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

**Tokyo, Japan, 18-19 January 2020**

# Report of the Meeting of the IWC-POWER Technical Advisory Group (TAG), January 2020[1]

The meeting was held at the Japanese Fisheries Agency Crew House, Tokyo, from 18-19 January 2020. 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. He called for a minute's silence in remembrance of Seiji Ohsumi who had been a key contributor to the IDCR/SOWER programme, predecessor to the IWC-POWER programme, as well as the POWER programme itself and who has been an important member of the IWC's Scientific Committee for many decades.

Moronuki (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. Although it has now left the IWC, Japan is willing 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.

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 Committee 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. He noted that in terms of data availability, data from IWC cruises are available to Scientific Committee members upon request. He also noted that for both the IWC-SOWER and IWC-POWER cruises, Japan has always held all of the data as well as shared the biopsy samples. He saw no reason to change this co-operative approach even though Japan was no longer a member of the IWC.

### 1.2 Election of Chair

Kitakado was elected Chair with Matsuoka as co-Chair.

### 1.3 Adoption of Agenda

The adopted Agenda is given as Annex B.

### 1.4 Appointment of rapporteurs

Palka and Crance 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 2010-19

### 2.1 Summary of survey results including 2019

Fig. 1 shows a map of the survey areas covered since 2010.

### 2.2 Review of Scientific Committee recommendations

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*

No new information was received this year. The previous TAG report (IWC, 2020a) summarised Russian sightings surveys that took place from 2015-17.

[1]Presented to the Scientific Committee as SC/68B/REP/01.

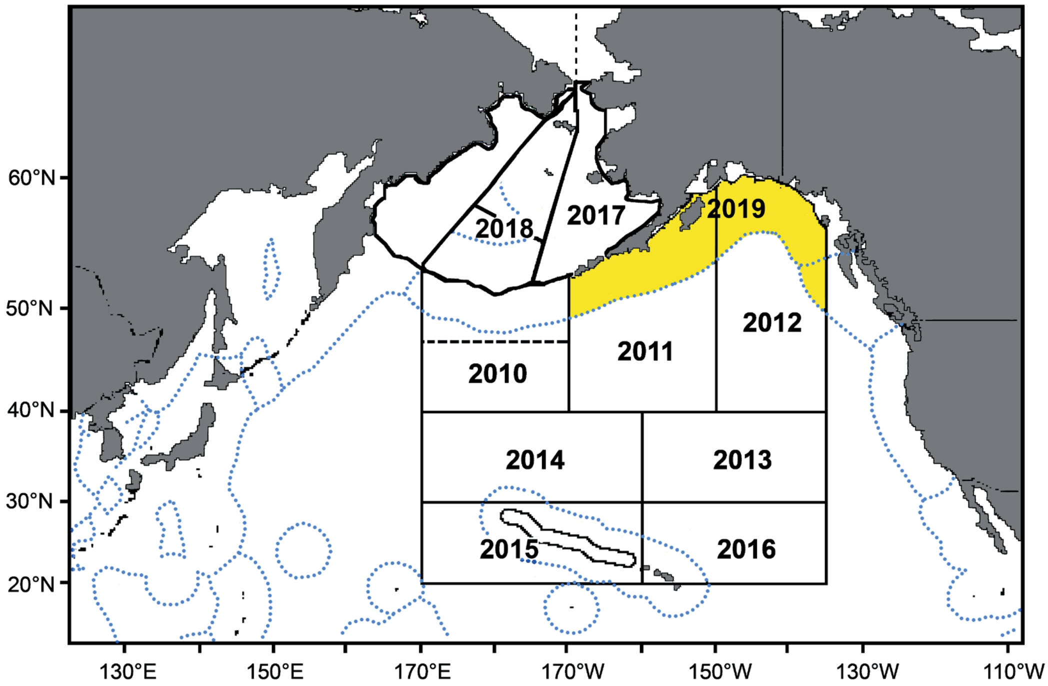



Fig.1. Research areas covered by IWC-POWER 2010-19 (EEZ shown by blue dotted line).
The yellow highlighted area is the most recently surveyed.

*Recommendation*
*The TAG* **reiterated** *the importance of surveys in Russian waters to the objectives of IWC-POWER and* **requested** *updates of any survey work undertaken in Russian waters in 2018 and 2019. It encouraged Russia to consider incorporating its cruises as part of the IWC-POWER programme in the future.*

*2.3.2 Korean waters*
No new information was received and a paper is expected to be presented at SC68B. The proposed schedule for sightings cruises by Korea has been included as part of the *Implementation Review* for common minke whales (IWC, 2020b).

*Recommendation*
*The TAG* **looked forward** *to updates of work undertaken in Korean waters at SC68B and* **encouraged** *Korea to consider incorporating its cruises as part of the IWC-POWER programme.*

*2.3.3 Other waters*
Although no other countries provided information directly to the TAG meeting it was noted that: (a) researchers from the Pacific Islands Fisheries Science Center are embarking on a winter research cruise to study cetaceans and seabirds around the main Hawaiian Islands aboard the NOAA Ship *Oscar Elton Sette* from January to March, a time of year not previously studied; and (b) there is also a proposal for a US cruise in the Gulf of Alaska in 2022.

## 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.'*

Table 1

Suggestions for updated medium-term priorities based upon results from Phase 1 for IWC-POWER (*refers to likelihood of obtaining an abundance estimate at least in some areas; **refers to likelihood of obtaining biopsy and/or photo-ID data from encountered schools).

| Initial priority/feasibility | Rationale/comments |
|---|---|
| **Blue whale (High)**<br>Medium direct*, high opportunistic** | • Depletion level (i.e. highly depleted based on catch history).<br>• Initial abundance estimates from IWC-POWER (still being finalised) suggest it remains heavily depleted.<br>• Results of analyses of existing samples (27 IWC-POWER samples available) in conjunction with other samples (e.g. samples collected under Japanese national programmes) important in addressing population structure in context of idea/scope of occasional focussed cruises, especially samples from the west (see (4) below).<br>• Potential for some blue whale focussed cruises in specific areas (including directional acoustics) should be considered (e.g. Gulf of Alaska) as well as continuing opportunistic studies.<br>• Continued collaboration with existing photo-id work e.g. US and Japanese national programmes is important (42 individuals available from IWC-POWER) – and Japan west existing samples.<br>• Consider telemetry studies. |
| **Fin whale (High)**<br>High direct*, high opportunistic** | • Depletion level (i.e. high based upon catch history).<br>• Initial abundance estimates from IWC-POWER (still being finalised) suggest some recovery.<br>• Results of genetic analyses important to contribute to future survey strategy and future Comprehensive Assessment (e.g. is there evidence of more than one stock from the existing 124 biopsy samples that cover waters from 170°E to 135°W?).<br>• Work in Russian Federation waters provided appropriate permits can be obtained is important.<br>• Co-ordination with national programmes in Japan, Korea and USA needed including existing samples. |
| **Right whale (High)**<br>Medium direct*, high opportunistic** | • Depletion level: (i.e. highly depleted based on catch history).<br>• Still critically low numbers in east (from US studies and IWC-POWER).<br>• Feasibility of collecting biopsy and photo-ID data high if targeted and using acoustics.<br>• Feasibility of obtaining abundance in east from line-transect low given such small numbers; may be much higher in west e.g. Sea of Okhotsk and southeast of Kamchatka Peninsula where population is at least 10X larger or more.<br>• Although new area, consideration should be given to a targeted survey in Sea of Okhotsk - high feasibility and priority to obtain good abundance, photo-id and biopsy data provided appropriate permits can be obtained from the Russian Federation. |
| **Sei whale (Medium)**<br>High direct*, high opportunistic** | • Depletion level: (i.e. high based on catch history).<br>• Initial abundance estimates from IWC-POWER (still being finalised) and Japan suggest some recovery.<br>• IWC-POWER has provided valuable information for the ongoing Comprehensive Assessment (the 2020 backup cruise will provide biopsy samples from a poorly covered area).<br>• Results of that CA will help focus future IWC-POWER medium-term strategy and priority for this species - e.g.: (a) possible focussed biopsy sampling in postulated coastal stock areas; and (b) frequency and scope dedicated abundance surveys in 'pelagic' area to examine trends. |
| **Humpback whale (Medium)**<br>High direct*, high opportunistic** | • Good information already available from SPLASH and national programmes suggests overall high abundance (genetic and photo-ID mark-recapture) hence medium priority.<br>• Continue to contribute to existing genetic and photo-ID databases.<br>• Ongoing Comprehensive Assessment will assess status and potential depletion of [sub-] populations.<br>• Abundance estimates from IWC-POWER (still being finalised) can provide interesting 'snapshot' estimates to compare with mark-recapture estimates by population/feeding aggregation.<br>• The results of the CA will assist in developing medium-term strategy and priority for this species within IWC-POWER. |
| **Sperm whale (Medium)**<br>Medium direct* and medium opportunistic** | • Depletion level: (unknown but possibly high given catch history).<br>• Lack of good information on population structure and status at present although good distributional data from IWC-POWER.<br>• Obtaining abundance estimates from visual surveys can be problematic due to long dive times and other issues.<br>• Combined acoustic (towed array)/visual surveys have been successful for sperm whales however feasibility in the context of IWC-POWER depends on availability of equipment and practicality in light of other priorities.<br>• Possibility of using towed acoustic arrays in some years should be considered. |
| **Gray whale (Medium)**<br>Low direct*, high opportunistic** | • There are ASW hunts but that primary data sources to evaluate those are from other visual, genetic and photo-ID programmes (e.g. US, Mexico, Sakhalin Island) – hence medium priority.<br>• Main IWC-POWER contribution is in obtaining biopsy/photo-ID in areas outside those programmes for comparison and information on population structure.<br>• Sharing of data with other programmes should continue. |
| **Bryde's whale (Medium)**<br>High direct*, high opportunistic** | • Suggest low priority for first six or so years of next phase of POWER because:<br>- recently completed IR shows good population status and apparently low level of threats; and<br>- removing from target species allows a great reduction in size of priority research area to north of 40°N.<br>• If required, a targeted survey or surveys could be designed towards end of 10-year period (e.g. from 2027). |
| **Common minke whale (Low)**<br>Suggest only opportunistic | • Depletion level (probably low east/central based upon catch history) and in west dealt with by national programmes.<br>• However, if Okhotsk Sea is able to be covered for high priority species (e.g. right whales) then would provide valuable information incl. biopsy samples.<br>• If permission granted by Russian Federation then consider modifying present 'acceptable' conditions as at the present high range they are unsuitable for estimating abundance for this species. |

Table 2

Summary of biopsy work undertaken during 2010-19 cruises, including transit surveys between Japan and the research areas (number of individuals sampled).

| Biopsy | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blue whale | 1 | 4 | 2 | 0 | 1 | 0 | 1 | 0 | 6 | 12 | 27 |
| Fin whale | 2 | 12 | 12 | 1 | 0 | 0 | 0 | 28 | 24 | 45 | 124 |
| Sei whale | 13 | 31 | 36 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 85 |
| Bryde's whale | 0 | 0 | 0 | 6 | 78 | 34 | 16 | 0 | 0 | 0 | 134 |
| Common minke whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback whale | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 18 | 29 | 12 | 60 |
| North Pacific right whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 6 |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 7 | 2 | 18 |
| Sperm whale | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 6 |
| Killer whale | 2 | 0 | 1 | 0 | 1 | 2 | 0 | 2 | 7 | 0 | 15 |
| Total | 18 | 48 | 51 | 7 | 80 | 37 | 23 | 60 | 76 | 75 | 475 |

