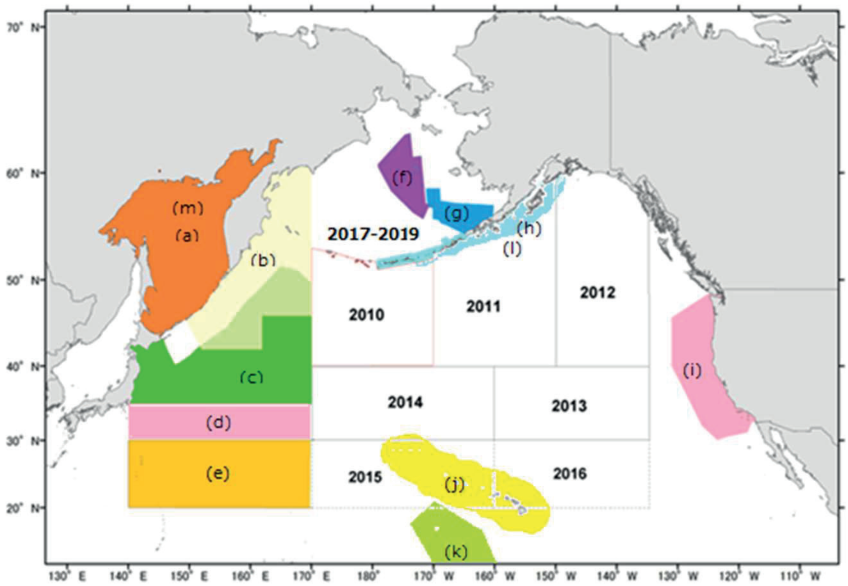

Fig. 4. Schematic showing the proposed areas for coverage in the 2017-19 period, prior to the start of the medium-term period. Coloured areas represent surveys conducted in the North Pacific in recent years: (a) Miyashita and Berzin (1991); (b) Miyashita (2006); (c) Pastene *et al.* (2009); (d) Matsuoka *et al.* (2013); (e) Matsuoka *et al.* (2014) (f) Moore *et al.* (1999); (g) Moore *et al.* (2002); (h) Zerbini *et al.* (2007); (i) Barlow and Forney (2007); (j) Barlow (2006a); (k) Barlow (2006b); (l) Rone *et al.* (2016); (m) Myasnikov *et al.* (2016).

