Report of the 2018 Meeting of the IWC-POWER Technical Advisory Group (TAG)

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The meeting was held at the Japanese Fisheries Agency crew house, Tokyo, from 12-14 October 2018. The list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Opening remarks and welcoming address

Matsuoka (Convenor) opened the meeting and welcomed the participants, especially those from abroad. Morita (Fisheries Agency of Japan) also welcomed the participants to Tokyo. He noted 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 of having co-sponsored the IWC-POWER programme over the last ten years. Japan is therefore eager to continue the IWC-POWER programme under a co-operative relationship with the IWC Scientific Committee and its scientists and is looking forward to discussing the future direction of the programme during the present meeting.

On behalf of the IWC, Donovan reiterated that the IWC-POWER programme represents an important component of international cooperation within the IWC. Scientists from Australia, Japan, Republic of Korea, Mexico, UK and the USA have contributed to the design and implementation of the programme thus far, in addition to the contribution of the Scientific and the Commission. Of course, none of this would be possible without the extremely generous donation each year of a vessel and crew by Japan.

1.2 Election of Chair

Kitakado was elected Chair. He called for a minute's silence in remembrance of John Bannister who had been a key contributor to the IWC-POWER programme, as well as the IDCR/SOWER programme and who has been an important member of the IWC's Scientific Committee since 1963.

1.3 Adoption of Agenda

The adopted agenda is given as Annex B.

1.4 Appointment of rapporteurs

Crance and Brownell were appointed rapporteurs, assisted by Donovan and Matsuoka.

1.5 Review of documents

The list of documents is given as Annex C.

2. REVIEW OF THE SURVEY RESULTS FROM 2010-18

2.1 Summary of survey results including 2018

Fig. 1 shows a map of the survey areas covered since 2010 (the original short-term plan was extended to include the Bering Sea by the Scientific Committee in 2015).

2.2 Review of Scientific Committee recommendations and the implications of the Commission's budget cut

The TAG reviewed the recommendations of the Scientific Committee relevant to the IWC-POWER cruises and these are referred to where relevant under the agenda items below. It was noted that the budget cut implemented by the Commission this year allowed for cruises in 2019 and 2020 but achieved this by using reserve funds previously allocated to additional cruise-related work (e.g. the development of the long-term database and some work on photo-identification validation). This is discussed further below under the relevant agenda items.

2.3 Other relevant sighting surveys

2.3.1 Russian waters

Three Russian sighting surveys have taken place in the Sea of Okhotsk since 2015 (Gushcherov *et al.*, 2017; 2018; Myasnikov *et al.*, 2016). Miyashita provided IWC oversight and participated for some of the cruises. In 2015, the first training and experimental survey was conducted in the central (outside the high seas) and the northern central blocks north of 57°N. In 2016, the survey covered the northern two blocks north of 57°N and in 2017, the coastal block west of the Kamchatka peninsula was covered. The northern blocks (north of 57°N) and the eastern block west of the Kamchatka peninsula have not been covered by the Japanese sighting surveys since the 1990s for permit reasons. During the three surveys, a total of five species of large cetaceans were seen; fin whale (n=93, all sightings not just primary), common minke whale (n=42), humpback whale (n=15), North Pacific right whale (n=10) and sperm whales (n=3). However, the survey coverage has still not covered the full Okhotsk Sea, e.g. Russian territorial waters cannot be surveyed when a foreign scientist is onboard and the high seas waters were not covered in 2015. Additional surveys are needed before robust abundance estimates can be obtained.

The TAG welcomed the information provided on the Russian/Japan cruises and:

(1) ***reiterated** the importance of surveys in Russian waters to the objectives of IWC-POWER; and*
(2) ***encouraged** Russia to consider incorporating its cruises as part of the IWC-POWER programme.*

2.3.2 Korean waters

Kim introduced the cetacean sighting survey programme organised by the Republic of Korea. Annual sighting surveys targeting common minke whales began in 1999. The survey has a four-year cycle to cover a research area comprising parts of the Yellow Sea and the East/Japan Sea in the Korean EEZ and adjacent waters (see Fig. 3). The common minke whale is the only baleen whale species observed on the surveys to date. However, bycatch data show at least 24 reported cases of large baleen whale bycatch events (e.g. fin, Bryde's and Omura's whale[2]) in Korean waters between 1996 and 2018. Small-scale sighting surveys also have been conducted 2-3 times per year in the coastal area of the southern part of Korean peninsula.

[1]Presented to the meeting as SC/68A/Rep01.

[2]Omura's whale was identified genetically.

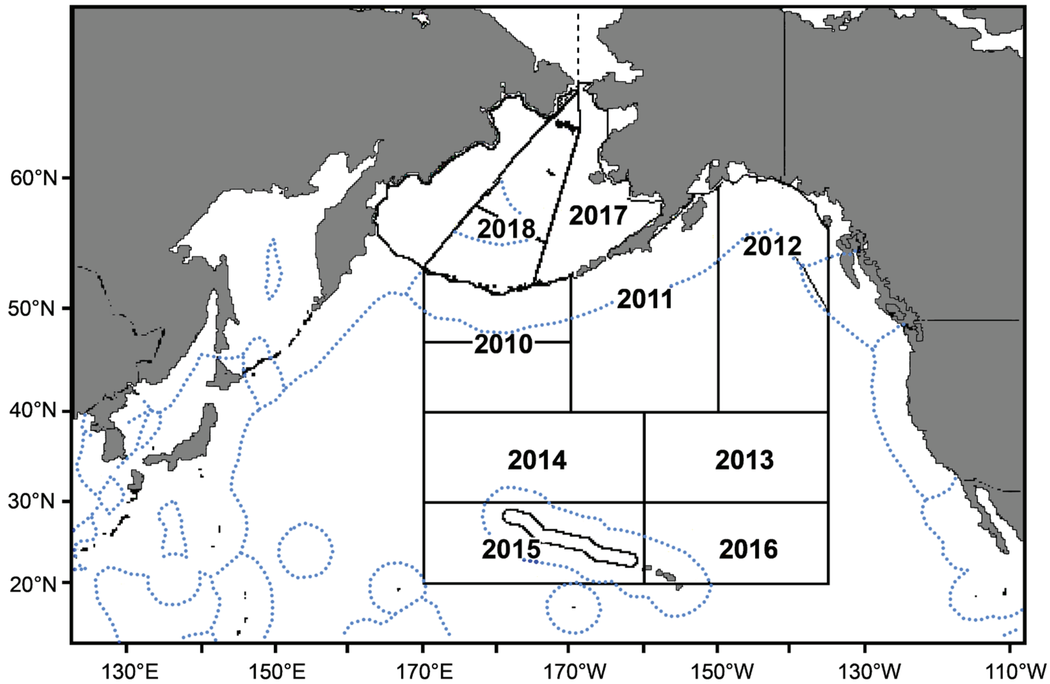

Fig.1. The research areas covered by IWC-POWER 2010-18 (EEZ shown by blue dotted line).

Table 1

Medium-term priorities agreed by the Scientific Committee, with an updated summary of the rationale.

Initial priority	Rationale
Blue whale Low direct, high opportunistic	Depletion level suggests high priority (i.e. highly depleted based on catch history and initial provisional estimates from the short-term programme suggest it remains heavily depleted), but feasibility of addressing outstanding issues (on abundance and stock structure) in short term is low. Continued photo-identification work is part of US national programme and IWC-POWER is contributing to this. Little information on stock structure and movements but IWC-POWER information has improved the situation. Telemetry may be possible.
Bryde's whale High, direct, high opportunistic	Depletion levels suggested low priority (i.e. low depletion given catch history). Western side dealt with by the Committee under RMP where a national programme exists. However, stock structure and abundance poorly understood in central and eastern North Pacific prior to IWC- POWER. Valuable baseline now available as well as new information on stock structure and potential photo-identification catalogue. Telemetry may be valuable.
Common minke whale Low direct, high opportunistic	Depletion levels (based upon catch history) suggest low priority on east. Western side already dealt with by the Committee under RMP where national programmes exists. However, if Okhotsk Sea covered for other priority species (e.g. right whales) then would provide valuable information incl. biopsy samples. Present 'acceptable' conditions for survey make surveys unsuitable for estimating abundance for this species. Telemetry priority to identify breeding areas
Fin whale High direct, moderate opportunistic	Depletion levels (based upon catch history) suggest high priority. Biopsy sampling from IWC-POWER has potential to improve overall understanding of stock structure. Coordination with US national work in Bering Sea is needed. Examination of existing data and coverage of uncovered areas needed to determine survey strategy for medium-term.
Humpback whale High direct, high opportunistic	Good information already available from a multi-national photo-identification/biopsy programme (SPLASH). Existing programmes sufficient but IWC-POWER has contributed to the overall biopsy and genetic database. Abundance estimates from IWC-POWER can also contribute to ongoing Comprehensive Assessment.
Right whale Moderate-high direct, high opportunistic	Depletion level suggests high priority, but feasibility of addressing outstanding issues (on abundance and stock structure) in short term is low. Continued photo-identification work part of US national programme and IWC-POWER has contributed to this. Feasibility of collecting biopsy and photo-identification data opportunistically high. New survey in Sea of Okhotsk has high feasibility and priority to obtain good abundance data provided appropriate permits can be obtained from the Russian Federation. Targeted surveys required.
Sei whale High direct, high opportunistic	High priority for ongoing in-depth assessment and due to long catch history. IWC-POWER has provided both baseline abundance estimates and biopsy samples for stock structure studies.
Sperm whale High direct, moderate opportunistic	High priority given lack of good information on status and high historic catches. Obtaining abundance estimates for sperm whales can be problematic due to its very long dive times and other issues but combined acoustic/visual surveys have been successful. Feasibility depends on equipment but consideration of using towed acoustic arrays in some years should be considered.