Table 3

Status of the biopsy samples collected from 2010-19 including during transit between Japan and the research areas. SWFSC=Southwest Fisheries Science Center; ICR=Institute of Cetacean Research.

| Analysts | Status/comments | References |
|---|---|---|
| **Blue whale (*n*=27)** | | |
| SWFSC | Mitogenome sequences for the IWC-POWER biopsy samples collected through 2017 (*n*=9) have been generated for use in a project evaluating the global subspecies taxonomy of blue whales. | An update on this work will be presented at SC68B. |
| ICR | Laboratory work to start in 2020 for mtDNA CR sequencing and microsatellite (17 loci). Plan to analyse the genetic data in conjunction with genetic data available for the western North Pacific from other sources. IWC-POWER biopsy samples for 2018 and 2019 are not available to ICR but will be shipped to ICR from SWFSC shortly. | An update on this work will be presented at future SC meetings. |
| **Fin whale (*n*=124)** | | |
| SWFSC | Laboratory work ongoing to develop method to genotype several thousand SNP loci. Currently using non-POWER samples for pilot project but will include ~ 40 IWC-POWER samples in later genotyping. | An update on this work will be presented at SC68B. |
| ICR | Laboratory work to start in 2020 for mtDNA CR sequencing and microsatellite (17 loci). The plan is to analyse these in conjunction with additional genetic data available for the western North Pacific from other sources. IWC-POWER biopsy samples for 2018 and 2019 are not available to ICR but will be shipped to ICR from SWFSC shortly. | An update on this work will be presented at future SC meetings. |
| **Sei whale (*n*=85)** | | |
| ICR | All IWC-POWER biopsy samples have been analysed apart from 4 samples from the 2019 survey. Two genetic markers were used, mtDNA CR sequencing and microsatellites at 17 loci. The analyses were conducted in conjunction with additional genetic data available for the western and eastern North Pacific from other sources. Documents have been presented to the IWC SC Comprehensive Assessment of North Pacific sei whales.<br>There are few samples available for the area between about 170°E-180° and 35°-45°N and in coastal areas in both sides of the North Pacific but this may be rectified if the backup plan for 2020 is implemented.<br>Parent-Offspring analyses are ongoing. Use of these to estimate abundance is being considered. | Pastene *et al.* (2016a); Pastene *et al.* (2016b). A paper is being prepared for publication. |
| **Bryde's whale (*n*=134)** | | |
| ICR | All IWC-POWER biopsy samples have been analysed. Two genetic markers were used, mtDNA CR sequencing and microsatellite at 17 loci. Analyses were conducted in conjunction with additional genetic data available for the western North Pacific from other sources. Documents were presented to the IWC SC *Implementation Review* of North Pacific Bryde's whale.<br>Few samples are available for areas east of 150°W. | Pastene *et al.* (2016b); Pastene *et al.* (2016c); Taguchi *et al.* (2017). |
| **Humpback whale (*n*=60)** | | |
| None yet | No samples have been analysed yet. Samples are available for analysis under the IWC process (*www.iwc.int*). | |
| **North Pacific right whale (*n*=6)** | | |
| ICR/ SWFSC | All IWC-POWER biopsy samples have been analysed for mtDNA CR sequencing in conjunction with additional genetic data available for the western and eastern North Pacific from other sources. A document was presented to the 2018 IWC SC meeting and a new document is being prepared for publication. There remains a need to analyse the available samples with nuclear markers. | Pastene *et al.* (2018). A paper is being prepared for publication. |
| **Gray whale (*n*=18)** | | |
| None yet | No IWC-POWER samples have been analysed yet. Samples are available for analysis under the IWC process (*www.iwc.int*) - would need to be part of a wider study given small sample size. | - |
| **Sperm whale (*n*=6)** | | |
| None yet | No IWC-POWER samples have been analysed yet. Samples are available for analysis under the IWC process (*www.iwc.int*) - would need to be part of a wider study given small sample size. | - |
| **Killer whale (*n*=15)** | | |
| None yet | No IWC-POWER samples have been analysed yet. Samples are available for analysis under the IWC process (www.iwc.int) - would need to be part of a wider study given small sample size. | - |

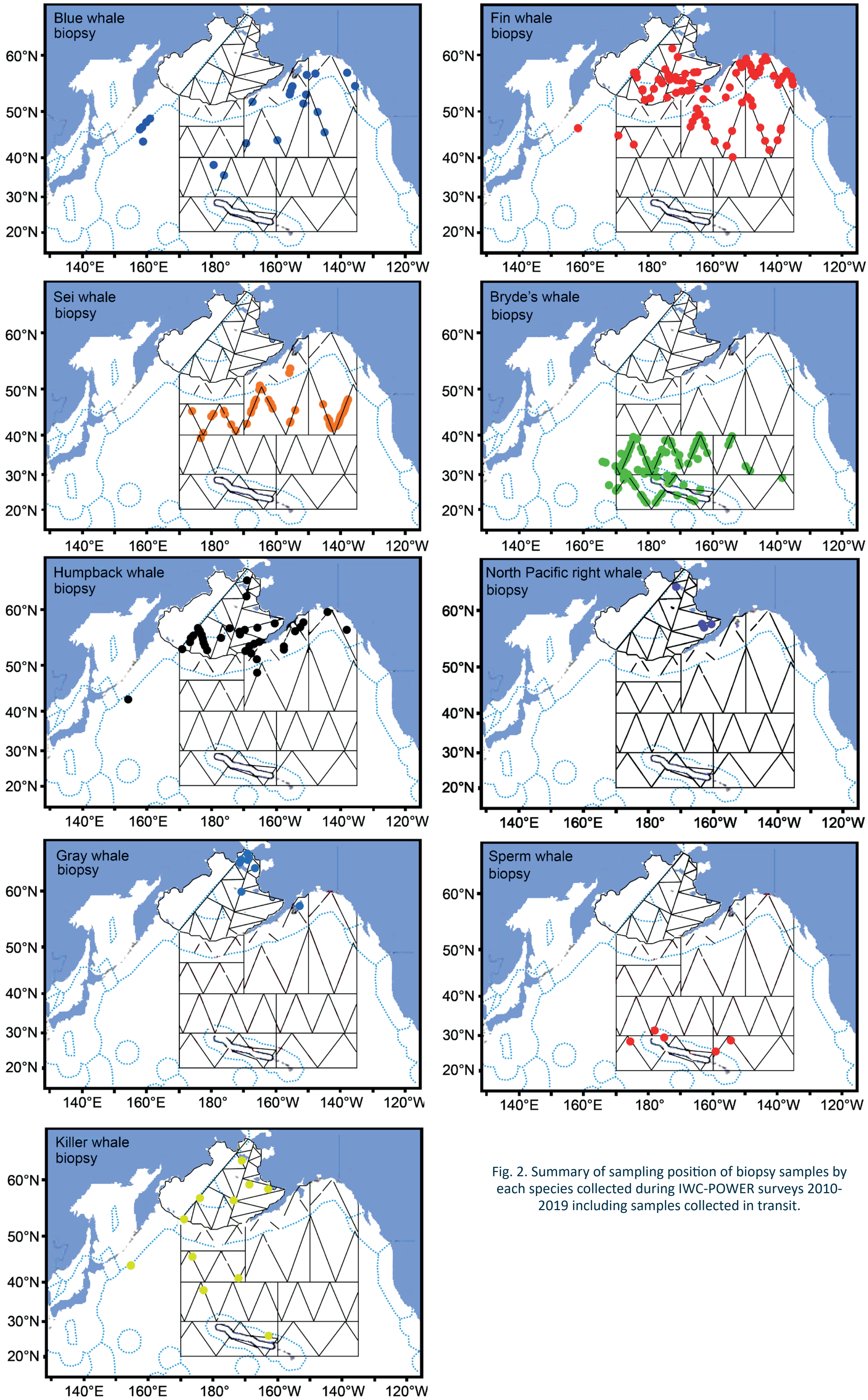



Fig. 2. Summary of sampling position of biopsy samples by each species collected during IWC-POWER surveys 2010-2019 including samples collected in transit.

### 3.2 Short-term

The identified 'least studied' areas of the central and Eastern North Pacific will soon have been covered under IWC-POWER (pending permission to operate in Russian waters of the Bering Sea), 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 3.3 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 (see discussion of a 'backup plan' for the 2020 cruise if permission to operate in Russian waters is not received).

### 3.3 Medium-term

The TAG reviewed the priorities previously agreed for the medium-term (IWC, 2017) in the light of the review of information obtained up until 2019, and revised these as shown in Table 1. Further discussion on the next phase of IWC-POWER in light of the medium-term priorities is provided under Items 8 and 9.

*Recommendation*
*The TAG* **recommends** *the revised medium-term priorities for the future IWC-POWER programme as provided in Table 1.*

## 4. STOCK STRUCTURE AND MOVEMENTS

### 4.1 Genetics

#### *4.1.1 Available genetic samples*

Table 2 and Fig. 2 summarise the 475 biopsy samples taken under the IWC-POWER programme from 2010-19. 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.

Table 4

Summary of photo-identification work undertaken during 2010-19 cruises including transit surveys between Japan and the research areas (**estimated number of individuals photographed, requires confirmation, especially of the killer whales from 2019).

| Photo-ID | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018** | 2019 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blue whale | 3 | 9 | 4 | 0 | 1 | 0 | 1 | 0 | 8 | 16 | 42 |
| Fin whale | 0 | 25 | 59 | 3 | 0 | 0 | 0 | 79 | 69 | 51 | 286 |
| Sei whale | 0 | 27 | 51 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 81 |
| Bryde's whale | 0 | 0 | 0 | 6 | 73 | 49 | 12 | 0 | 0 | 0 | 140 |
| Common minke whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 4 |
| Humpback whale | 5 | 48 | 26 | 0 | 0 | 0 | 0 | 48 | 39 | 30 | 196 |
| North Pacific right whale | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 12 | 3 | 0 | 16 |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 41 | 6 | 63 |
| Sperm whale | 0 | 0 | 1 | 0 | 4 | 22 | 2 | 0 | 4 | 0 | 33 |
| Killer whale | 45 | 18 | 50 | 0 | 3 | 4 | 0 | 84 | 33 | 19 | 256 |
| Total | 53 | 127 | 192 | 11 | 81 | 75 | 16 | 239 | 201 | 122 | 1,117 |

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 2019 will be submitted. |
| Fin whale | Secretariat and others/ICR | Photos being checked and matched, 2011-13, 2017-18. |
| Sei whale | Secretariat and others/ICR | Photos available for 2011-13, 2016. |
| Bryde's whale | Secretariat and others/ICR | Photos available for 2013-16. |
| Common minke | TBD | Photos available for 2018. |
| Humpback whale | Cascadia, HappyWhale<br>TUMSAT/ICR | Photos submitted for matching from 2010 to 2017. Photos for 2018 and 2019 will be submitted.<br>TUMSAT and ICR will collaborate in analysis. |
| Gray whale | Cascadia/ICR | 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 and 2019 will be submitted. |
| Sperm whale | ICR | B Photos available for 2012, 2014, 2015, 2016, 2018. |

#### *4.1.2 Status of analyses*

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

*Recommendation*

*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 recently completed Implementation Review of Bryde's whales in the western North Pacific and to the ongoing Comprehensive Assessment of sei whales. The gray whale samples can contribute to 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 and planning for the next phase of IWC-POWER. An overview of the results in light of stock structure should be developed for SC68B.*

### 4.2 Individual identification

Table 4 summarises the estimated >1,100 individuals photo-identified under the IWC-POWER programme from 2010-19 (note that individual identification is also possible using genetic techniques). Table 5 summarises the work underway on these photographs.