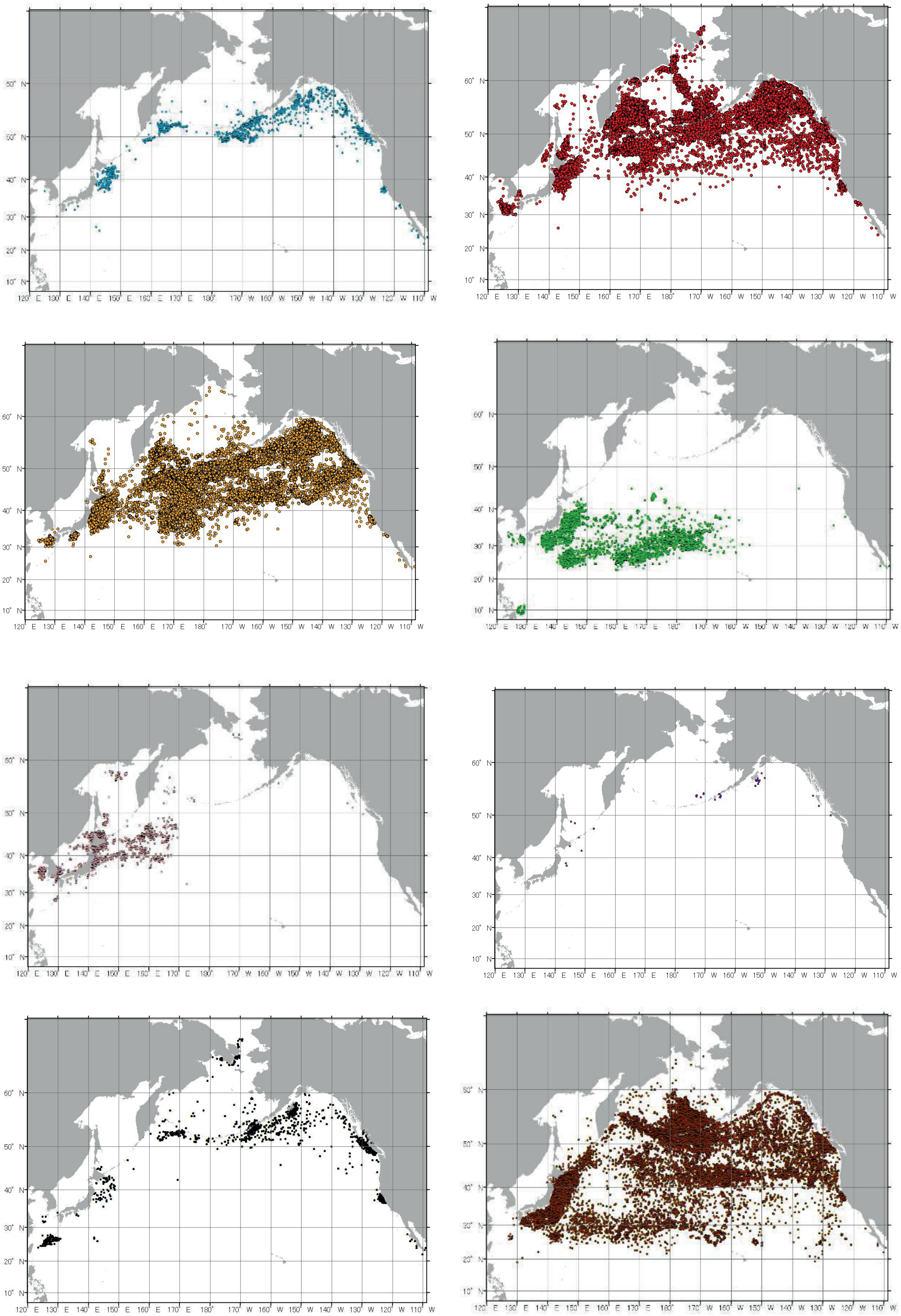

Fig. 5. Plot of North Pacific blue (top left), fin (top right), sei (1st middle left), Bryde's (1st middle right), common minke (2nd middle, left), NP right (2nd middle, right), humpback (bottom left) and sperm (bottom right) whale catches from the IWC Database (Version 6.1).

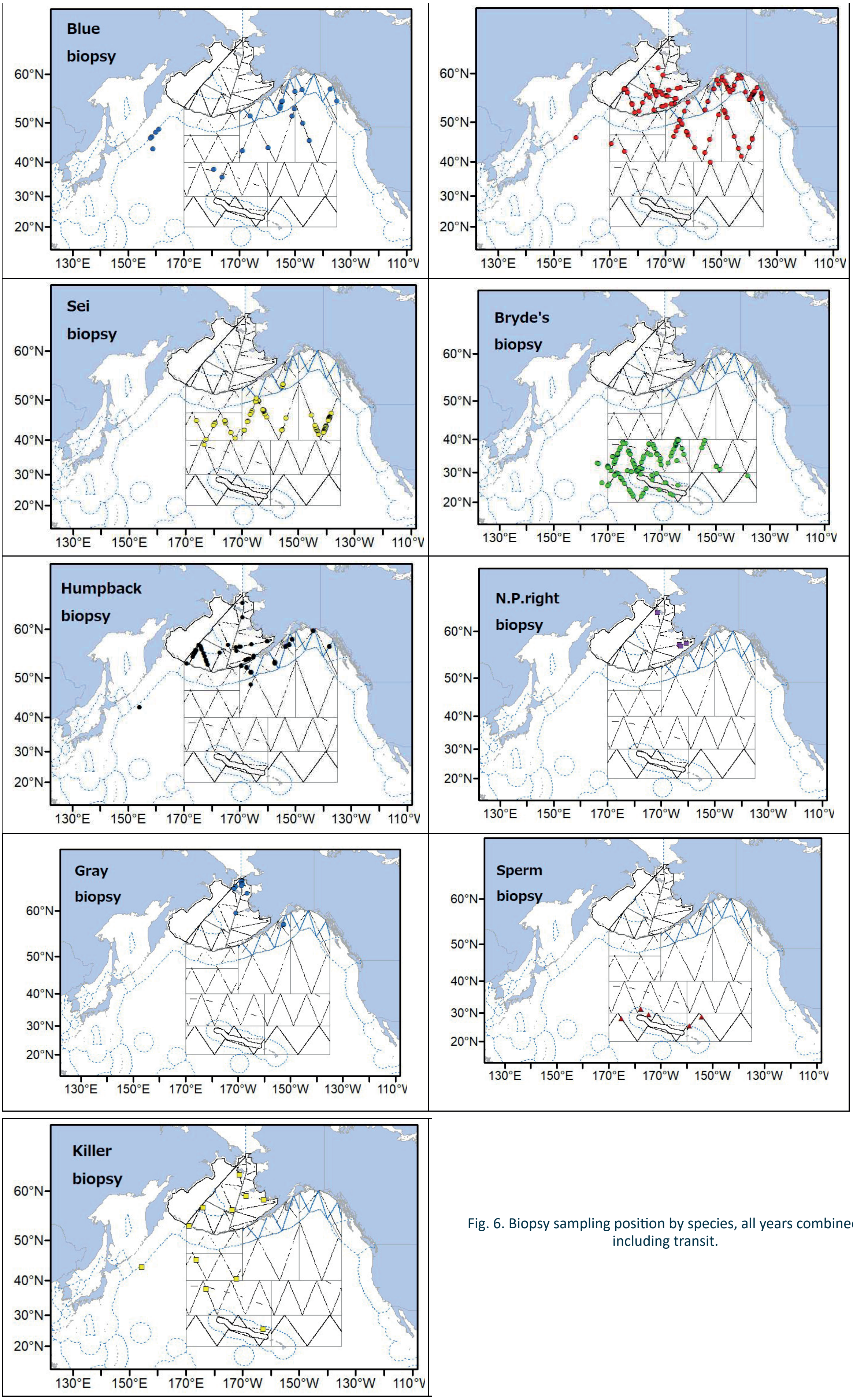

Fig. 6. Biopsy sampling position by species, all years combined, including transit.

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