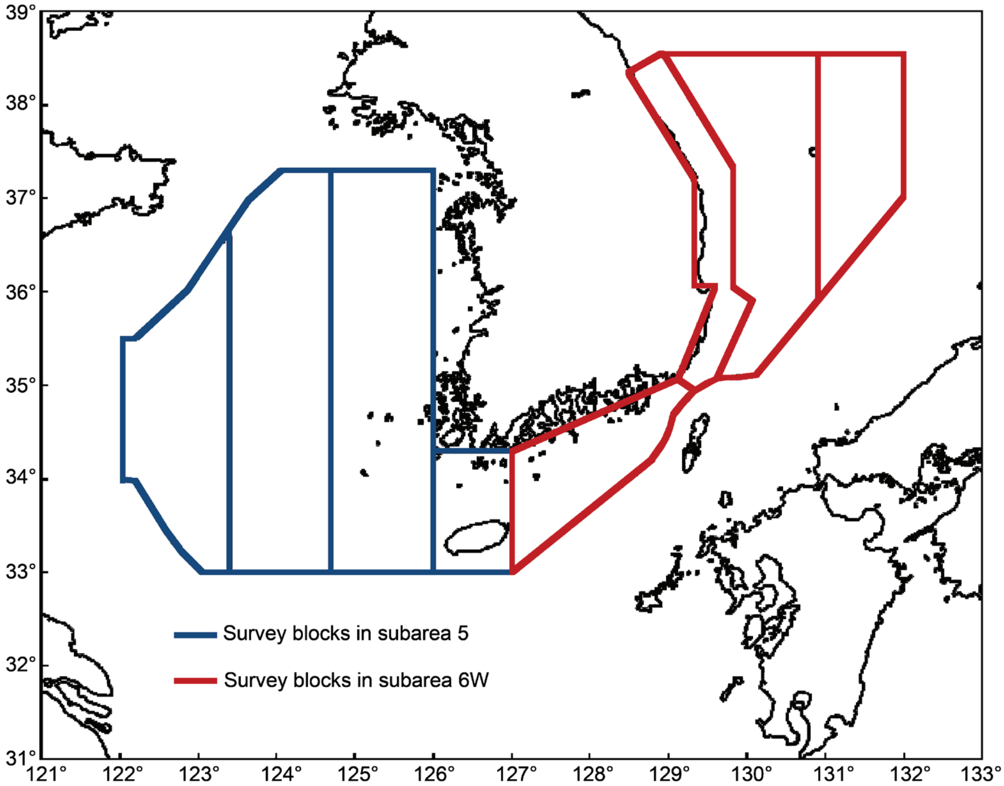

Fig. 3. Korean survey areas (see text).

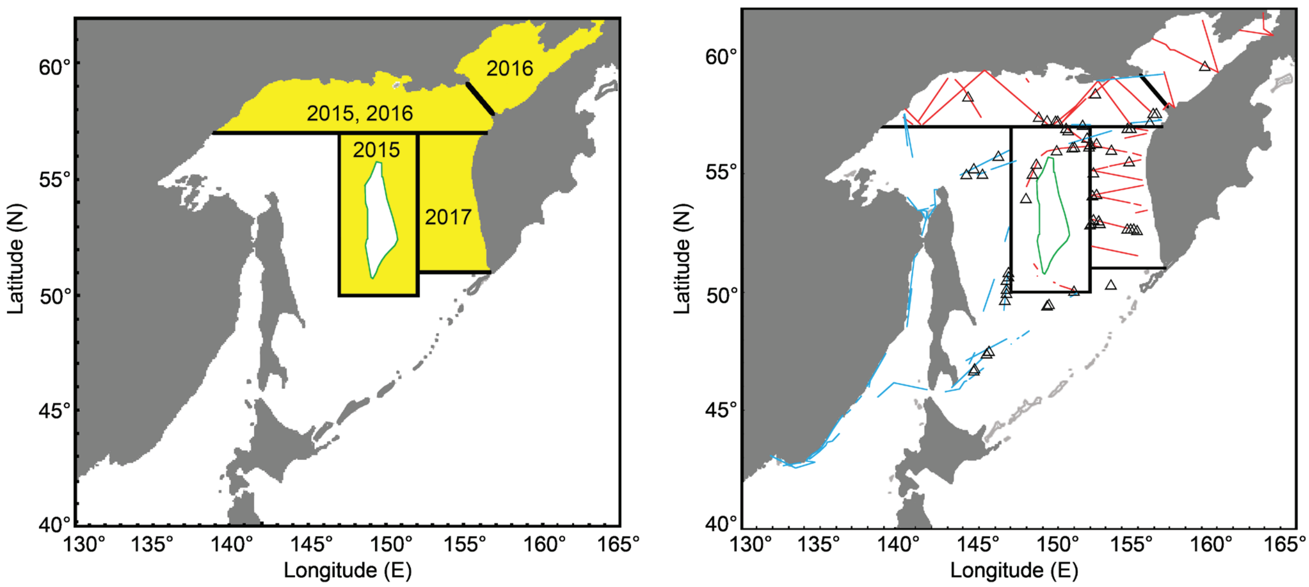

Fig. 2. The Russian research areas in the Okhotsk Sea covered from 2015-17 showing (right) primary and secondary fin whale sightings.

In discussion, it was noted that the number of sightings of common minke whales was small compared to the levels of bycatch. This suggested that the survey area may not be optimal and it was confirmed that the cruises do not enter the waters close (5 n.miles) to the coast where the bycatches (mainly smaller animals) occur. The TAG was informed that the possibility of aerial surveys is being investigated.

The TAG:

(1) ***welcomed*** *the information provided on the Korean cruises;*

(2) ***encouraged*** *consideration of ways to ensure that all areas likely to include common minke whales are covered, including use of aerial surveys; and*

(3) ***encouraged*** *Korea to consider incorporating its cruises as part of the IWC-POWER programme.*

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3. OBJECTIVES AND PRIORITIES

3.1 Long-term

The IWC agreed (IWC, 2012a) that the long-term IWC-POWER programme:

> '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.'

3.2 Short-term

By 2020 at the latest, it is expected that the identified 'least studied' areas of the central and Eastern North Pacific will

Table 2

Summary of whole biopsy work undertaken during 2010-18 cruises, including transit surveys between Japan and the research areas (number of individuals sampled).

Biopsy	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Blue whale	1	4	2	0	1	0	1	0	6	15
Fin whale	2	12	12	1	0	0	0	28	24	79
Sei whale	13	31	37	1	0	0	1	0	0	83
Bryde's whale	0	0	0	6	78	34	16	0	0	134
Humpback whale	0	1	0	0	0	0	0	18	29	48
North Pacific right whale	0	0	0	0	0	0	0	3	3	6
Gray whale	0	0	0	0	0	0	0	9	7	16
Sperm whale	0	0	0	0	0	1	5	0	0	6
Killer whale	2	0	1	0	1	2	0	2	7	15
Total	**18**	**48**	**52**	**8**	**80**	**37**	**23**	**60**	**76**	**402**

Table 3

Status of the biopsy samples collected from 2010-18.

Species	Analysts	Status
Blue whale (*n*=15)	SWFSC request permission for most recent	Paper expected at SC/68a in 2019
Fin whale (*n*=79)	SWFSC request permission for most recent	Paper expected at SC/68a in 2019
Sei whale (*n*=83)	ICR	Kanda *et al.* (2013)
Bryde's whale (*n*=134)	ICR	Taguchi *et al.* (2018)
Humpback whale (*n*=48)	SWFSC (store only) TUMSAT (abundance)	-
NP right whale (*n*=6)	SWFSC (underway)	Paper expected at SC/68a in 2019
Gray whale (*n*=16)	SWFSC (if funding)	Paper expected at SC/68b in 2020 if funding available
Sperm whale (*n*=6)	SWFSC?	Part of a wider study
Killer whale (*n*=15)	NMML if requested	Part of a wider study

*SWFSC=Southwest Fisheries Science Center; ICR=Institute of Cetacean Research; TUMSAT=Tokyo University of Marine Science and Technology.

have been covered under IWC-POWER, thereby completing the 'short-term' objectives (IWC, 2012b). Analyses of these data will form the basis of the medium-term plan (see discussion under Items 3 and 8 below) and may also result in one or two more cruises aimed at filling specific knowledge gaps before implementing the medium-term programme.

3.3 Medium-term

The TAG reviewed the priorities previously agreed for the medium-term (IWC, 2017) as shown in Table 1 and **agreed** that these remain valid although the rationale has been updated in light of IWC-POWER results thus far, recognising that these may be updated in light of the analytical work recommended under Item 8.

4. STOCK STRUCTURE AND MOVEMENTS

4.1 Genetics

4.1.1 Available genetic samples

Table 2 and Fig. 4 summarise the 402 biopsy samples taken under the IWC-POWER programme from 2010-18. The TAG noted that the programme has greatly increased the number of available biopsy samples in the North Pacific, particularly for blue, fin, sei and Bryde's whales, for which few if any samples were previously available from the survey area.

4.1.2 Status of analyses

Table 3 summarises the status of the analyses of the collected biopsy samples.

The TAG **reiterated** the importance of the biopsy sampling work undertaken and **welcomed** the analyses of these samples. They have already made a major contribution to the *Implementation Review* of Bryde's whales in the western North Pacific and to the Comprehensive Assessment of sei whales. The gray whale samples will be valuable for the forthcoming *Implementation Review* of gray whales. Analyses of the blue and fin whale data will provide greatly needed information on the stock structure of these species in the North Pacific and contribute to future discussions of the assessment of their status.

4.2 Individual identification

Table 4 summarises the estimated 995 individuals photo-identified under the IWC-POWER programme from 2010-18 (note that individual identification is also possible using genetic techniques).

Table 5 summarises the work underway on these photographs.

The TAG **reiterated** the importance of the photo-identification studies and **welcomed** the matching work on these photographs. For some species (e.g. blue, gray, humpback, right, killer and sperm whales) there are existing catalogues to which the IWC-POWER photographs make an important contribution. For other species (fin, sei and Bryde's), the IWC-POWER photographs are being analysed to develop IWC catalogues.

5. DISTRIBUTION, ABUNDANCE AND TRENDS

5.1 Review of available data

5.1.1 Sightings data including angle and distance experiments

Annex D summarises the available sightings data over the 2010-18 period when a total of almost 21,500 n.miles were covered in the research areas and almost 80% of the planned tracklines were achieved. The Annex also plots the distribution of sightings for the major species.