*Recommendation*

*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. It is also stressed the great value of the full IWC-POWER photographic database that stored and categorised all photographs from the cruises.*

## 5. DISTRIBUTION, ABUNDANCE AND TRENDS

### 5.1 Review of available data

#### *5.1.1 Sightings data*

Annex D summarises the available sightings data over the 2010-19 period when a total of almost 23,500 n.miles were covered in the research areas and almost 80% of the planned tracklines were achieved. Annex D also provides maps of the distribution of sightings for the major species.

Table 6

Summary of duplicates and total sightings during IO mode surveys, 2015-19.

| Species | 2015 | 2016 | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|---|---|
| Gray whales | 0 | 0 | 4 / 8 | 2 / 2 | 0 | 6 / 10 |
| Common minke whales | 0 | 0 | 1 / 7 | 0 / 5 | 1/1 | 2 / 13 |
| Bryde's whales | 5 / 11 | 13 / 20 | 0 | 0 | 0 | 18 / 31 |
| Sei whales | 0 | 0 | 0 | 0 | 12/16 | 12/16 |
| Fin whales | 0 | 0 | 33 / 81 | 34 / 67 | 60/74 | 127 / 222 |
| Blue whales | 0 | 0 | 0 | 0 | 4/6 | 4/6 |
| Humpback whales | 0 | 0 | 26 / 80 | 10 / 16 | 34/42 | 70 / 138 |
| Right whales | 0 | 0 | 1 / 2 | 0 / 1 | 0 | 1 / 3 |
| Sperm whales | 1 / 5 | 17 / 30 | 5 / 12 | 14 / 22 | 8/16 | 45 / 85 |

Table 7

Summary of sonobuoy deployments, successful sonobuoy deployments, success rate and recording hours for the 2017-19 cruises.

| Year | No. sonobuoys deployed | No. successful deployments | % success rate | Recording time (hh:mm:ss) |
|---|---|---|---|---|
| 2017 | 240 | 219 | 91.25% | 841:05:06 |
| 2018 | 253 | 217 | 85.7% | 699:46:12* |
| 2019 | 229 | 212 | 92.6% | 821:32:57 |
| Total | 722 | 648 | 89.75% | 2362:24:15 |

*The lower monitoring time is the result of less time spent in the North Pacific right whale critical habitat.

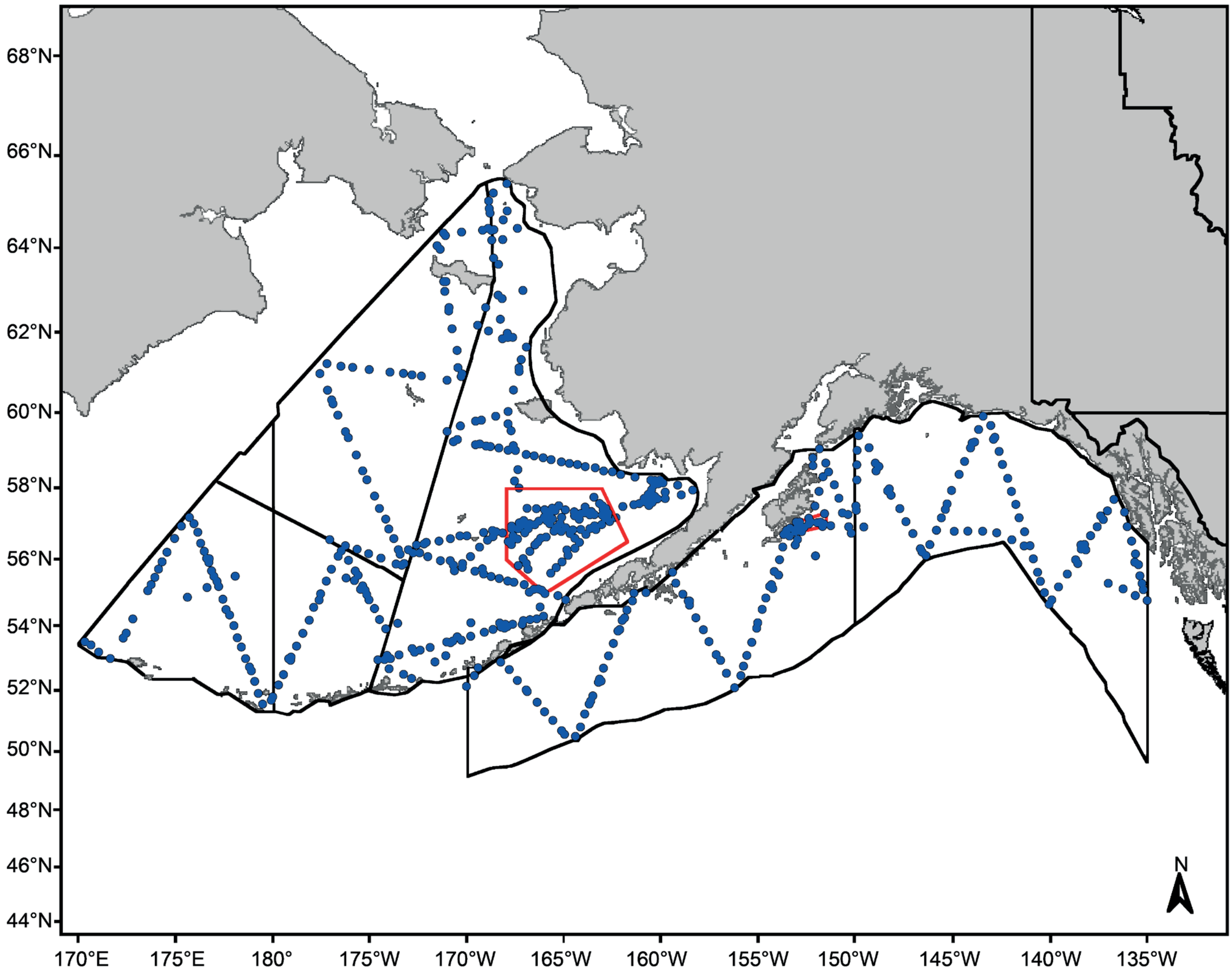



Fig. 3. Map showing location of all sonobuoy deployments during the 2017-19 IWC-POWER cruises. Black lines indicate study areas. Red polygons=North Pacific Right Whale Critical Habitat. Maps of detections by species can be found in Annex E.

The initial surveys were covered under normal sighting mode. Since 2015, Independent Observer (IO) mode has also been 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 *et al.*, 2018) and the work on sei whales discussed further under Item 5.2 below.

### *5.1.2 Environmental data*

The TAG recognises that oceanographic data are valuable for *inter alia* 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.

*Recommendation*
*In 2016, the TAG had noted that if sufficient funds had been available, oceanographic data could be obtained using a SeaGlider and it* ***reiterated*** *that this should be considered as part of the medium-term programme discussion.*

### *5.1.3 Mark-recapture data*

The estimation of abundance using individual identification mark-recapture data obtained from the IWC-POWER programme alone is impractical for most species given the time needed to collect sufficient biopsy or photo-identification data. However, data collected from IWC-POWER contributes to wider efforts for several species (see Tables 4 and 5) and the data are also valuable for studies of stock structure (see Tables 2 and 3) and movements.

Table 8

Species detected per year for the 2017-19 IWC-POWER cruises.

| Year | Fin | Sperm | Killer | Hump | Right | Blue | Gray | Sei | Baird's | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 112 | 44 | 49 | 23 | 38 | 0 | 4 | 0 | 0 | Cuvier's beaked – 1; seismic airgun - 2 |
| 2018 | 101 | 72 | 56 | 24 | 27 | 0 | 10 | 0 | 1 | Earthquake - 2 |
| 2019 | 119 | 112 | 76 | 47 | 10 | 54 | 0 | 4 | 3 | Pacific white-sided - 3; earthquake - 33 |
| Total | 332 | 228 | 181 | 94 | 75 | 54 | 14 | 4 | 4 | Cuvier's beaked - 1; Pacific white-sided - 3; seismic airgun - 2; earthquake - 35 |

### *5.1.4 Acoustic data*

Paper SC/TAG/2020/WP/05 summarised the acoustic results from the 2017 to 2019 IWC-POWER surveys. Passive acoustics monitoring using sonobuoys was successfully implemented for the first time in 2017; after its successful first year, it was included in the two following years. 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 (Fig. 3, Table 7). Note, unsuccessful deployments are nearly always due to deployment of old expired sonobuoys.

Table 8 shows that the most frequently detected species were fin whales, heard on 332 total buoys (51.2%), sperm whales (228, 35.1%), and killer whales (181, 27.9%), followed by humpback whales (94, 14.5%), North Pacific right whales (75, 11.5%), blue whales (54, 8.3%), gray whales (14, 2.1%), and sei whales (4, 0.6%). Maps of detections by species can be found in Annex E.

Acoustic detections were in good agreement with the visual sightings in all three years. There were, however, some differences. The more frequently acoustically active killer whales and sperm whales were detected more frequently with acoustics than they were visually sighted whilst the reverse was true for quieter common minke and gray whales - in fact there were no acoustic detections of common minke whales in any year. Of the 12 total sightings of North Pacific right whales, seven were the result of acoustic localisation where the first cue had been sounds (5 in 2017, 2 in 2018). During two sighting/acoustic encounters (one each in 2017 and 2018), right whale song was detected; these data contributed to a manuscript published by Crance *et al.* (2017). Although right whales were acoustically detected in 2019, there were no visual sightings due to inclement weather and infrequent calling of the animal.

Recordings of species that are not often detected (e.g. Baird's and Cuvier's beaked whales, Pacific white-sided dolphins) were made during the cruises. The 2017-19 results further emphasise the utility of using sonobuoys to monitor for marine mammals, particularly in remote areas or for visually cryptic species.

*Recommendation*
*The TAG* **thanked** *Crance for the report on the successful acoustic work undertaken from 2017-19 (SC/TAG/2020/WP/05) and* **thanked** *the Government of the USA for providing the necessary equipment and experts. It* **recommended** *that when possible such studies should be undertaken during future cruises and noted the value of the use of directional acoustic work for targeted studies of rare species such as blue and North Pacific right whales.*

### *5.1.5 Other data*

The TAG noted that other datasets can assist in examining distribution, stock structure and status during mid-term planning discussions, e.g. the revised IWC catch database and the JSV data (Miyashita *et al.*, 1995).

## 5.2 Review of results from visual sightings

Table 9 summarises the status of the analyses of the visual sightings data. Most progress has been made with large baleen whales. In addition 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 TUMSAT will examine these to see if useful abundance estimates can be obtained.

### *5.2.1 Analytical methods to estimate g(0)*

Last year the TAG recommended that additional IO mode data (especially for sei whales) be collected to confirm whether or not the assumption that $g(0)=1$ is appropriate for large whales. The value of $g(0)$ is the probability of detecting groups on the trackline. As a result, IO mode was conducted for over 1,400 n.miles during 125 hours in the 2019 survey. The 2019 survey resulted in over 234 sightings of 7 species (blue (9), fin (102), sei (22), humpback (48), sperm (26) and killer whales (15)) that could be used to estimate $g(0)$ (from Table 2c in SC/TAG/2020/WP/03).

Hakamada reported on the initial results of mark-recapture distance sampling analyses (SC/TAG/2020/WP/06rev) of the 2019 IWC-POWER data of North Pacific sei whales to estimate $g(0)$. Group size and Beaufort Sea State were potential covariates for the mark-recapture (MR) or distance sampling (DS) models. Interactions between the covariates and with

Table 9

Summary of work on the analyses of the sightings data*.
D=design based; M=model based.

| Species | Analysts | Status and schedule |
|---|---|---|
| Blue whale | ICR/TUMSAT (D, M) | Revised version of Kitakado *et al.* (2018) expected at SC68B. |
| Fin whale | TUMSAT/ICR (D, M) | Draft by Inai *et al* (SC/TAG/2020/WP/07) reviewed here, revised version expected at SC68B. |
| Sei whale | ICR (D) | Hakamada *et al.* (2017). |
| | TUMSAT (D, M) | Draft by Inai *et al* (SC/TAG/2020/WP/07) reviewed here, revised version expected at SC68B. |
| Bryde's whale | ICR (D) | Completed up to 2015 survey (Hakamada *et al.*, 2018) to be updated with 2016 data in 2020. |
| | TUMSAT (D, M) | Draft by Inai *et al.* (SC/TAG/2020/WP/07) reviewed here, revised version expected at SC68B. |
| Humpback whale | TUMSAT/ICR (D, M) | Draft by Inai *et al.* (SC/TAG/2020/WP/07) reviewed here, revised version expected at SC68B. |
| Sperm whale | ICR | No work conducted to date-this is correct for SWFSC-rlb. |
| Killer whale | TUMSAT/ICR | Initial estimates expected at the next TAG meeting. |
| Dolphin sp. | TUMSAT+NRFSFS+ICR | Initial estimates expected at the next TAG meeting. |
| Marine debris | TUMSAT/ICR | Draft by Yasuhara *et al*. (SC/TAG/2020/WP/09) reviewed here. Expected 2020 publication (see Item 6.2). |

*The feasibility of estimating the abundance of common minke whales will be considered by ICR given the non-optimal 'acceptable' conditions for this low priority species for IWC-POWER.

the platform were also considered. The hazard rate and half normal detection functions were considered and both point and full independence were investigated. Using the AIC value, the best fitting model resulted in an estimate of *g*(0) for the topman team of 0.867 (CV=0.089). However, it was noted that: (a) sample size was small; and (b) even the best model fits were poor for the detection function for the IO platform.

*Recommendation*
*The TAG thanked the authors of SC/TAG/2020/WP/06 revised, and* **recommended** *that a revised version be submitted to the next TAG meeting where the same methodology is also applied to other species. Several suggestions were made that might improve the analysis including consideration of:*

(1) *models that improve the fit to the IO team's detection function;*
(2) *other diagnostics such as the Cramer-von Mises criterion; and*
(3) *pooling the sei whale data with another similar species that has a larger sample size (e.g. fin whales) to develop species-specific estimates of g(0).*

### *5.2.2 Distance and angle experiments*
In response to previous advice from the TAG and the Scientific Committee, Kitakado presented a review of the annual distance and angle experiments that are conducted on all of the IWC-POWER cruises (SC/TAG/2020/WP/08). The analysis showed that although (as expected) there is variation in ability to estimate angles and distances there was no evidence of any systematic underestimation or overestimation that would translate into any significant bias in abundance estimates. Although the buoys used in the experiments were concentrated forward of the ship with limited locations near abeam of the ship, the design and implementation of the experiment meant that this was acceptable. Estimated radial distances and angles, along with the calculated perpendicular distances were shown on average to be unbiased but variable. Radial distances showed more variability at farther distances from the ship whilst angle estimates were more variable close to the ship. These patterns held for the various platforms, within different Beaufort sea states and across years. As one would expect, 'novice' observers were generally found to be more variable. In discussion it was noted that perhaps the reason Beaufort sea state had little effect was because the buoy (3.5m above the sea surface) was easier to see than an actual whale. Observer experience should be considered when accounting for measurement error in actual abundance estimates.

*Recommendation*
*The TAG* **commended** *the authors of SC/TAG/2020/WP/08 for this through investigation and* **recommended** *that the paper be submitted to SC68B and for publication.*

### *5.2.3 Abundance estimates*
Inai presented initial abundance estimates for humpback, fin, Bryde's and sei whales using sightings data from the 2010-18 IWC-POWER surveys (SC/TAG/2020/WP/07). She also presented initial information on the analysis of fin whale data from a cruise carried out to the east of Kamchatka in 2005 (SC/TAG/2020/WP/14). In SC/TAG/2020/WP/07, both design-based line transect methods and model-based spatial modelling methods (generalised additive model (GAM), random forest, and

boosting regression tree methods) were investigated. It was assumed that *g*(0)=1 for all analyses although the potential to estimate g(0) for these species was recognised. Transit data were included to estimate the effective strip half width but not final abundance. Covariates considered in the design-based analysis included: year of survey, group size, cue, visibility and wind speed. Covariates considered in the spatial modelling included: latitude, longitude, sea surface temperature, depth, distance from the coast, sea surface salinity, oxygen, silica, phosphate and nitrate. The best spatial model was selected by the deviance explained. The most commonly selected environmental covariates chosen were sea surface temperature, sea surface salinity and nitrate. Preliminary abundance estimates derived from the design-based methods were approximately 20,000 humpback whales, 40,000 fin whales, 27,000 Bryde's whales and 30,000 sei whales. In general, the CVs of the abundance estimates from the design-based and GAM methods were larger than those from the machine learning methods (random forest and boosting regression tree methods). The point estimates from all of the model-based methods were less than those from the design-based methods but not significantly different give the CVs.

*Recommendation*
*The TAG* **commended** *the authors for the work presented in SC/TAG/2020/WP/07 and* **recommended** *that it be updated and submitted to the SC68B meeting and made several suggestions for the updated paper:*

(1) *provide more explanation of the machine learning methods;*
(2) *consider why the inclusion of transit sightings changed the effective strip half width as much as it did – understanding the robustness esw calculations will assist in designing future analyses;*
(3) *include multiple diagnostics to choose the preferred model, including investigating the top few models (rather than simply the best) if they have similar AIC values;*
(4) *consider restricting the analyses by removing areas where there are none (or very few) animals and assuming that abundance there is zero – this should lead to lower CVs;*
(5) *consider using the 2019 IWC-POWER data to validate the habitat-density models developed using the 2010-2018 data;*
(6) *provide a more through comparison of the IWC-POWER estimates to published estimates from other projects using similar or other analytical methods; and*
(7) *include the estimates for humpback whales in the waters off Kamchatka.*

*No new abundance estimates were presented for species other than those discussed under Item 5.2.1.*
*The TAG* **recommended** *that the most up-to-date analysis for all species for which there were sufficient data be presented to the SC68B meeting. This could be a summary of previously approved estimates or the provision of either new or updated analyses taking into account previous TAG and SC advice on potential improvements of previous estimates.*

Kitakado presented the early results of a simulation study to investigate spatial line transect methods by applying the model-based methods used in SC/TAG/2020/WP/07 (generalised additive and random forest methods) to simulated spatially distributed whales and 100 random tracklines place within a simulated whale distribution (SC/TAG/2020/WP/12). As a simplification, strip transect methods were used to remove the need to consider possible effects of a detection function from the evaluation at this stage. Two general spatial distributions were investigated: a random distribution and a distribution similar to that seen for humpback whales during the IWC-POWER cruises, which was dependent on sea surface temperature, depth, latitude and longitude. The initial results showed that for the simulated randomly distributed whales, the generalised additive model performed better. For the 'humpback' distributed whales, the random forest abundance estimates performed better. The authors reported that future work would included using different underlying distributions of whales and different analysis methods, including 2-stage analysis techniques.

*Recommendation*
*The TAG* **commended** *the simulation-based approach and* **encouraged** *its continuation.*

### *5.2.4 Future detection of trends*
SC/TAG/2020/WP/10 reported on a preliminary analysis of the statistical power of the IWC-POWER surveys to detect a trend (either decrease or increase) of whale abundance from two abundance estimates. The first estimate was from the IWC-POWER series from 2010-18 and the second was from future surveys, under the assumption of no additional variance. This analysis showed, like other similar analyses, when the CV for an estimate is high (greater than 0.4), then it is difficult or impossible to detect a change in abundance. The smaller the true change, the harder it is to detect it with statistical confidence.

In discussion it was noted that the results re-emphasise the importance of such studies to the design of the next phase of IWC-POWER and meeting the long-term objective of obtaining information on trends. As noted under Item 5.2.3 it is important to develop ways to reduce the variability of abundance estimates given the resources available. For example by excluding large areas of the overall study area for which the density of a particular species is zero or very low, pooling to produce more precise estimates of the detection function, using spatial habitat models and investigating perhaps machine learning and other techniques that may produce more accurate, less variable estimates. With improved information on population structure, it may be possible to reduce the size of the study areas for particular cruises in a targeted manner to obtain a longer time series within a smaller area to increase the statistical power to detect a trend. Also, when appropriate, the variability of an abundance estimate may be reduced.

*Recommendation*
*The TAG* **reiterated** *the importance of such analyses based upon the initial phase of IWC-POWER to the development of the next phase of the programme (as had originally been envisaged) and thanked the authors for this initial study. It recommended that an updated version of SC/TAG/2020/WP/10 be submitted to SC68B with more description of the results and discussion.*

### 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. The use of directional acoustic studies (such as occurred for North Pacific right whales) should be considered for rare species such as North Pacific right and blue whales in phase 2 of IWC-POWER. Similarly, the possibility of occasional targeted cruises using towed arrays (e.g. to estimate sperm whale abundance) should be evaluated for the next phase of IWC-POWER, recognising the limitations this may impose (e.g. with respect to biopsy sampling and photo-ID studies).

## 6. OTHER ASSOCIATED STUDIES

### 6.1 Oceanographic studies
Only basic oceanographic information (e.g. SST) is collected during the cruises (see discussion under Item 5.1.2). However, the TAG noted that oceanographic data from remote sensing has proved valuable in spatial modelling approaches (e.g. see Item 5.2.3).

### 6.2 Marine debris
SC/TAG/2020/WP/09 provided an updated version of the abundance estimation of floating marine debris using the 2010-16 IWC-POWER data that incorporated comments provided at the last TAG and SC meetings. A multiple covariate distance sampling analysis showed that environmental covariates such as sea state and weather condition can affect the detectability of debris. A model-based method showed that densities of debris were high in between 20°N-40°N and concentrated in and around 145°W. The authors suggested that some of the debris might be attributed to the 2011 tsunami in Japan. They also indicated this paper was submitted to *Marine Pollution Bulletin*.