The initial surveys were covered under normal sighting mode but since 2015, Independent Observer mode was also

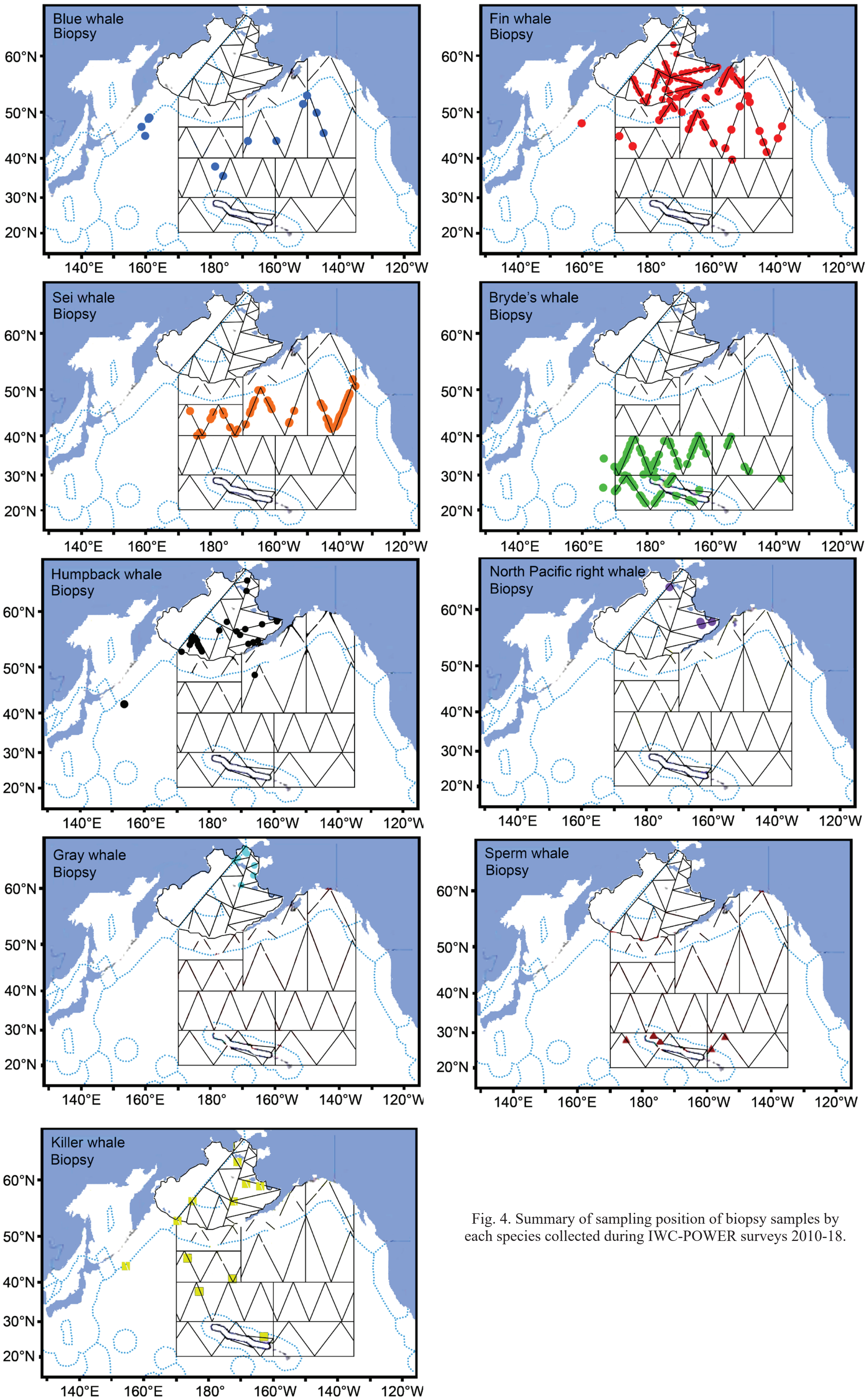

Fig. 4. Summary of sampling position of biopsy samples by each species collected during IWC-POWER surveys 2010-18.

Table 4

Summary of photo-identification work undertaken during 2010-18 cruises including transit surveys between Japan and the research areas (estimated number of individuals photographed, requires confirmation, especially of the killer whales from 2018).

Photo-identification	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Blue whale	3	9	4	0	1	0	1	0	8	26
Fin whale	0	25	59	3	0	0	0	79	69	235
Sei whale	0	27	51	2	0	0	1	0	0	81
Bryde's whale	0	0	0	6	73	49	12	0	0	140
Common minke whale	0	0	0	0	0	0	0	0	4	4
Humpback whale	5	48	26	0	0	0	0	48	39	166
North Pacific right whale	0	0	1	0	0	0	0	12	3	16
Gray whale	0	0	0	0	0	0	0	16	41	57
Sperm whale	0	0	1	0	4	22	2	0	4	33
Killer whale	45	18	50	0	3	4	0	84	33	237
Total	**53**	**127**	**192**	**11**	**81**	**75**	**16**	**239**	**201**	**995**

Table 5

Summary of the status of the photo-identification work undertaken.

Species	Analysts	Status/comments
Blue whale	*Cascadia*/ICR	Photos submitted for matching from 2010 to 2012, 2014, 2016. Photos for 2018 will be submitted.
Fin whale	Secretariat and others	Photos being checked and matched, 2011-13, 2017-18.
Sei whale	Secretariat and others	Photos available for 2011-13, 2016.
Bryde's whale	Secretariat and others	Photos available for 2013-16.
Common minke whale	TBD	Photos available for 2018.
Humpback whale	Cascadia, HappyWhale, TUMSAT/ICR	Photos submitted for matching from 2010 to 2017. Photos for 2018 will be submitted. TUMSAT and ICR will collaborate in analysis.
Gray whale	Cascadia	Photos submitted for matching for 2017. Photos for 2018 will be submitted.
NP right whale	AFSC/ICR	Photos submitted for matching from 2012, 2017, 2018.
Killer whale	AFSC/ICR	Photos submitted for matching from 2010 to 2017, 2018. Photos for 2018 will be submitted.
Sperm whale	TBD	Photos available for 2012, 2014, 2015, 2016, 2018.

Table 6

Summary of duplicates and total sightings during IO mode surveys.

Species	2015	2016	2017	2018	Total
Gray whales	0	0	4/8	2/2	6/10
Common minke whales	0	0	1/7	0/5	1/12
Bryde's whales	5/11	13/20	0	0	18/31
Sei whales	0	0	0	0	0
Fin whales	0	0	33/81	34/67	67/148
Blue whales	0	0	0	0	0
Humpback whales	0	0	26/80	10/16	36/96
Right whales	0	0	1/2	0/1	1/3
Sperm whales	1/5	17/30	5/12	14/22	37/69

Table 7

Summary of work on the analyses of the sightings data.

Species	Analysts	References	Status and schedule
Blue whale	TUMSAT	SC/Oct2018/TAG/WP/14	Draft reviewed here, revised version expected at SC/68a.
Fin whale	TUMSAT	SC/Oct2018/TAG/WP/8	Draft reviewed here, revised version expected at SC/68a.
Sei whale	TUMSAT (model- based)	SC/Oct2018/TAG/WP/8	Draft reviewed here, revised version expected at SC/68a.
Bryde's whale	TUMSAT (model-base)	SC/Oct2018/TAG/WP/8	Draft reviewed here, revised version expected at SC/68a.
Sei whale	ICR (design-based)	Hakamada and Matsuoka (2015)	-
Bryde's whale	ICR (design-based)	Hakamada *et al.* (2018)	Completed up to 2015 survey, to be updated with 2016 data in 2019.
Common minke whale	TUMSAT	-	Feasibility to be addressed given low priority assigned and thus non-optimal 'acceptable' conditions. SC/68a.
Humpback whale	TUMSAT	-	Draft reviewed here, revised version expected at SC/68a.
Sperm whale	SWFSC?	-	-
Killer whale	TUMSAT	-	SC/68a, 2019.
Dolphin sp.	TUMSAT+NRFSFS+ICR (Japan) + CRI (Korea)	-	SC/68a, 2019?
Marine debris	TUMSAT	SC/Oct2018/TAG/WP/10	Draft reviewed here (see Item 6.2).

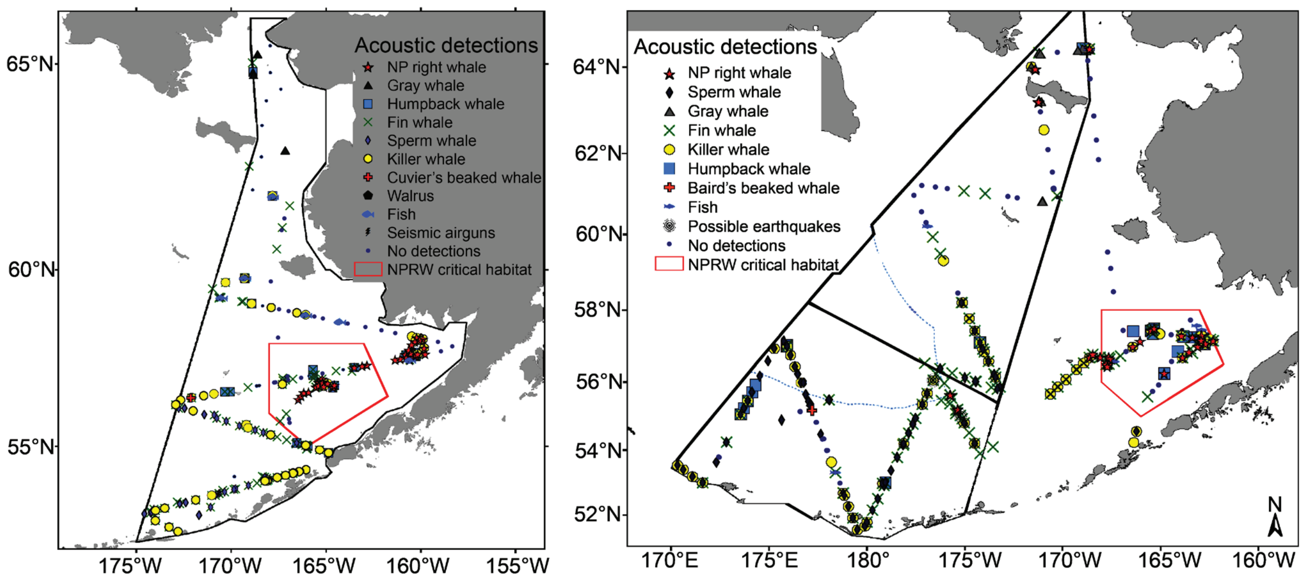

Fig. 5. Summary of all sonobuoy deployments and species detected during the 2017 (left) and 2018 (right) IWC-POWER survey.

undertaken to see if it was possible to estimate $g(0)$ for some species. Table 6 shows that with the existing information it should be possible to estimate $g(0)$ for fin, humpback and sperm whales in addition to the already completed analysis for Bryde's whales (Hakamada, 2018). The need to collect IO data for sei whales is discussed under Item 8.1.