*Recommendation*
*The TAG* **welcomed** *the contribution IWC-POWER was making to the issue of marine debris,* **thanked** *the authors for the update in SC/TAG/2020/WP/09 and* **looked forward** *to its publication.*

### 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.

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

## 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 and this should continue.

*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 and an English language version).

*Recommendation*

*The TAG* **thanked** *Matsuoka for his work in this regard and* **recommended** *that he continues to: (a) work with the IWC Secretariat to ensure the prompt validation of the data after each cruise; and (b) provide 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 reiterated the importance of the IWC-POWER photographic database that stores, classifies and keywords all photographs taken on the cruises. This provides an extremely valuable resource that will facilitate use of the photographs in ancillary studies related to, for example, ship strikes, entanglement and health.

*The TAG* **reiterates:**

(1) *the need for an improved long-term database for the IWC-DESS system but noted that this is unlikely to occur under the present financial restrictions; and*
(2) *continued support for the IWC-POWER photographic database.*

*The TAG also confirms that in terms of data availability, Japan and the IWC share all the data and biopsy samples from IWC-POWER cruises, and that these are available to Scientific Committee members upon request.*

## 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 in the last three years. However, given the difficulties previously experienced, the TAG **agreed** that it was important to consider a backup plan for the 2020 cruise. If the Russian area cannot be covered in 2020 then every effort should be made to cover this in 2021 given its importance to meeting the objectives of the IWC-POWER programme.

The TAG examined the existing data and SC/TAG/2020/WP/11 when considering a backup plan for 2020.

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 and other species, as possible. There was some discussion about how best to achieve this. It was also noted that the cruise could incorporate acoustics and target any North Pacific blue and right whales that might be encountered.

*Recommendation*

*The TAG* **agreed** *that the draft backup plan considering the waters to the west of 170°E (the westernmost border of IWC-POWER to date) adjacent to the southern strata covered in 2010 with some overlap with the 2010 survey should form the basis of further discussions at the planning meeting for the 2019 cruise. Those discussions should consider:*

(1) *undertaking IO mode surveys during transits as well as during the survey (the vessels will need to return to Japan for refuelling half-way through the cruise) to increase sample size for g(0) estimation;*
(2) *the extent to which it is possible to cover waters to the east of 170°E to enable comparison with the results from 2010, recognising also that in 2010 sightings of at least fin and sei whales were made right up to the western boundary;*
(3) *biopsy sampling in this region will fill an important gap for sei whales as well as provide valuable data for the other species (see Table 3); and*
(4) *a sighting survey in this region will fill a gap in previous sighting surveys.*

### 8.2 Medium-term plan (6-10 years starting in 2022)

As previously noted, development of a medium-term programme (in light of the revised priorities given in Table 1) is heavily dependent on considering the analyses of the data collected under the first phase of IWC-POWER and an understanding of the likely resources that may be made available.

*Recommendation*

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

(1) *Updated power analyses should be undertaken. TUMSAT* **agreed** *to try to undertake this work in advance of the 2020 Scientific Committee meeting.*

(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 for presentation either at SC68B or the next TAG meeting.*

(3) *In the light of (2) and data from the first phase of the 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, humpback and other large whales should be evaluated as part of the next phase.*

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

(5) *The Scientific Committee should hold a pre-meeting in 2021 to develop a detailed proposal for a workshop to design the next phase of the IWC-POWER programme before the 2021 Scientific Committee meeting with an emphasis on participation from all range states and on the availability of analyses/data required - as noted in Table 1, that workshop should include consideration of more methodologically focussed cruises in some years (e.g. use of a towed acoustic array, telemetry work, use of SeaGlider, etc.).*

Table 10

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 2019 cruise and submit GPS and shape files. | **Matsuoka** and Hughes | By end of February 2020 |
| (2) | Encourage continued collaboration with other groups holding genetic samples and individual identification data. | **Brownell, Donovan** and Steering Group | Report progress to SC68B |
| (3) | Complete importation and classification of 2019 IWC-POWER photographs into the IWC photographic database. | Taylor and **Donovan** | Report progress to SC68B |
| (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 SC68B if not completed |
| (5) | 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 in relation to IWC-POWER data and future IWC-POWER surveys. | Brownell, Kim, Miyashita, **Matsuoka**, Zharikov | Report progress at SC68B and final summaries to 2020 autumn TAG meeting |
| **Analyses** | | | |
| (1) | Complete review of angle/distance experiments, following the guidance provided in IWC (2019), Item 6.2.1, and publish. | **Kitakado** and Team DAE | Submit revise to SC68B and then publish |
| (2) | Develop updated abundance estimates (design- and model-based) for humpback, blue, fin, sei and Bryde's whales following the advice provided at this meeting (incorporating estimates from (3) below if available). | **Kitakado** and scientists from TUMSAT/ICR | By SC68B |
| (3) | Provide updated estimates of *g*(0) for those species it is considered possible (including fin, sei and humpback) following the advice provided at this meeting. | **Hakamada** and scientists from TUMSAT/ICR | By the next TAG meeting |
| (4) | Develop abundance estimates for small cetacean species. | **Kim, Matsuoka and Kitakado** and others | Paper to 2020 autumn TAG meeting |
| (5) | Continue simulation work investigating spatial modelling approaches following advice provided at this meeting. | **Kitakado, Inai** and Palka | Submit revise to SC68B |
| (6) | Continue work on power analyses following advice provided at this meeting. | **Kitakado, Inai,** Palka and Donovan | Submit revise to SC68B |
| (5) | Develop summary overview paper of results of genetic studies that have included data from IWC-POWER and 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 | **Pastene** and colleagues | Progress report at SC68b with a draft to 2020 autumn TAG meeting |
| **Future** | | | |
| (1) | Develop a summary document of the results of IWC-POWER up to 2019 focussing on achievements and how to develop the next phase. | **Donovan** and Steering Group | Present at SC68B |
| (2) | Hold pre-meeting associated with SC68C, to focus on the next phase of IWC-POWER in light of medium-term priorities (see Table 1) and results of the analyses of the data thus far. | Steering Group | Develop proposal for workshop to design the next phase prior to SC69A |

## 9. WORK PLAN

The TAG reviewed progress on the previous work plan (IWC, 2020a) and developed the updated work plan provided in Table 10.

## 10. ADOPTION OF REPORT

The meeting closed at 5pm on 19 January 2020. The final report was agreed by e-mail on 14 February 2020.

Kitakado thanked the participants for their hard work and in particular thanked the Cruise Leader, Matsuoka, for processing the 2019 data so promptly. He also thanked the rapporteurs. The participants thanked Kitakado for his efficient handling of the meeting and noted the considerable work outlined under Item 9. The meeting also thanked the Fisheries Agency of Japan for the excellent working environment.

### References

Crance, J.L., Berchok, C.L. and Keating, J.L. 2017. Gunshot call production by the North Pacific right whale *Eubalaena japonica* in the southeastern Bering Sea. *Endang. Spec. Res.* 34: 251-67.

Hakamada, T., Matsuoka, K. and Miyashita, T. 2018. Updated *g*(0) estimate for western North Pacific Bryde's whales and its application to previous abundance estimates. Paper SC/67b/ASI15rev2 presented to the IWC Scientific Committee, April-May 2018, Bled, Slovenia (unpublished). 11pp. [Paper available from the Office of this Journal].

Hakamada, T., Matsuoka, K., Murase, H. and Kitakado, T. 2017. Estimation of the abundance of the sei whale *Balaenoptera borealis* in the central and eastern North Pacific in summer using sighting data from 2010 to 2012. *Fish. Sci.* DOI: 10.1007/s12562-017-1121-1.

International Whaling Commission. 2012a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 13:1-74.

International Whaling Commission. 2012b. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on In-Depth Assessments. Appendix 4. Report of the Small Group planning for the 2012 IWC Pacific Ocean Whales and Research (POWER). *J. Cetacean Res. Manage. (Suppl.)* 13:189-90.

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.

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.)* 20:483-98.

International Whaling Commission. 2020a. Report of the 2018 Meeting of the IWC-POWER Technical Advisory Group (TAG), 12-14 October 2018, Tokyo, Japan. *J. Cetacean Res. Manage. (Suppl.)* 21:311-32.

International Whaling Commission. 2020b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on *Implementation Reviews* and *Simulation Trials*. *J. Cetacean Res. Manage (Suppl.)* 21:77-106.

Kitakado, T., Inai, K., Yasuhara, T., Hamabe, K. and Matsuoka, K. 2018. Preliminary report of the abundance estimation of blue whales in the North Pacific using IWC-POWER data from 2010-2016. Paper SC/O18/TAG/WP14 presented to the IWC-POWER Technical Advisory Group (TAG), 12-14 October 2018, Tokyo (unpublished). 8pp. [Paper available from the Office of this Journal].

Miyashita, T., Kato, H. and Kasuya, T. 1995. *Worldwide Map of Cetacean Distribution Based on Japanese Sighting Data*. Vol. 1. National Research Institute of Far Seas Fisheries, Shimizu, Japan. 140pp.

Pastene, L.A., Goto, M. and Taguchi, M. 2016a. Additional genetic analyses on stock structure in North Pacific Bryde's and sei whales. Paper SC/66b/SD01 presented to the IWC Scientific Committee, June 2016, Bled, Slovenia (unpublished). 12pp. [Paper available from the Office of this Journal].

Pastene, L.A., Goto, M., Taguchi, M. and Kitakado, T. 2016b. Genetic analyses based on mtDNA control region sequencing and microsatellite DNA confirmed the occurrence of a single stock of sei whales in oceanic regions of the North Pacific. Paper SC/F16/JR46 presented to the Expert Panel Workshop of the Final Review on the Western North Pacific Japanese Special Permit Programme (JARPN II), 22-26 February 2016, Tokyo, Japan (unpublished). 11pp. [Paper available from the Office of this Journal].

Pastene, L.A., Goto, M., Taguchi, M. and Kitakado, T. 2016c. Updated genetic analyses based on mtDNA and microsatellite DNA suggest possible stock differentiation of Bryde's whales between management sub-areas 1 and 2 in the North Pacific. Paper SC/F16/JR44 presented to the Expert Panel Workshop of the Final Review on the Western North Pacific Japanese Special Permit Programme (JARPN II), 22-26 February 2016, Tokyo, Japan (unpublished). 18pp. [Paper available from the Office of this Journal].

Pastene, L.A., Taguchi, M., Lang, A.R., Goto, M. and Matsuoka, K. 2018. Population genetic structure and historical demography of North Pacifiv right whales. Paper SC/67b/NH02 presented to the IWC Scientific Committee, April-May 2018, Bled, Slovenia (unpublished). 18pp. [Paper available from the Office of this Journal].

Taguchi, M., Goto, M., Takahashi, M., Kitakado, T. and Pastene, L.A. 2017. DAPC analysis for Bryde's whales in the North Pacific using microsatellite DNA data. Paper SC/M17/RMP01 presented to the RMP Bryde's Whale Workshop, March 2017, Tokyo, Japan (unpublished). 8pp. [Paper available from the Office of this Journal].

# Annex A

# List of Participants

| | |
|---|---|
| Robert Brownell | Southwest Fisheries Science Center, USA |
| Jessica Crance | Alaska Fisheries Science Center, USA |
| Greg Donovan | Head of Science, IWC |
| Yoshihiro Fujise | Institute of Cetacean Research, Japan |
| Takashi Hakamada | Institute of Cetacean Research, Japan |
| Yuri Hosoda | Fisheries Agency of Japan |
| Kanako Inai | Tokyo University of Marine Science and Technology, Japan |
| Hidehiro Kato | Institute of Cetacean Research, Japan |
| Toshihide Kitakado | Tokyo University of Marine Science and Technology, Japan |
| Koji Matsuoka | Institute of Cetacean Research, Japan |
| Tomio Miyashita | National Research Institute of Far Seas Fisheries, Japan |
| Joji Morishita | Tokyo University of Marine Science and Technology, Japan |
| Hideki Moronuki | Fisheries Agency of Japan |
| Hiroto Murase | Tokyo University of Marine Science and Technology, Japan |
| Debra Palka | Northeast Fisheries Science Center, USA |
| Luis Pastene | Institute of Cetacean Research, Japan |
| Shinichi Suzuki | Fisheries Agency of Japan |
| Mioko Taguchi | Institute of Cetacean Research, Japan |
| Megumi Takahashi | Institute of Cetacean Research, Japan |
| Hideyoshi Yoshida | National Research Institute of Far Seas Fisheries, Japan |
| Saemi Baba | Interpreter, Japan |
| Hiroko Yasokawa | Interpreter, Japan |

# 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 2010-2019
    - 2.1 Summary of survey results including 2019
    - 2.2 Review of Scientific Committee recommendations
    - 2.3 Other relevant sighting surveys
        - 2.3.1 Russian waters
        - 2.3.2 Korean waters
        - 2.3.2 Other 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 Distance and angle experiments
        - 5.2.3 Abundance estimates
        - 5.2.4 Future detection of trends
    - 5.3 Mark-recapture methods
    - 5.4 Acoustic methods
6. Other potential associated studies
    - 6.1 Oceanographic studies
    - 6.2 Marine debris
    - 6.3 Other
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 2022)
9. Work plan
10. Adoption of report

# Annex C

# List of Documents

**SC/TAG/2020/WP/**

01. International Whaling Commission. 2020. Report of the 2018 meeting of the IWC-POWER Technical Advisory Group (TAG). *J. Cetacean Res. Manage (Suppl.)* 21: 311-332.
02. International Whaling Commission. 2020. Report of the Planning Meeting for the 2019 IWC-POWER Cruise. *J. Cetacean Res. Manage. (Suppl.)* 21: 333-346.
03. Matsuoka, K. *et al.* Cruise report of the 2019 IWC-POWER.
04. Summary of IWC-POWER surveys (2010-19).
05. Crance, J. and Matsuoka, K. Results of the passive acoustic component of the IWC-POWER cruises, 2017-19.
06. Hakamada, T. Estimation of *g*(0) for North Pacific sei whale based on 2019 POWER sighting data.
07. Iani, K., Matsuoka, K. and Kitakado, T. Abundance estimation for the North Pacific large baleen whales using IWC-POWER data (2010-18).
08. Kitakado, T. and Matsuoka, K. Measurement errors in the distance and angle in the line transect surveys in the IWC-POWER data and their possible impact to the abundance estimation.
09. Yasuhara, Matsuoka, K. and Kitakado, T. Abundance estimation of floating marine debris in the North Pacific using 2010-16 IWC-POWER data.
10. Kitakado, T. and Inai, K. Power analysis for the IWC-POWER.
11. Matsuoka, K., Takahashi, M. and Hakamada, T. Proposal for the backup plan of 2020 IWC-POWER future survey.
12. Inai, K. and Kitakado, T. Some progress on simulation studies for assessing effectiveness of spatial line transect methods.
13. Hakamada, T. Updates on estimation of *g*(0) for North Pacific sei whale.
14. Inai, K. Updates on humpback in Kamchatka.

# Annex D

# Summary of Effort and Sightings Information From 2010-19

Compiled by Koji Matsuoka

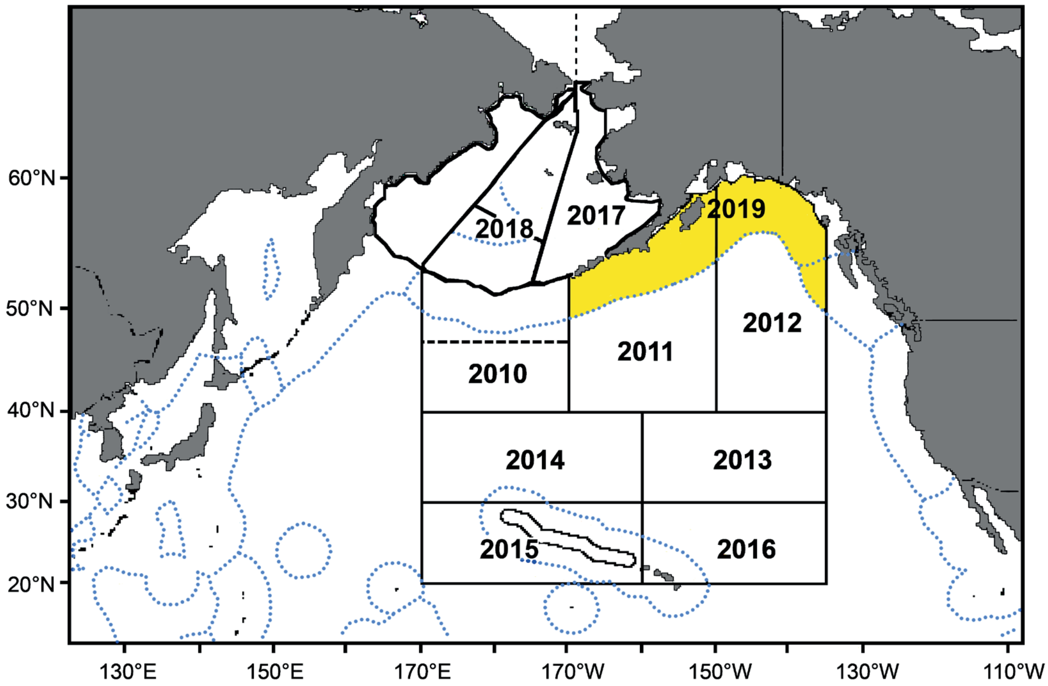



Fig. 1. Research area for the 2010-2019 IWC-POWER cruises. Yellow: 2019 research area. Dotted blue line: EEZs.

Table 1

Summary of effort and sighting of large whales during 2010 to 2019 POWER surveys.

| Year | 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vessel | *Kaiko-Maru* | | | | | | | | | | | |
| Area | Transit to R.A | | Transit from R.A | | Transit total | | Northern stratum | | Southern stratum | | R.A total | |
| Planned distance (n.miles) | - | | - | | - | | 1,347.8 | | 2,023.3 | | 3,371.1 | |
| Searching effort (n.miles) | 0.0 | | 170.1 | | 170.1 | | 490.5 | | 1,325.7 | | 1,816.2 | |
| Searching coverage (%) | - | | - | | - | | 34.0 | | 70.0 | | 53.9 | |
| Species | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. |
| Blue whale | 0 | 0 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 3 | 3 |
| Fin whale | 0 | 0 | 5 | 7 | 5 | 7 | 16 | 38 | 7 | 10 | 23 | 48 |
| Like fin | - | - | - | - | - | - | - | - | - | - | - | - |
| Sei whale | 0 | 0 | 9 | 17 | 9 | 17 | 4 | 4 | 49 | 97 | 53 | 101 |
| Like sei | - | - | - | - | - | - | - | - | - | - | - | - |
| Bryde's whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like Bryde's | - | - | - | - | - | - | - | - | - | - | - | - |
| Common minke whale | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 8 | 0 | 0 | 8 | 8 |
| Like minke | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| Humpback whale | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 8 | 0 | 0 | 5 | 8 |
| Like humpback | - | - | - | - | - | - | - | - | - | - | - | - |
| NP right whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like right | - | - | - | - | - | - | - | - | - | - | - | - |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like gray | - | - | - | - | - | - | - | - | - | - | - | - |
| Sperm whale | 0 | 0 | 8 | 8 | 8 | 8 | 22 | 22 | 45 | 62 | 67 | 84 |
| Like sperm | - | - | - | - | - | - | - | - | - | - | - | - |
| Total | 0 | 0 | 24 | 34 | 24 | 34 | 57 | 82 | 103 | 171 | 160 | 253 |

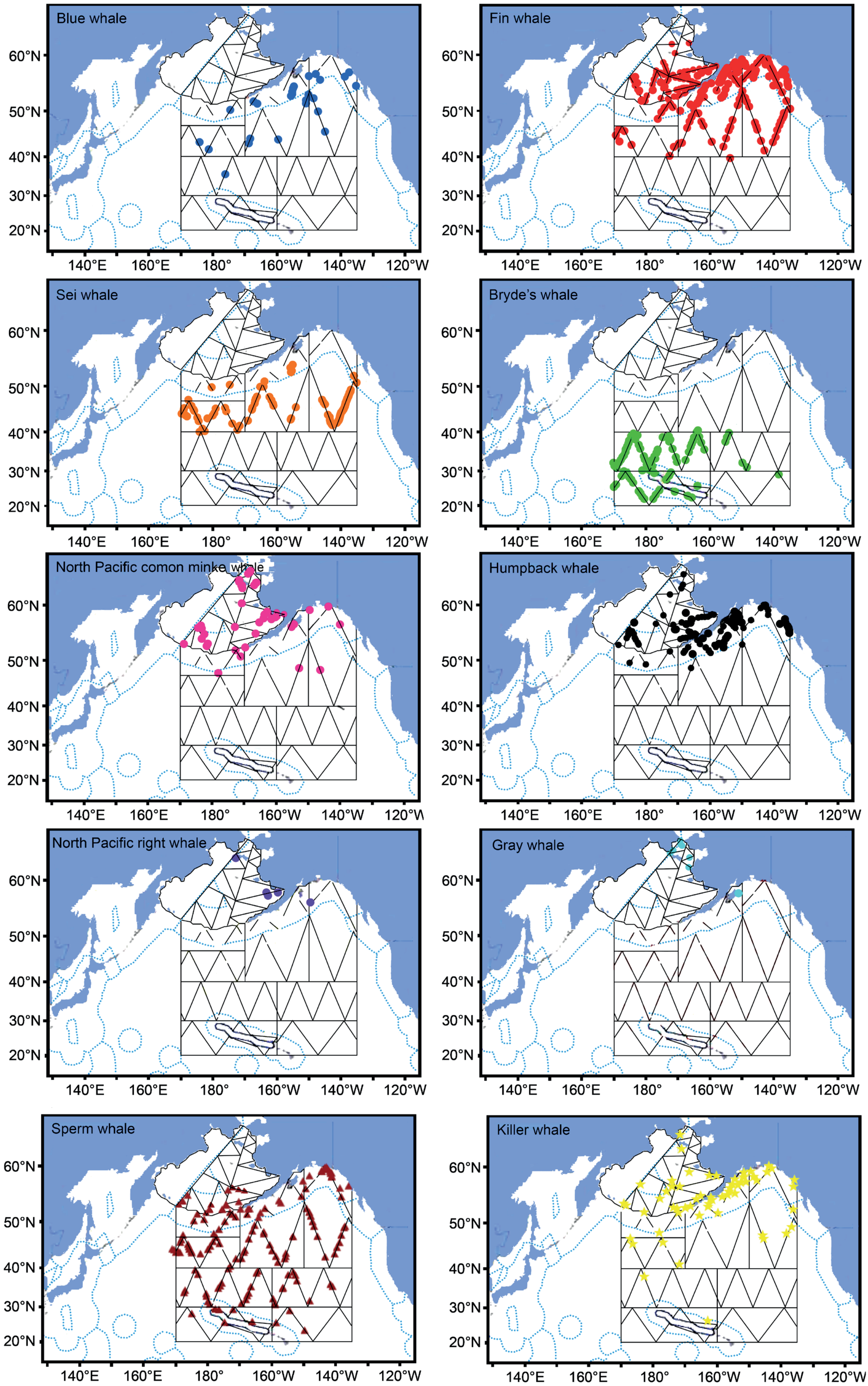
| Year | 2011 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vessel | *Yushin-Maru No.3* | | | | | | | | | | | |
| Area | Transit to R.A | | Transit from R.A | | Transit total | | Northern stratum | | Southern stratum | | R.A total | |
| Planned distance (n.miles) | - | | - | | - | | 1,290.2 | | 2,145.5 | | 3,435.7 | |
| Searching effort (n.miles) | 467.3 | | 232.7 | | 699.9 | | 723.8 | | 1,674.0 | | 2,397.8 | |
| Searching coverage (%) | - | | - | | - | | 58.0 | | 78.0 | | 69.8 | |
| Species | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. |
| Blue whale | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 8 | 9 | 9 |
| Fin whale | 1 | 1 | 1 | 1 | 2 | 2 | 47 | 91 | 33 | 48 | 80 | 139 |
| Like fin | - | - | - | - | - | - | - | - | - | - | - | - |
| Sei whale | 0 | 0 | 20 | 22 | 20 | 22 | 0 | 0 | 38 | 73 | 38 | 73 |
| Like sei | - | - | - | - | - | - | - | - | - | - | - | - |
| Bryde's whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like Bryde's | - | - | - | - | - | - | - | - | - | - | - | - |
| Common minke whale | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| Like minke | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| Humpback whale | 0 | 0 | 0 | 0 | 0 | 0 | 74 | 131 | 2 | 2 | 76 | 133 |
| Like humpback | - | - | - | - | - | - | - | - | - | - | - | - |
| NP right whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like right | - | - | - | - | - | - | - | - | - | - | - | - |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like gray | - | - | - | - | - | - | - | - | - | - | - | - |
| Sperm whale | 23 | 23 | 15 | 22 | 38 | 45 | 6 | 10 | 51 | 64 | 57 | 74 |
| Like sperm | - | - | - | - | - | - | - | - | - | - | - | - |
| Total | 24 | 24 | 37 | 46 | 61 | 70 | 130 | 235 | 134 | 197 | 264 | 432 |