5.1.2 Environmental data

The TAG recognised that oceanographic data are valuable for spatial modelling. However, when developing the IWC-POWER programme it was agreed that it was not feasible to collect detailed oceanographic data at the necessary frequency without interfering with the primary task of collecting line-transect data for cetaceans. In 2016, the TAG had noted that if sufficient funds had been available, such data could be obtained using a SeaGlider and it had agreed that this should be considered as part of the medium-term programme.

5.1.3 Mark-recapture data

The TAG reiterated that the estimation of abundance using individual identification mark-recapture data was impractical for most species given the time needed to collect sufficient biopsy or photo-identification data. However, data collected from IWC-POWER can contribute to wider efforts for several species (see Table 6) and the data are also valuable for studies of stock structure and movements.

5.1.4 Acoustic data

SC/Oct2018/TAG/WP/11 summarised the acoustic results from 2017 and 2018 (and see Fig. 5). Passive acoustics using sonobuoys was successfully implemented in the 2017 and 2018 POWER cruises. In 2017, a total of 240 sonobuoys (219 successful, 91.3%) were deployed during the cruise for a total of over 841 hours of acoustic monitoring. A total of 10 species/signals were detected, with fin whales the most commonly detected (46.7% of sonobuoys), followed by killer whales (20.4%). In 2018, a total of 253 buoys (217 successful, 85.6%) were deployed, for a total of almost 700 monitoring hours. A total of 9 species/signals were detected, and again, fin whales were the most commonly detected (46.5% of sonobuoys), followed by sperm whales (33.2%). In both years, the majority of detections occurred in the southern portion of the survey area.

Acoustic detections were in good agreement with the visual sightings in both years; in particular, humpback and gray whales aligned very nicely with visual sightings. There were, however, a few exceptions. Killer whales, sperm whales, and (to a lesser extent) fin whales were detected more frequently with acoustics than they were visually sighted. Common minke whales, however, were only visually sighted; there were no acoustic detections of minke whales in either year. Of the 9 sightings of right whales in 2017, five were the result of acoustic localisation. Similarly, of the 3 sightings in 2018, two were the result of acoustic localisation. These results are similar to previous surveys, where roughly two-thirds of sightings were the result of acoustic localisation.

In 2018, in mid-September, the southeastern Bering Sea was visually and acoustically surveyed for three days at the end of the IWC-POWER cruise. Despite continuous acoustic monitoring, very few right whale calls were detected. Additionally, very few sightings occurred of any species. This lack of acoustic detections and sightings was unusual, given the usual high density of cetaceans in this area in September. This decrease is likely due to the warm temperatures in the Bering Sea in 2018. When the Bering Sea is in a 'cold pool' regime, meaning the overall temperatures are cool, prey are concentrated in the southeastern Bering Sea. With this prey concentration comes a high density of whales in the same area. However, during 'warm pool' years, where overall temperatures are high, the prey are less concentrated. As a result, whale distribution is more widespread over a larger area than when in a cold pool regime. This hypothesis is supported by satellite tagging data (Zerbini *et al.*, 2015), joint large whale and fish surveys (Friday *et al.*, 2012; Stabeno *et al.*, 2012), and results from our long-term acoustic recorder moorings within the Bering Sea (Wright *et al.*, 2018). This is also reflected in the POWER data, with the sighting of a right whale near St. Lawrence Island, far north of the Critical Habitat, and acoustic detections of a right whale to the west in the deep water stratum. It is highly likely that given the warm temperatures, that prey were less concentrated, and as a result, whale distribution was more widely dispersed throughout the Bering than in previous years. This should be taken into account in any mid-term planning.

5.1.5 Other data

The TAG also noted that other datasets can assist in examining distribution and stock structure e.g.:

(1) the revised IWC catch database – it encouraged examination of these data during the mid-term planning Workshop proposed under Item 8 including updating in accord with: (a) the revised Soviet data; and (b) allocating the catches to sei and Bryde's whales; and
(2) the JSV data (Miyashita *et al.*, 1995) – it again encouraged revisiting these data to examine past distribution for comparison with that revealed by the IWC-POWER surveys.

5.2 Review of results from visual sightings

Table 7 summarises the status of the analyses of the visual sightings data. Most progress has been made with large baleen whales. There are 10 species codes (Cuvier's beaked whale, Mesoplodon spp., *Ziphiidae*, Risso's dolphin, spotted dolphin, striped dolphin, common dolphin, Pacific white-sided dolphin, northern right whale dolphin, *Dalli* type Dall's porpoise) with more than 15 sightings and these will be examined to see if useful abundance estimates can be obtained.

5.2.1 Analytical methods including g(0) estimation

The authors of SC/OCT2018/TAG/WP/7 presented a draft version of manual for analysing visual sighting data obtained from the IWC-POWER surveys. The original authors' intention of this manual is to help scientists (including themselves) to identify the process required to undertake standard analyses in a transparent manner. The authors have analysed IWC-POWER sighting data for blue, fin, humpback, sei and Bryde's whales as well as marine debris to produce recent abundance estimates based on the IWC-POWER data (see below). However, the data might be used by other scientists who might be interested in developing models and estimation procedures. Data for sperm whales, common minke whales and other dolphin species have not yet been analysed. Furthermore, the data will be updated and accumulated in the future as the programme continues and abundance estimates should be updated in a timely manner. To help this future process, the authors decided to spend time to make the manual more formal to cover data handling, estimation and graphical presentation. The current version of manual consists of several sections. Section 1 provides some introductory items such as an overview of IWC-POWER surveys since 2010 including the original objectives and an overview of the analytical platform, which is 'R'. An R-version of the valuable and prestigious package 'Distance' is used (*http://distancesampling.org/*). Section 2 provides a tutorial of statistical models behind the line transect analyses. The next sections are more practical; Section 3 illustrates how the IWC-POWER data are read and manipulated in 'R' and Section 4 provides code for mapping the planned and implemented transect lines planned and the sighting positions. Sections 5 and 6 provide code for the estimation of the detection function and effective strip width. The authors are still working on the manual and will add some sections on model-based abundance estimation and g(0) estimation. This will become available in due course.

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*The TAG **commended** the authors and **recommended** that this work on a manual continues. In discussion, several suggestions were made to the authors:*

(1) the manual should reflect issues discussed in the past TAG meetings (e.g. inclusion of methods and codes for the distance and angle experiments and methods for the variance estimation to account for inter-annual whale distribution;
(2) the manual should provide not only brief theory and code to produce abundance estimates in a 'cookbook' manner but also provide guidance on how the results are interpreted (e.g. choice of models, cases with different abundance estimates under similar AIC values);
(3) the manual should provide references to the cruise reports to allow analysts to better understand the methods of data collection and any associated difficulties or uncertainties that can assist in interpretation of results; and
(4) feedback should be obtained by asking other scientists to use the manual.

The Workshop also **reiterated** the advice it had given last year (IWC, 2018a) towards final analysis of the distance and angle experiments (see Item 9).

5.2.2 Results for humpback whales

SC/Oct2018/TAG/WP/8 reported on the results of abundance estimation for humpback whales in a summer feeding ground in the North Pacific using the IWC-POWER sighting data in 2010-12 and 2017. A design-based line transect method was primarily used for the estimation of density and abundance. In the estimation of detection function, both half- normal and hazard-rate functions were used with covariates/factors such as 'year of survey', 'school size', 'cue' and 'visibility' as well as some likely interaction terms among them. The best model was selected using AIC. The density and abundance were estimated by Horvitz-Thompson-like estimators to account for possible heterogeneity in the detection process within the leg. In addition, in order to assess environmental impact on the spatial distribution and to estimate the abundance, a spatial modelling approach was tested as a model-based method using the generalised additive model (GAM) with potential covariates of 'longitude', 'latitude', 'SST', 'depth', 'distance from the coast', and 'chlorophyll'. The best model was selected by examining the AIC and the amount of deviance explained. Results using the design-based model estimated the summer (July-August) abundance of humpback whales in the southern Aleutian archipelago (2010-12 survey areas, see Fig. 1) as around 10,000 (CV=0.53) and that in the eastern Bering Sea (2017 survey areas) as around as 4,500 (CV=0.64). As for the model- based attempt, a GAM model with the longitude, latitude and SST (longitude, latitude, SST and distance from the coat) was selected. However, its preliminary estimate was unreasonably greater than the design-based estimate, and therefore further investigation using different types of distribution assumptions as well as information on primary production will be continued.

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*The TAG thanked the authors for presenting an updated paper since SC/67b. It **recommended** that a revised version be submitted to SC/68a that focusses on:*

(1) incorporation of data from the 2018 cruise and from the non-POWER survey conducted in waters to the east of Kamchatka (see Item 3.1);
(2) consideration of the approach to estimate esw, including investigation of the data for fin whales; and
(3) estimation of g(0).

5.2.3 Results for blue whales

The authors of SC/Oct2018/TAG/WP/7 tested (and as a result corrected) the manual (see item 5.2.1) by analysing the available data for blue whales (2010-14 and 2017-18) as presented in SC/Oct2018/TAG/WP/14rev, recognising that the sample size was small. The estimated preliminary abundance was around 700 (CV=0.4). Although the limited sample size resulted in a poor fit to the detection function, not surprisingly, blue whales were seen at considerable distances from the trackline.

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*The TAG thanked the authors for presenting an updated paper since SC/67b. It **recommended** that a revised version be submitted to SC68a and made several suggestions for improvements including:*

(1) incorporation of data from the 2018 cruise and from the non-POWER survey conducted in waters to the east of Kamchatka (see Item 3.1).
(2) examination of the use of covariates such as Beaufort and wind speed recognising that these cannot both be used if found to be correlated (as one would expect);
(3) use of appropriate in transit sightings from all cruises in estimating the detection function; and
(4) consideration of assuming a 'strip' survey if the detection function fits are poor.

5.2.4 Results for fin, Bryde's and sei whales

SC/Oct2018/TAG/WP/9 reported on preliminary estimates of abundance for fin, Bryde's and sei whales using IWC-POWER data for the 2010-17 surveys. A design-based line transect method was used for the estimation of density and abundance. In the estimation of detection function, both of half-normal and hazard-rate functions were used with covariates/factors such as 'year of survey', 'school size', 'cue', 'visibility' and 'Beaufort' as well as some likely interaction terms among them. The best model was selected by using AIC. The density and abundance were estimated by Horvitz-Thompson-like estimators to account for possible heterogeneity in detection process within the leg. The estimated abundances in summer (July-August) were around 24,000 fin whales (CV=0.14), 23,000 Bryde's whales (CV=0.27); and 19,000 sei whales (CV=0.22). The authors also attempted to use a model-based method with potential covariates of 'longitude', 'latitude', 'SST' and 'distance from the coast'. The results of exercises will be reported at SC68a with final results of design-based estimates.

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*The TAG thanked the authors for presenting an updated paper since SC/67b. It **recommended** that a final version be submitted to SC/68a and made several suggestions for improvements including:*

(1) examining the impact of using like-fin, like-Bryde's and like-sei species codes (recognising that these were not introduced until 2014);
(2) examining ways to incorporate information on 'unidentified whales' as discussed in the 2016 TAG report;
(3) estimate g(0) for fin whales; and
(4) consider additional approaches to spatial modelling (including two-stage models).

5.2.6 Results for common minke whales

Common minke whales were not a priority species and given that the surveys are carried out in sub-optimal sea states for this species, the data are probably not suitable for obtaining abundance estimates although the TAG **agreed** that the feasibility of using the data should be examined.

5.2.7 Other species

The TAG recognised that there were sufficient sightings of several other species to allow the development of abundance estimates, whilst recognising the inherent difficulties in estimating abundance of the deep diving species (e.g. sperm whales and beaked whales).

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*The TAG **agreed** that Japanese and Korean scientists should collaborate to develop estimates of abundance for those small cetacean species for which there are sufficient data.*

5.3 Mark-recapture methods

As noted under Item 5.1.3, there are no plans to develop mark-recapture estimates from the IWC-POWER data, although the data can contribute to broader efforts (e.g. humpback whales as part of the Comprehensive Assessment).

5.4 Acoustic methods

The acoustic data collected using sonobuoys, whilst useful to inform distribution, are not suitable (at least at present) to use to develop abundance estimates.

6. OTHER POTENTIAL ASSOCIATED STUDIES

6.1 Oceanographic studies

Only basic oceanographic information (e.g. SST) is collected during the cruises, however the TAG noted that oceanographic data from remote sensing can be valuable in spatial modelling approaches.

6.2 Marine debris

SC/Oct2018/TAG/WP/10 reported on the progress of work to estimate the abundance of marine debris in the North Pacific Ocean. Marine debris is an element of concern in the marine ecosystem and therefore data have been routinely collected during IWC-POWER cruises in order to observe the type and the extent of the marine debris. A statistical analysis was conducted to estimate the density and distribution of marine debris in the North Pacific Ocean. Line transect methods were used for estimating detection function and abundance for several types of marine debris ('fishing gear net', 'long line', 'single fishing float', 'cluster fishing float', 'wood', 'unidentified styrofoam', 'styrofoam others', 'unidentified plastic', 'plastic small', 'plastic medium and large', 'garbage' and 'others'). A multiple- covariate distance sampling (MCDS) analysis was applied to take environmental factors into consideration. In addition to 'design-based' method, 'model-based' approach was also conducted to estimate distribution of debris. MCDS analyses showed environmental covariates such as wind speed and weather can affect detectability of debris. Abundance of 'plastic small' and 'single fishing float' were especially high. Some of this debris might be attributed to the Japanese tsunami in 2011. A model-based method showed distribution of debris was high between 20°N-40°N and extended east and west but especially concentrated around 145°W.

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*The TAG thanked the authors for presenting this informative paper and **recommended** that a final version be submitted for publication and to the IWC marine debris Workshop in 2019. It made several suggestions for improvements including:*

(1) providing a more informative introduction on the background to the study;
(2) providing more guidance on the definition of different categories of debris (with pictures as appropriate) chosen and review whether some of these could be 'merged';

(3) examine the (likely) correlation between 'sea state' and 'wind speed' and consider whether it is appropriate to include both variables in the same model;
(4) examine the impact of changes of truncation distance; and
(5) distinguish 'on' and 'off' effort in the plots showing track lines.

6.3 Other

On several occasions the IWC has been asked to consider the collection of data on other marine life than cetaceans. For example, the North Pacific Marine Science Organization (PICES) has suggested that bird surveys would be valuable. However, the proposed survey protocols require a bird specialist and the workload would interfere with the cetacean studies and as such it would be unrealistic for the present IWC-POWER programme and vessel.

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*The TAG **reiterated** that provided it did not interfere with cetacean work, IWC-POWER could record marine turtles and pinnipeds. It was **agreed** that only general codes would be used. If sightings could be identified to species and/ or where photographs could be obtained, this would be included in the 'comments' column.*

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7. DATA COLLECTION, STORAGE AND ANALYSES

7.1 On board recording

7.1.1 'Information for researchers'

The TAG welcomed news that the Guide for Researchers had been updated to include guidance on the process to import photographs into the IWC Lightroom photo-catalogue. Improvements to the Information for Researchers are regularly made by Matsuoka and Donovan in the light of recommendations from planning meetings and experiences on the cruise.

7.1.2 ICR automated data acquisition system

The TAG welcomed the news from Matsuoka that the ICR system had been and was continuing to be improved and updated (e.g. to include weather and effort data).

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*The TAG **recommends** that Matsuoka: (a) continues to work with the IWC Secretariat to ensure the prompt validation of the data after each cruise; and (b) provides the GPS data and shape files for the research area and cruise tracks to the Secretariat.*

7.2 Potential software/hardware systems including the long-term database

As noted under Item 2.2, the present funding situation means that work previously identified with respect to onboard acquisition of data in conjunction with the development of a new long-term database is unlikely to occur within the next few years.

The TAG
*(1) **recommends** that an English language version of the ICR data acquisition system be created to enable foreign researchers to also enter data into the system;*
*(2) **reiterates** the need for an improved long-term database for the IWC-DESS system but notes that this will be difficult under present financial restrictions; and*
*(3) **recommends** that the existing Steering Group continues to work under the existing Terms of Reference (IWC, 2018b).*

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8. INTEGRATED STRATEGY TO ACHIEVE SHORT-MEDIUM GOALS

8.1 Short-term plan (up to 2020 including backup plan)

The TAG **reiterated** the importance of completing the Bering Sea survey areas as agreed by the Scientific Committee last year. It also noted that the **recommendation** for the Russian Federation to issue a permit for this work in 2019 had been endorsed by the Commission at IWC/67 this year. A timetable to achieve this is given in the cruise planning report (SC/68). However, given the difficulties previously experienced, the TAG **agreed** that it was important to consider a backup plan for the 2019 cruise. If the Russian area cannot be covered in 2019 then every effort should be made to cover this in 2020 given its importance to meeting the objectives of the IWC-POWER programme.

The TAG examined the existing data and also SC/Oct2018/TAG/WP/13 providing two alternative backup plans, one in the US EEZ from around 170°W to 135°W (the northern strata of surveys conducted in 2011 and 2012) and one to the east of 135°W down to 30°N along the US and Canadian coast. It was **agreed** that extending the research area to the east of 135°W was not a priority given the relatively small numbers of large whales expected there and recognising that information was or would soon be available for that area from the 2018 PRISMM survey[3] within the Canadian EEZ as well as the 2015 NOAA Collaborative Large Whale Survey, CLaWS (Weller *et al.*, 2017).

With respect to the backup plan, it was **agreed** that a high priority should be to try to obtain sufficient IO data to allow an estimate of $g(0)$ to be obtained for sei whales. There was some discussion about how best to achieve this. Although the 2011 and 2012 surveys had not seen sei whales in the northern strata (see Annex D), it was noted that the later timing of the surveys in 2019 meant that it was likely that there would be concentrations of sei whales in those areas (the surveys of 2010-12 had all seen sei whales south of the US EEZ). It was also noted that the cruise could incorporate acoustics and target any North Pacific right whales that might be encountered.

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*The TAG **agreed** that the draft backup plan considering the waters of the US EEZ also covered in 2011 and 2012 should form the basis of further discussions at the planning meeting for the 2019 cruise (or, if Russian waters are covered in 2019, this plan should be enacted in 2020). Those discussions should consider potential strategies to maximise IO data for sei whales including:*
(1) the possibility of undertaking IO mode surveys on the way to Dutch Harbor before entering the main research area by including an international scientist onboard from Japan (the acoustician and equipment could still be picked up in Dutch Harbor);
(2) the possibility of developing a more flexible strategy depending on sei whale encounters; and
(3) the possibility of modifying the proposed research area slightly (e.g. by covering areas south of the EEZ but not as far as in 2010-12.

8.2 Medium-term plan (6-10 years starting in 2021)

As previously noted, development of a medium-term programme (in light of the priorities given in Table 1) is heavily dependent on considering the analyses of the data collected under the short-term programme.

[3]*http://dfo-mpo.gc.ca/science/atsea-enmer/missions/2018/prismm-eng.html.*

Table 8

Work plan for IWC-POWER related work.