| Year | 2012 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vessel | *Yushin-Maru No.3* | | | | | | | | | | | |
| Area | Transit to R.A | | Transit from R.A | | Transit total | | Northern stratum | | Southern stratum | | R.A total | |
| Planned distance (n.miles) | - | | - | | - | | 959.7 | | 1,898.7 | | 2,858.4 | |
| Searching effort (n.miles) | 550.5 | | 0.0 | | 550.5 | | 767.5 | | 1,358.6 | | 2,126.1 | |
| Searching coverage (%) | - | | - | | - | | 80.0 | | 85.0 | | - | |
| Species | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. |
| Blue whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 4 |
| Fin whale | 35 | 41 | 0 | 0 | 35 | 41 | 76 | 116 | 38 | 53 | 114 | 169 |
| Like fin | - | - | - | - | - | - | - | - | - | - | - | - |
| Sei whale | 6 | 13 | 0 | 0 | 6 | 13 | 2 | 4 | 79 | 147 | 81 | 151 |
| Like sei | - | - | - | - | - | - | - | - | - | - | - | - |
| Bryde's whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like Bryde's | - | - | - | - | - | - | - | - | - | - | - | - |
| Common minke whale | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| Like minke | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback whale | 14 | 26 | 0 | 0 | 14 | 26 | 7 | 7 | 0 | 0 | 7 | 7 |
| Like humpback | - | - | - | - | - | - | - | - | - | - | - | - |
| NP right whale | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| Like right | - | - | - | - | - | - | - | - | - | - | - | - |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like gray | - | - | - | - | - | - | - | - | - | - | - | - |
| Sperm whale | 5 | 5 | 0 | 0 | 5 | 5 | 17 | 24 | 28 | 28 | 45 | 52 |
| Like sperm | - | - | - | - | - | - | - | - | - | - | - | - |
| Total | 60 | 85 | 0 | 0 | 60 | 85 | 104 | 153 | 150 | 233 | 254 | 386 |

| Year | 2013 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Vessel | *Yushin-Maru No.3* | | | | | | | |
| Area | Transit to R.A | | Transit from R.A | | Transit total | | R.A total | |
| Planned distance (n.miles) | - | | - | | - | | 3,233.8 | |
| Searching effort (n.miles) | 854.9 | | 451.4 | | 1,306.3 | | 3,035.9 | |
| Searching coverage (%) | - | | - | | - | | 93.9 | |
| Species | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. |
| Blue whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fin whale | 0 | 0 | 2 | 2 | 2 | 2 | 1 | 1 |
| Like fin | - | - | - | - | - | - | - | - |
| Sei whale | 0 | 0 | 4 | 4 | 4 | 4 | 0 | 0 |
| Like sei | - | - | - | - | - | - | 0 | 0 |
| Bryde's whale | 48 | 58 | 0 | 0 | 48 | 58 | 6 | 6 |
| Like Bryde's | - | - | - | - | - | - | - | - |
| Common minke whale | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| Like minke | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like humpback | - | - | - | - | - | - | - | - |
| NP right whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like right | - | - | - | - | - | - | - | - |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like gray | - | - | - | - | - | - | - | - |
| Sperm whale | 21 | 23 | 13 | 26 | 34 | 49 | 33 | 50 |
| Like sperm | - | - | - | - | - | - | - | - |
| Total | 69 | 81 | 20 | 33 | 89 | 114 | 40 | 57 |

| Year | 2014 | | | | | | | | 2015 | | | | | | | | 2016 | | | | | | | | 2017 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vessel | *Yushin-Maru No.3* | | | | | | | | *Yushin-Maru No.3* | | | | | | | | *Yushin-Maru No.3* | | | | | | | | *Yushin-Maru No.2* | | | | | | | | | | | |
| Area | Transit to R.A | | Transit from R.A | | Transit total | | R.A total | | Transit to R.A | | Transit from R.A | | Transit total | | Total | | Transit to R.A | | Transit from R.A | | Transit total | | R.A Total | | Transit to R.A | | Transit from R.A | | Transit total | | Transit survey in R.A | | R.A original trackline | | R.A total | |
| Planned distance (n.miles) | - | | - | | - | | 3,878.4 | | - | | - | | - | | 3,588.7 | | - | | - | | - | | 2,302.7 | | - | | - | | - | | - | | 2,183.7 | | - | |
| Searching effort (n.miles) | 234.9 | | 293.2 | | 528.1 | | 3,233.0 | | 765.2 | | 291.9 | | 1,057.1 | | 3,248.5 | | 626.2 | | 580.1 | | 1,206.3 | | 2,237.5 | | 288.3 | | 0.0 | | 288.3 | | 130.7 | | 1,570.9 | | 1,701.6 | |
| Searching coverage (%) | - | | - | | - | | 83.4 | | - | | - | | - | | 90.5 | | - | | - | | - | | 97.2 | | - | | - | | - | | - | | 71.9 | | - | |
| 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. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. |
| Blue whale | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fin whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 2 | 3 | 2 | 2 | 141 | 193 | 143 | 195 |
| Like fin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 20 | 17 | 20 |
| Sei whale | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like sei | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bryde’s whale | 29 | 41 | 1 | 1 | 30 | 42 | 88 | 98 | 17 | 18 | 2 | 2 | 19 | 20 | 27 | 32 | 14 | 18 | 13 | 13 | 27 | 31 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Like Bryde’s | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 10 | 12 | 0 | 0 | 10 | 12 | 2 | 2 | 2 | 2 | 6 | 6 | 8 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Common minke whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 22 | 22 | 23 | 23 |
| Like minke | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| Humpback whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 8 | 0 | 0 | 7 | 8 | 5 | 5 | 124 | 152 | 129 | 157 |
| Like humpback | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 12 | 9 | 12 |
| NP right whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 5 | 11 | 7 | 15 |
| Like right | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 14 | 21 | 15 | 22 |
| Like gray | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sperm whale | 7 | 10 | 6 | 8 | 13 | 18 | 65 | 137 | 21 | 43 | 0 | 0 | 21 | 43 | 11 | 50 | 2 | 3 | 24 | 82 | 26 | 85 | 6 | 30 | 10 | 18 | 0 | 0 | 10 | 18 | 0 | 0 | 15 | 15 | 15 | 15 |
| Like sperm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 36 | 51 | 7 | 9 | 43 | 60 | 158 | 240 | 48 | 73 | 2 | 2 | 50 | 75 | 40 | 84 | 20 | 25 | 43 | 101 | 63 | 126 | 7 | 31 | 20 | 30 | 0 | 0 | 20 | 30 | 11 | 13 | 350 | 449 | 361 | 462 |