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 the 2018 cruise and submit GPS and shape files.	**Matsuoka** and Hughes	By end of December 2018
(2)	Encourage continued collaboration with other groups holding: genetic samples; individual identification data (see Tables 3 and 5).	**IWC-POWER Steering Group**	Report progress to SC/68a
(3)	Complete importation and classification of 2018 IWC-POWER photographs into the IWC photographic database.	Taylor and **Donovan** if funding available	Report progress to SC/68a
(4)	Compile a list of habitat-related information sources for the time frame of the IWC POWER cruises to contribute to spatial modelling analyses.	**Palka** and Matsuoka	Report progress to SC/68a
(5)	Develop English language version of the ICR data acquisition software.	**Matsuoka**	Report progress to SC/68a
(6)	Continue to develop integrated proposal for onboard data collection system and long-term database, recognising the funding issues.	**Palka** (with Donovan, Matsuoka, Hammond)	Report progress to SC/68a
(7)	Develop a matching exercise to compare different ID catalogues with data from IWC-POWER, recognising the funding issues.	**Donovan**, Taylor, Cooke, Panigada	Report progress at SC/68a
(8)	Complete work on the IWC-POWER data analysis manual following advice provided at this meeting.	**Kitakado**, Matsuoka and others	Report progress at SC/68a
(9)	Liaise with the USA, Japan, Republic of Korea and Russian Federation on providing a compilation of the results from their national surveys and plans for future national surveys and how these relate to the IWC- POWER data and future IWC-POWER surveys.	Brownell, Kim, Miyashita, **Matsuoka**, Zharikov	Report progress at SC/68a with view to presenting results at the proposed medium-term workshop
(10)	Develop IWC catch record and JSV databases for the distribution analyses for large whale species.	Allison, Donovan, **Matsuoka**, Miyashita, Yoshida	Report progress to SC/68a
Analyses			
(1)	Complete review of angle/distance experiments, following the guidance provided in IWC (2018a, Item 6.2.1).	**Kitakado** and Team DAE	By SC/68a
(2)	Develop updated abundance estimates for humpback, blue, fin, sei and Bryde's whales following the advice provided at this meeting, including estimation of $g(0)$ for fin and humpback whales.	**Kitakado** and scientists from TUMSAT	By SC/68a
(3)	Develop abundance estimates for small cetacean species.	**Kim** and **Miyashita** and scientists from Korea and Japan	Progress report to SC/68a
(4)	Develop proposal for spatial analyses of sightings data to inform *inter alia* medium-term plans for submission - and see Item (4) under data with respect to environmental data.	**Kitakado** (with Palka, Donovan, Matsuoka, Kelly, Bravington, Redfern)	Progress report at SC68a with view to presenting results at the proposed medium-term workshop
(5)	Develop proposal for additional analyses of genetic data, including those from IWC-POWER, to inform *inter alia* stock structure discussions related to medium-term plans.	**Lang**, with Pastene and Steering Group	Progress report at SC/68a with view to presenting results at the proposed medium-term workshop
(6)	Develop proposal to undertake power analyses (based on existing sightings data) to estimate effort required to detect various levels of change in abundance to assist in the development of the medium-term programme.	**Kitakado** (with Palka, Donovan, Matsuoka, Kelly, Bravington)	Progress report at SC/68a with view to presenting results at the proposed medium-term workshop
Future (post-2020 cruises)			
(1)	Hold Workshop to develop medium-term (post-2021) programme based upon the analyses of the data thus far.	Steering Group	Develop proposal for SC/68a for workshop in 2020

The TAG considered the available information and developed the advice and recommendations given below.

*(1) Power analyses should be undertaken using the existing information on abundance (and associated uncertainty), encounter rates and distribution to estimate the levels of effort required to detect various levels of change in the population. TUMSAT **agreed** to try to undertake this work in advance of the 2019 Scientific Committee meeting and a steering group was established under Kitakado to assist in this work comprising (Palka, Hakamada, Matsuoka, Donovan etc.);*

*(2) Japanese, Korean and Russian scientists are **encouraged** to develop an overview of the survey information (including cruise tracks, effort, sightings, encounter rates and available abundance estimates by species), biopsy data and photo-identification data available from national cruises in the waters west of 170°E since 2010;*

(3) in the light of (2) and the existing data from the IWC-POWER programme, the need to undertake IWC-POWER surveys west of 170°E (including the Okhotsk Sea) with a focus on blue, North Pacific right, fin and humpback and other large whales should be evaluated;

(4) the priorities identified for the medium-term programme should be reviewed in the light of the above information;

*(5) IWC members and especially Japan, Korea, the Russian Federation and the USA should be **encouraged** to participate more fully in the IWC-POWER programme to ensure co-ordinated research and facilitation of permit issuance;*

(6) the Scientific Committee should convene a workshop to develop the medium-term programme before the 2020 Scientific Committee meeting with an emphasis on participation from all range states; and

(7) consideration should be given to more focussed cruises in some years (e.g. use of a towed acoustic array, telemetry work, use of SeaGlider).

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9. WORK PLAN

The TAG reviewed progress on the previous work plan (IWC, 2018a) and developed the updated work plan provided in Table 8.

10. ADOPTION OF REPORT

The meeting closed at 17:00hrs on 14 October after reviewing most of the report. The final report was agreed by email 25 October 2018.

Kitakado thanked the participants for their hard work and in particular thanked the Cruise Leader, Matsuoka, for processing the 2018 data so promptly. He also thanked the rapporteurs. The participants thanked Kitakado for his efficient handling of the meeting and noted that considerable work was needed as outlined under Item 9. The meeting also thanked the Fisheries Agency of Japan for the excellent working environment.

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Annex A

List of Participants

***=joined the meeting by Skype**

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Annex B

Agenda

1. Introductory items
   - 1.1 Opening remarks and welcoming address
   - 1.2 Election of Chair
   - 1.3 Adoption of Agenda
   - 1.4 Appointment of rapporteurs
   - 1.5 Review of documents
2. Review of the survey results from 2010-18
   - 2.1 Summary of survey results including 2018
   - 2.2 Review of SC recommendations and the implications of the Commission's budget cut
   - 2.3 Other relevant sighting surveys
     - 2.3.1 Russian waters
     - 2.3.2 Korean waters
3. Objectives and priorities
   - 3.1 Long-term
   - 3.2 Short-term
   - 3.3 Medium-term
4. Stock structure and movements
   - 4.1 Genetics
     - 4.1.1 Available genetic samples
     - 4.1.2 Status of analyses
   - 4.2 Individual identification
5. Distribution, abundance and trends
   - 5.1 Review of available data
     - 5.1.1 Sightings data
     - 5.1.2 Environmental data
     - 5.1.3 Mark-recapture data
     - 5.1.4 Acoustic data
     - 5.1.5 Other data
   - 5.2 Review of results from visual sightings
     - 5.2.1 Analytical methods including *g*(0) estimation
     - 5.2.2 Results for humpback whales
     - 5.2.3 Results for blue whales
     - 5.2.4 Results for fin, Bryde's and sei whales
     - 5.2.5 Results for common minke whales
     - 5.2.6 Other species
   - 5.3 Mark-recapture methods
   - 5.4 Acoustic methods
6. Other potential associated studies
   - 6.1 Oceanographic studies
   - 6.2 Marine debris
7. Data collection, storage and analyses
   - 7.1 On board recording
     - 7.1.1 'Information for researchers'
     - 7.1.2 ICR automated data acquisition system
   - 7.2 Potential software/hardware systems including the long-term database
8. Integrated strategy to achieve short-medium goals
   - 8.1 Short-term plan (up to 2020 including backup plan)
   - 8.2 Medium-term plan (6-10 years starting in 2021)
9. Work plan
10. Adoption of Report

Annex C

List of Documents

SC/Oct2018/TAG/WP/

1. International Whaling Commission. 2019. Report of the Planning Meeting for the 2018 and 2019 IWC-POWER Cruise in the North Pacific, 15-17 September 2017, Tokyo, Japan. *J. Cetacean Res. Manage. (Suppl.)* 20: 27pp.
2. International Whaling Commission. 2017. Report of the Meeting of the IWC-POWER Technical Advisory Group (TAG), 7-9 October 2015, Tokyo, Japan. *J. Cetacean Res. Manage. (Suppl.)* 18:459-76.
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5. Draft cruise report of the 2018 IWC-POWER.
6. Summary of IWC-POWER surveys (2010-18).
7. Kitakado, T., Inai, K., Yasuhara, T., Hamabe and Matsuoka, K. Manual for the abundance estimation using IWC-POWER sighting survey data.
8. Inai, K., Matsuoka, K. and Kitakado, T. Abundance estimation for the North Pacific humpback whales using IWC-POWER data.
9. Inai, K., Matsuoka, K. and Kitakado, T. Preliminary reports of the abundance estimation for fin, sei and Bryde's whales in the North Pacific Ocean using IWC-POWER data.
10. Yasuhara, T., Matsuoka, K. and Kitakado, T. Abundance estimation of marine debris in the North Pacific using IWC-POWER data.
11. Crance, J. *et al.* Results of passive acoustic detections and a comparison to sighting data during the IWC-POWER cruises, 2017-18 (summary of Powerpoint figures).
12. Zharikov, Matsuoka, K., and Morita, Y. Draft working plan of preparations for 2019 IWC-POWER cruise.
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15. Hakamada, T. Progress Bryde's whale abundance estimate considering *g*(0) using IWC-POWER data
16. Miyashita, T. Results of the Russian sighting surveys in the Sea of Okhotsk 2015-17
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Annex D

Summary of Effort and Sightings Information from 2010-18

Complied by K. Matsuoka

Table 1

Summary of effort spent on different activities in the research area during the 2010-18 cruises.

Item	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total (days)	60	60	60	60	60	60	60	85	85
Research area (days)	50	42	38	32	41	44	39	60	47
Working hours	169:08	206:45	181:59	268:40	278:05	203:26	193:50	136:13	147:26
Biopsy/photo-identification	22:27	38:59	33:05	01:53	30:34	14:18	01:50	44:24	46:44
Distance/angle	06:02	03:48	04:17	03:30	03:17	07:37	07:12	08:52	05:18
Primary effort	1,816.2	2,397.8	2,126.1	3,035.9	3,233.0	3,248.5	2,237.5	1,570.9	1,685.5
Independent Observer						99:04	155:11	64:22	70:45

Table 2

Characteristics of the three vessels used thus far.

Vessel	*Kaiko-Maru* (2010)	*Yushin-Maru No.3* (2011-16)	*Yushin-Maru No.2* (2017-18)
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]	1,471	5,280/3,900	5,303/3,900

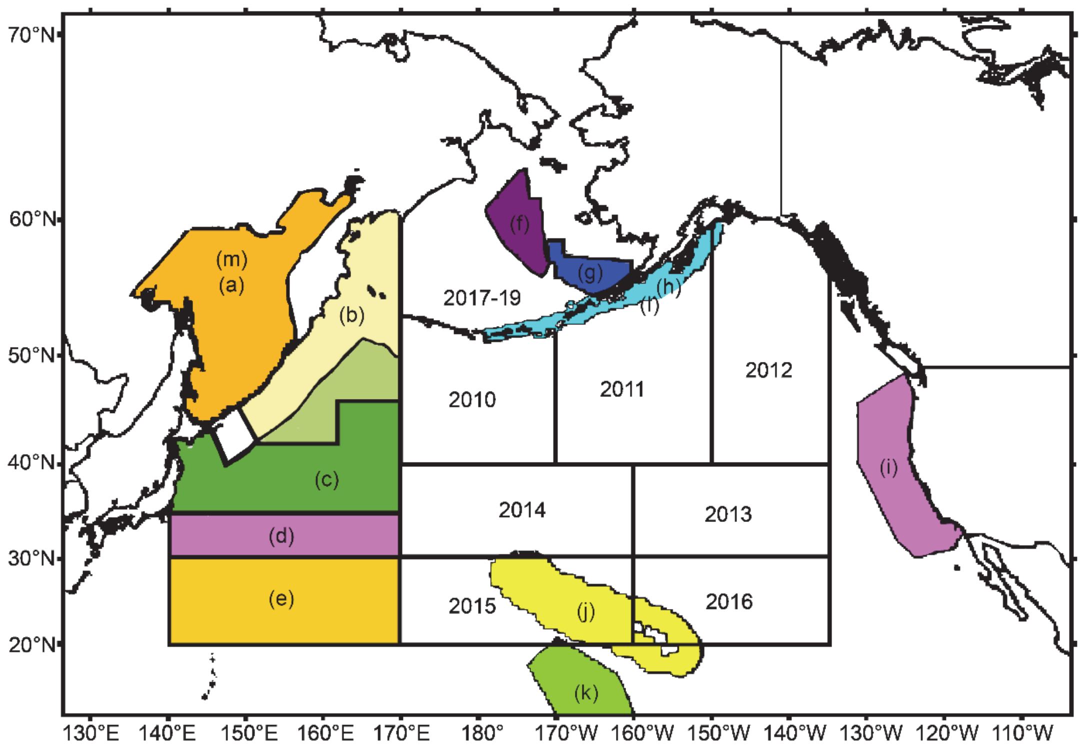

Fig. 1. Schematic showing the proposed areas for coverage in the 2017-19 period, prior to the start of the medium term period in 2021. Coloured areas represent surveys conducted in the North Pacific in recent years: (a) Miyashita and Berzin (1991); (b) Miyashita (2006); (c) Pastene *et al.* (2009); (d) 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); and (m) Myasnikov *et al.* (2016). The US and Canadian surveys in 2015 and 2018 (see Item 8.1) will be added later.

Table 3

Summary of total sightings made by species code, 2010-18. For breakdown by cruises see Tables 4 and 5.

Area	Subtotal (transit between Japan and research area)		Subtotal (research area original trackline)		Subtotal (research area transit survey)		Total (transit + research area)	
Planned distance (n.miles)	-		27,090		-		-	
Searching effort (n.miles)	5,997		21,482		667		28,146	
Searching coverage (%)	-		79.3		-		-	
Species	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.
Blue whale	12	16	17	17	0	0	29	33
Fin whale	61	82	466	701	15	23	542	806
Like fin	1	2	32	37	3	3	36	42
Sei whale	45	64	173	326	0	0	218	390
Like sei	2	2	0	0	0	0	2	2
Bryde's whale	124	151	122	137	0	0	246	288
Like bryde's	18	20	5	5	0	0	23	25
Common minke whale	2	2	50	50	1	1	53	53
Like minke	1	1	6	6	0	0	7	7
Humpback whale	22	35	267	375	35	51	324	461
Like humpback	0	0	12	15	0	0	12	15
North Pacific right whale	0	0	7	13	4	6	11	19
Like right	0	0	2	2	0	0	2	2
Gray whale	0	0	40	107	2	3	42	110
Like gray	0	0	1	4	0	0	1	4
Sperm whale	164	280	325	519	0	0	489	799
Like sperm	0	0	1	1	0	0	1	1
Baird's beaked whale	1	6	3	44	0	0	4	50
Cuvier's beaked whale	3	8	13	29	0	0	16	37
Longman's beaked whale	0	0	1	110	0	0	1	110
Stejneger's beaked whale	0	0	1	4	0	0	1	4
Mesoplodon spp.	5	14	30	75	0	0	35	89
Zhiphiidae	24	53	109	204	0	0	133	257
Pygmy killer whale	0	0	1	16	0	0	1	16
Southern form short finned pilot whale	3	40	4	64	0	0	7	104
Pygmy sperm whale	2	5	0	0	0	0	2	5
Dwarf sperm whale	0	0	2	8	0	0	2	8
Killer whale	12	123	74	420	2	5	88	548
Risso's dolphin	13	208	14	260	0	0	27	468
Bottlenose dolphin	1	37	8	112	0	0	9	149
Rough toothed dolphin	2	65	3	56	0	0	5	121
Spinner dolphin	1	13	0	0	0	0	1	13
Fraser's dolphin	0	0	2	333	0	0	2	333
Spotted dolphin	8	592	13	963	0	0	21	1,555
Striped dolphin	6	503	27	2,024	0	0	33	2,527
Common dolphin	14	492	71	4,203	0	0	85	4,695
Pacific white-sided dolphin	14	276	30	1,701	0	0	44	1,977
Northern right whale dolphin	5	291	10	990	0	0	15	1,281
Truei type Dall's porpoise	0	0	3	5	0	0	3	5
Dalli type Dall's porpoise	24	100	265	1,338	3	12	292	1,450
Unidentified type Dall's porpoise	23	111	90	351	1	2	114	464
Harbour porpoise	0	0	7	13	0	0	7	13
Unidentified large baleen whale	30	32	50	56	0	0	80	88
Unidentified *Kogia*	0	0	3	4	0	0	3	4
Unidentified pilot whale	2	36	5	119	0	0	7	155
Unidentified large cetacean	74	96	150	228	0	0	224	324
Unidentified small cetacean	13	86	16	96	1	1	30	183
Unidentified dolphin	38	1,358	115	3,383	0	0	153	4,741
Unidentified cetacean	9	9	41	107	0	0	50	116

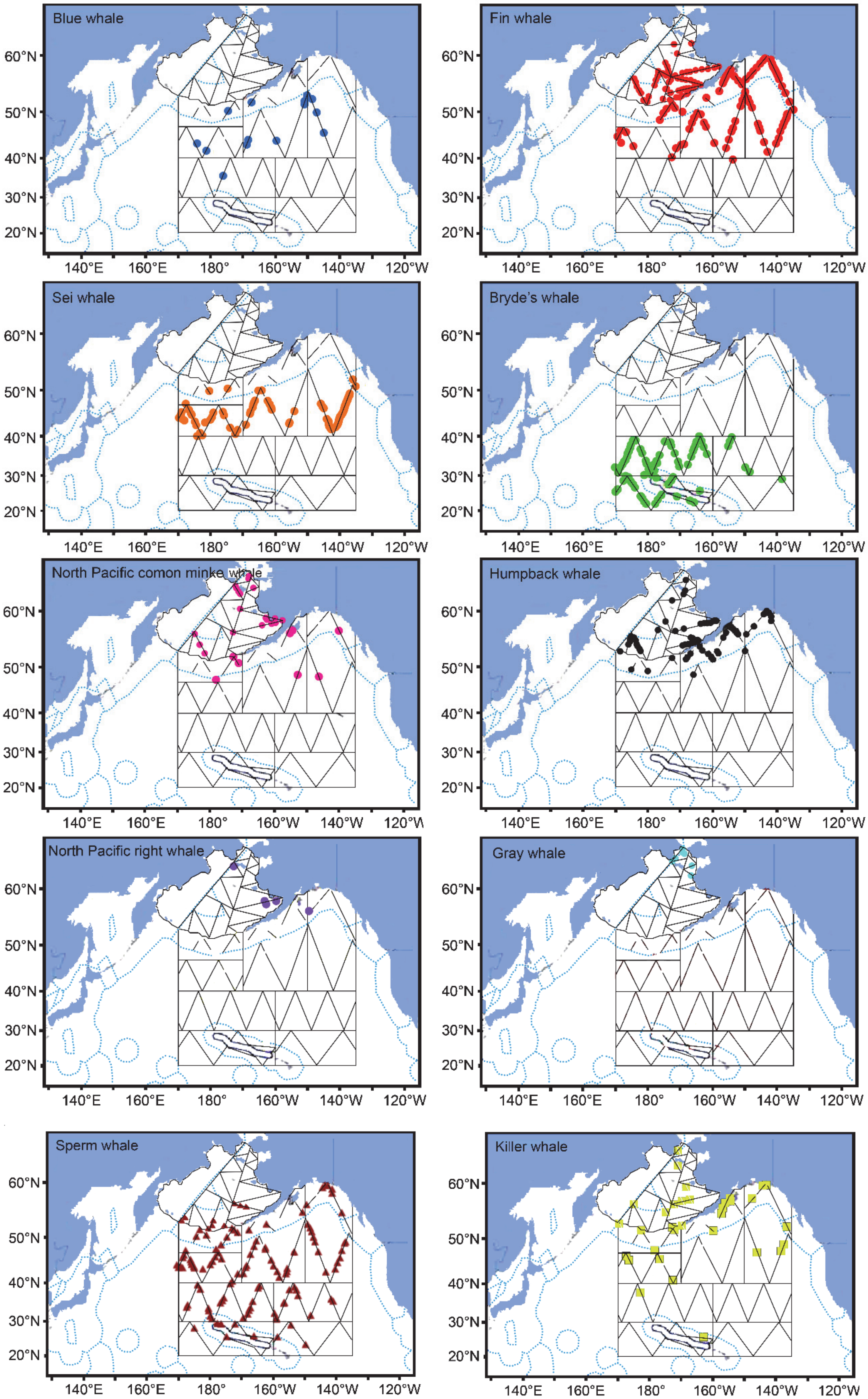

Fig. 2. Distribution of sightings made during the IWC-POWER cruises 2010-18.