| Year | 2018 | | | | | | | | | | | | | | 2019 | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vessel | *Yushin-Maru No.2* | | | | | | | | | | | | | | *Yushin-Maru No.2* | | | | | | | | | | | | | | Total | | | | | |
| Area | Transit to R.A | | Transit from R.A | | Transit Total | | Northern stratum | | Southern stratum | | Transit survey in R.A | | R.A Total | | Transit to R.A | | Transit from R.A | | Transit Total | | Western stratum | | Eastern stratum | | Transit survey in R.A | | R.A Total | | Subtotal Transit | | Subtotal R.A (original trackline) | | Total (Transit + R.A) | |
| Planned distance (n.miles) | - | | - | | - | | 994.0 | | 1,243.9 | | - | | 2,237.9 | | - | | - | | - | | 1,263.7 | | 1,212.5 | | - | | 2,476.2 | | - | | 29,566.6 | | - | |
| Searching effort (n.miles) | 89.9 | | 100.4 | | 190.3 | | 708.5 | | 1,035.5 | | 536.4 | | 1,744.0 | | 322.3 | | 115.0 | | 437.3 | | 1,030.7 | | 1,088.1 | | 420.0 | | 2,118.8 | | 6,434.1 | | 23,659.5 | | 30,093.6 | |
| Searching coverage (%) | - | | - | | - | | 71.3 | | 83.2 | | - | | 77.9 | | - | | - | | - | | 81.6 | | 89.7 | | - | | 85.6 | | - | | 80.0 | | - | |
| 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. | sch. | ind. | sch. | ind. | sch. | ind. | sch. | ind. |
| Blue whale | 4 | 7 | 4 | 5 | 8 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 10 | 10 | 7 | 9 | 0 | 0 | 17 | 19 | 14 | 18 | 34 | 36 | 48 | 54 |
| Fin whale | 12 | 22 | 3 | 5 | 15 | 27 | 40 | 64 | 67 | 87 | 13 | 21 | 120 | 172 | 0 | 0 | 0 | 0 | 0 | 0 | 77 | 149 | 162 | 256 | 27 | 53 | 266 | 458 | 61 | 82 | 747 | 1,182 | 808 | 1,264 |
| Like fin | 1 | 2 | 0 | 0 | 1 | 2 | 8 | 10 | 7 | 7 | 3 | 3 | 18 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 15 | 11 | 13 | 1 | 2 | 20 | 30 | 1 | 2 | 55 | 70 | 56 | 72 |
| Sei whale | 0 | 0 | 5 | 7 | 5 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 22 | 1 | 1 | 17 | 23 | 9 | 20 | 0 | 0 | 0 | 0 | 9 | 20 | 62 | 87 | 182 | 346 | 244 | 433 |
| Like sei | 0 | 0 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 1 | 2 | 4 | 5 |
| Bryde's whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 124 | 151 | 122 | 137 | 246 | 288 |
| Like Bryde's | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 20 | 5 | 5 | 23 | 25 |
| Common minke whale | 1 | 1 | 0 | 0 | 1 | 1 | 11 | 11 | 5 | 5 | 0 | 0 | 16 | 16 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | 4 | 0 | 0 | 5 | 5 | 3 | 3 | 56 | 56 | 59 | 59 |
| Like minke | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 6 | 7 | 7 |
| Humpback whale | 1 | 1 | 0 | 0 | 1 | 1 | 3 | 3 | 52 | 72 | 30 | 46 | 85 | 121 | 0 | 0 | 0 | 0 | 0 | 0 | 95 | 224 | 52 | 65 | 26 | 113 | 173 | 402 | 22 | 35 | 475 | 828 | 497 | 863 |
| Like humpback | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 14 | 0 | 0 | 1 | 1 | 7 | 15 | 0 | 0 | 19 | 30 | 19 | 30 |
| NP right whale | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 19 | 11 | 19 |
| Like right | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 86 | 0 | 0 | 1 | 2 | 27 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 15 | 0 | 0 | 0 | 0 | 6 | 15 | 0 | 0 | 48 | 125 | 48 | 125 |
| Like gray | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 4 |
| Sperm whale | 0 | 0 | 9 | 9 | 9 | 9 | 1 | 1 | 25 | 26 | 0 | 0 | 26 | 27 | 16 | 27 | 14 | 14 | 30 | 41 | 14 | 14 | 6 | 6 | 0 | 0 | 20 | 20 | 194 | 321 | 345 | 539 | 539 | 860 |
| Like sperm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| Total | 19 | 33 | 23 | 28 | 42 | 61 | 92 | 181 | 161 | 202 | 49 | 74 | 302 | 457 | 34 | 51 | 17 | 17 | 51 | 68 | 227 | 464 | 242 | 353 | 55 | 169 | 524 | 986 | 503 | 723 | 2,110 | 3,388 | 2,613 | 4,111 |


Blue whale
Fin whale
Sei whale
Bryde's whale
North Pacific comon minke whale
Humpback whale
North Pacific right whale
Gray whale
Sperm whale
Killer whale
60°N
50°N
40°N
30°N
20°N
140°E
160°E
180°
160°W
140°W
120°W

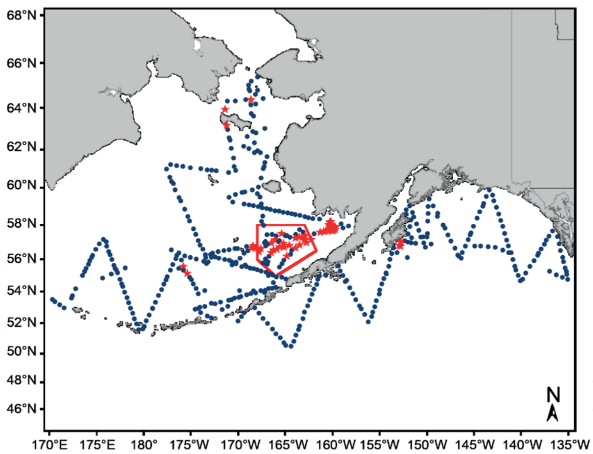
# Annex E

# Summary of Acoustic Information From 2017-19

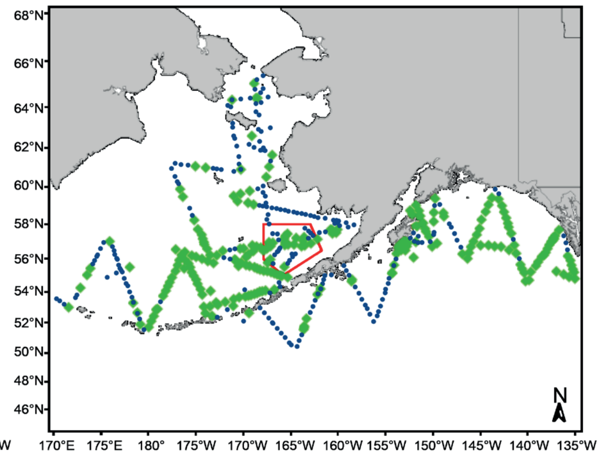
**Compiled by Jessica Crance**

### MAPS SHOWING ACOUSTIC DETECTIONS BY SPECIES FOR THE 2017-19 CRUISES

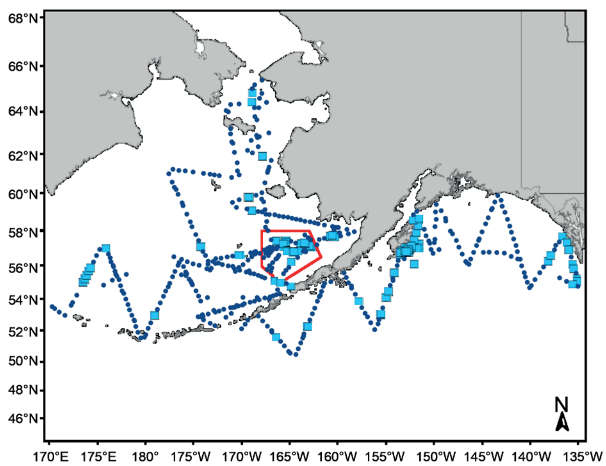
Dark blue dots show the sonobuoy deployments and the red polygons represent designated North Pacific Right Whale Critical Habitat.



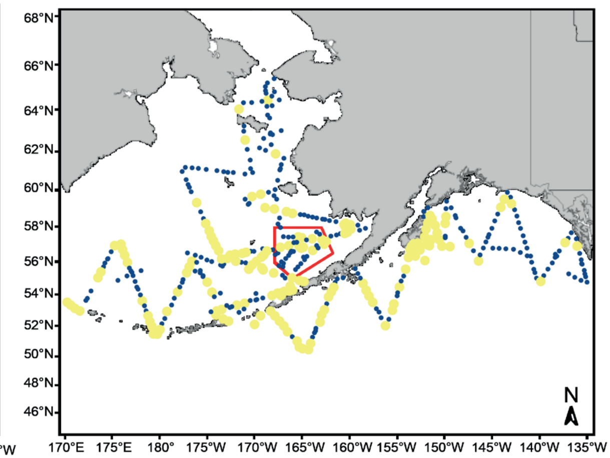

North Pacific right whale detections



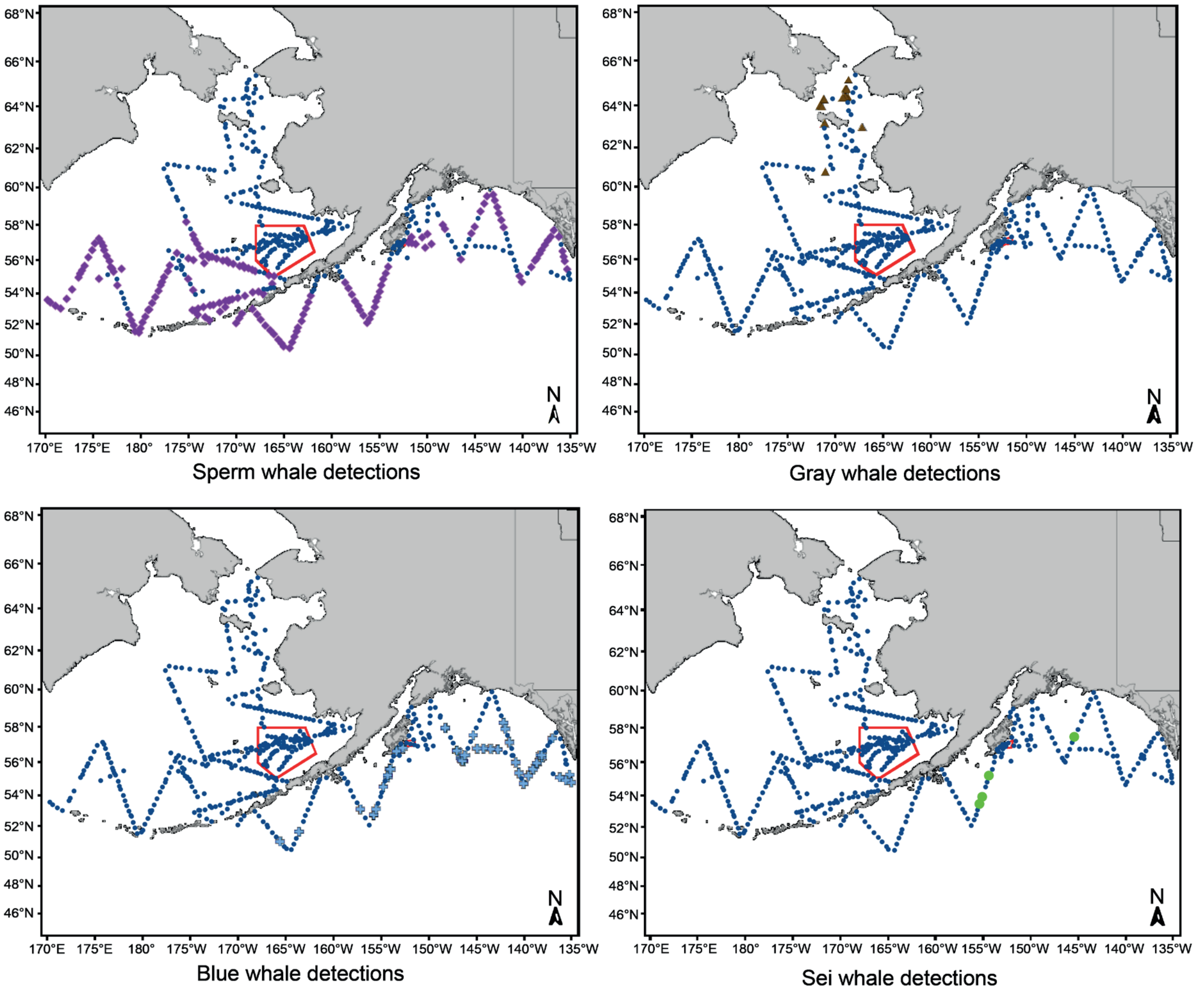

Fin whale detections




Humpback whale detections




Killer whale detections


68°N
66°N
64°N
62°N
60°N
58°N
56°N
54°N
52°N
50°N
48°N
46°N
N
170°E 175°E 180° 175°W 170°W 165°W 160°W 155°W 150°W 145°W 140°W 135°W
Sperm whale detections
Gray whale detections
Blue whale detections
Sei whale detections