Table 4

Summary of sightings made during cruises covering waters south of 40°N (note that humpback, North Pacific right, gray and Baird's beaked whales were not seen, neither were harbour porpoises or *Truei* type Dall's porpoises).

Year	2013				2014				2015				2016				Total			
Vessel	*Yushin-Maru No.3*				*Yushin-Maru No.3*				*Yushin-Maru No.3*				*Yushin-Maru No.3*							
Area	Transit		Research		Transit		Research		Transit		Research		Transit		Research		Transit		Research	
Planned distance (n.miles)	-		3,234		-		3,878		-		3,589		-		2,303		-		13,004	
Searching effort (n.miles)	1,306		3,036		528		3,233		1,057		3,249		1,206		2,237		4,098		11,755	
Searching coverage (%)	-		94		-		83		-		91		-		97		-		90	
Species	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.	sch.	ind.
Blue whale	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	1	1	1
Fin whale	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	1
Like fin	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sei whale	4	4	0	0	0	0	1	1	0	0	0	0	1	1	0	0	5	5	1	1
Bryde's whale	48	58	6	6	30	42	88	98	19	20	27	32	27	31	1	1	124	151	122	137
Like Bryde's	-	-	-	-	0	0	3	3	10	12	2	2	8	8	0	0	18	20	5	5
Common minke whale	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Sperm whale	34	49	33	50	13	18	65	137	21	43	11	50	26	85	6	30	94	195	115	267
Cuvier's beaked whale	0	0	2	6	1	5	5	8	2	3	3	6	0	0	2	5	3	8	12	25
Longman's beaked whale	0	0	0	0	0	0	0	0	0	0	1	110	0	0	0	0	0	0	1	110
Stejneger's beaked whale	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Mesoplodon spp.	1	2	8	20	1	6	7	13	2	2	1	2	0	0	2	3	4	10	18	38
Ziphiidae	8	20	28	51	4	13	35	73	4	6	4	4	5	9	2	2	21	48	69	130
Pygmy killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16	0	0	1	16
Southern form short finned pilot whale	0	0	1	1	2	12	0	0	1	28	1	32	0	0	2	31	3	40	4	64
Pygmy sperm whale	0	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0	2	5	0	0
Dwarf sperm whale	0	0	1	2	0	0	0	0	0	0	1	6	0	0	0	0	0	0	2	8
Killer whale	0	0	0	0	0	0	1	3	0	0	1	4	0	0	0	0	0	0	2	7
Risso's dolphin	2	39	7	169	3	68	5	72	6	82	1	3	2	19	0	0	13	208	13	244
Bottlenose dolphin	0	0	1	7	0	0	3	69	0	0	4	36	1	37	0	0	1	37	8	112
Rough-toothed dolphin	1	60	1	2	0	0	0	0	1	5	2	54	0	0	0	0	2	65	3	56
Spinner dolphin	0	0	0	0	0	0	0	0	1	13	0	0	0	0	0	0	1	13	0	0
Fraser's dolphin	0	0	0	0	0	0	0	0	0	0	2	333	0	0	0	0	0	0	2	333
Spotted dolphin	1	55	5	400	1	35	5	401	5	369	3	162	1	133	0	0	8	592	13	963
Striped dolphin	2	120	14	1,275	1	72	4	348	0	0	5	279	3	311	2	67	6	503	25	1,969
Common dolphin	3	175	0	0	0	0	42	1,747	0	0	0	0	8	217	0	0	11	392	42	1,747
Pacific white-sided dolphin	5	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	68	0	0
Northern right whale dolphin	2	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	21	0	0
Dalli type Dall's porpoise	7	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	21	0	0
Unidentified type Dall's porpoise	4	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	17	0	0
Unidentified large baleen whale	-	-	-	-	14	14	46	49	14	16	1	1	1	1	0	0	29	31	47	50
Unidentified *Kogia*	0	0	0	0	0	0	0	0	0	0	3	4	0	0	0	0	0	0	3	4
Unidentified pilot whale	0	0	1	4	0	0	4	115	2	36	0	0	0	0	0	0	2	36	5	119
Unidentified large cetacean	31	35	8	8	2	2	9	9	0	0	3	3	0	0	0	0	33	37	20	20
Unidentified small cetacean	2	9	5	9	6	6	1	1	5	71	4	4	0	0	3	55	13	86	13	69
Unidentified dolphin	11	446	28	1,255	7	168	53	1,592	11	266	6	114	3	141	1	6	32	1,021	88	2,967
Unidentified cetacean	4	4	7	62	1	1	9	10	0	0	2	2	3	3	4	4	8	8	22	78

Table 5

Summary of sightings made during cruises covering waters north of 40°N (note that Bryde's, Longman's beaked, Stejneger's beaked, pygmy killer, pygmy sperm, dwarf killer, dwarf sperm or pilot whales were not seen, neither were bottlenose, rough-toothed, spinner, Fraser's or spotted dolphins).

Year	2010				2011				2012				2017				2018				Total			
Vessel	*Kaiko-Maru*				*Yushin-Maru No.3*				*Yushin-Maru No.3*				*Yushin-Maru No.2*				*Yushin-Maru No.2*							
Area	Transit		Research		Transit		Research		Transit		Research		Transit		Research		Transit		Research		Transit		Research	
Planned distance (n.miles)	-		3,371		-		3,436		-		2,858		-		2,184		-		2,238				14,087	
Searching effort (n.miles)	170		1,816		700		2,398		551		2,126		288		1,702		190		1,685		1,899		9,727	
Searching coverage (%)	-		54		-		70		-		74		-		78		-		75				69	
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.
Blue whale	2	2	3	3	1	1	9	9	0	0	4	4	0	0	0	0	8	12	0	0	11	15	16	16
Fin whale	5	7	23	48	2	2	80	139	35	41	114	169	2	3	141	193	15	27	107	151	59	80	465	700
Like fin	-	-	-	-	-	-	-	-	-	-	-	-	0	0	17	20	1	2	15	17	1	2	32	37
Sei whale	9	17	53	101	20	22	38	73	6	13	81	151	0	0	0	0	5	7	0	0	40	59	172	325
Like sei	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	2	2	0	0	2	2	0	0
Common minke whale	0	0	8	8	0	0	2	2	0	0	2	2	0	0	22	22	1	1	16	16	1	1	50	50
Like minke	0	0	1	1	0	0	2	2	0	0	0	0	1	1	1	1	0	0	2	2	1	1	6	6
Humpback whale	0	0	5	8	0	0	76	133	14	26	7	7	7	8	124	152	1	1	55	75	22	35	267	375
Like humpback	-	-	-	-	-	-	-	-	-	-	-	-	0	0	9	12	0	0	3	3	0	0	12	15
North Pacific right whale	0	0	0	0	0	0	0	0	0	0	1	1	0	0	5	11	0	0	1	1	0	0	7	13
Like right	-	-	-	-	-	-	-	-	-	-	-	-	0	0	2	2	0	0	0	0	0	0	2	2
Gray whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	21	0	0	26	86	0	0	40	107
Like gray	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	1	4	0	0	1	4
Sperm whale	8	8	67	84	38	45	57	74	5	5	45	52	10	18	15	15	9	9	26	27	70	85	210	252
Like sperm	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	1	1	0	0	1	1
Baird's beaked whale	0	0	1	20	0	0	0	0	1	6	0	0	0	0	0	0	0	0	2	24	1	6	3	44
Cuvier's beaked whale	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	1	4
Mesoplodon spp.	0	0	3	6	1	4	6	22	0	0	3	9	0	0	0	0	0	0	0	0	1	4	12	37
Ziphiidae	0	0	4	9	2	3	12	20	1	2	22	42	0	0	2	3	0	0	0	0	3	5	40	74
Killer whale	0	0	10	102	1	4	6	66	5	57	12	42	4	36	26	93	2	26	18	110	12	123	72	413
Risso's dolphin	0	0	0	0	0	0	0	0	0	0	1	16	0	0	0	0	0	0	0	0	0	0	1	16
Striped dolphin	0	0	0	0	0	0	2	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	55
Common dolphin	0	0	17	1,196	2	70	10	1,155	1	30	2	105	0	0	0	0	0	0	0	0	3	100	29	2,456
Pacific white-sided dolphin	0	0	20	1,341	2	40	7	333	0	0	3	27	7	168	0	0	0	0	0	0	9	208	30	1,701
Northern right whale dolphin	0	0	6	750	2	60	3	230	0	0	1	10	1	210	0	0	0	0	0	0	3	270	10	990
Truei type Dall's porpoise	0	0	0	0	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5
Dalli type Dall's porpoise	1	3	51	300	6	25	46	205	1	8	92	473	8	35	20	108	1	8	56	252	17	79	265	1,338
Unidentified type Dall's porpoise	1	4	20	91	8	45	20	72	4	27	35	128	4	15	10	47	2	3	5	13	19	94	90	351
Harbour porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	11	0	0	1	2	0	0	7	13
Unidentified large baleen whale	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	1	1	1	2	5	1	1	3	6
Unidentified large cetacean	15	25	27	43	11	11	59	95	15	23	44	70	0	0	0	0	0	0	0	0	41	59	130	208
Unidentified small cetacean	0	0	1	1	0	0	1	25	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3	27
Unidentified dolphin	0	0	8	48	2	240	10	158	1	30	8	207	3	67	0	0	0	0	1	3	6	337	27	416
Unidentified cetacean	0	0	6	16	0	0	3	3	0	0	1	1	1	1	5	5	0	0	4	4	1	1	19	29

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