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Cruise report of the 2021 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER)

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ABSTRACT

IWC-POWER is a joint research program between IWC and Japan conducted in the North Pacific, which has followed since 2011 IWC/IDCR-SOWER (Southern Ocean Whale and Ecosystem Research) that were conducted in the Antarctic Ocean from 1978 to 2010. The 12th annual IWC-POWER cruise was conducted between 2 August and 30 September 2021 in the eastern North Pacific (between 40°00'N and US and Canadian EEZ boundaries, 135°00'W and 155°00'W, comprised entirely of the High-Sea). The survey was conducted aboard the Japanese R/V *Yushin-Maru No. 2.* The cruise plan was endorsed at the 68C IWC/Scientific Committee (IWC/SC) meeting. Same as previous IWC-POWER cruises, the present cruise made a valuable contribution to the work of the IWC/SC on the management and conservation of populations of large whales in the North Pacific in a number of ways, including providing: (a) information for the ongoing assessments of North Pacific sei, humpback and gray whales in terms of abundance, distribution and stock structure; (b) information on endangered North Pacific right whales; (c) baseline information on distribution, stock structure and abundance for a poorly known area for other cetacean species/populations, including those that were known to have been depleted in the past but whose status is unclear; (d) essential information for the development of the medium-long term international programme in the North Pacific to meet the Commission's long-term conservation and management objectives. At the pre-cruise meetings, the crew of the vessel and international researchers confirmed the objectives and agreed on the procedures of this survey. The survey was conducted using methods based on the guidelines of the IWC/SC. Survey trackline coverage was 77.2 % (1562.5 n.miles of a planned distance of 2,022.4 n.miles)., with a total of 833.7 n.miles in Passing with abeam closing mode (NSP) and 728.8 n.miles in Independent Observer passing mode (IO). During the entire cruise, sightings of: blue (6 schools / 7 individuals), fin (79/115), sei (25/40), Bryde's (20/22), sperm (19/22) and killer (1/4) whales were observed. Blue and fin whales were mainly distributed in the northern part of the research area. Sei whales were distributed in mid-latitudes of the research area. Bryde's whales were distributed in the southern part of the research area. North Pacific right whale was not sighted during the cruise. A total of 19 biopsy (skin and sometimes blubber) samples were collected from 3 blue, 9 fin, 4 sei, 2 Bryde's and 1 killer whales. Photo-identification data were collected for: 7 blue, 31 fin, 15 sei 13 Bryde's and 3 killer whales. These data are preliminary, pending further processing and photo-identification confirmation. No acoustic survey was conducted in the cruise. The Estimated Angle and Distance Training Exercise and Experiment were completed. A total of 88 objects of marine debris were observed. Feasibility experiment of dive behavior tagging was conducted at the discretion of Japan and the tags were deployed 2 fin and 3 sei whales. This cruise was successfully completed and provided important information on cetacean distribution, in particular blue, fin sei and Bryde's whales, in a poorly-known and logistically difficult area, where limited survey effort had been made in the recent decades. These results will contribute to the aforementioned objectives of the IWC/SC.

KEY WORDS: BLUE WHALE, FIN WHALE, SEI WHALE, BRYDE'S WHALE, SURVEY VESSEL, EASTERN NORTH PACIFIC, IWC-POWER

1. INTRODUCTION

1.1 Research objectives

This research cruise (the 2021 IWC-POWER) was organised in the context of IWC-POWER (Pacific Ocean Whale and Ecosystem Research), a joint research program between the International Whaling Commission (IWC) and Japan (IWC, 2012a, 2012b, 2013, 2016, 2017, 2021a). The 2021 cruise plan was discussed at the planning meeting in November 2020 (IWC, 2021b) and endorsed at the 68C IWC/Scientific Committee (IWC/SC) meeting (IWC, 2021c; 2021d). Same as previous cruises of IWC-POWER, the present cruise was focused on the collection of line transect data to estimate abundance and biopsy/photo-identification data, would made a valuable contribution to the work of IWC/SC on the management and conservation of populations of large whales in the North Pacific in a number of ways, including (IWC, 2021e):

(a) information for the in-depth assessments of North Pacific sei, humpback and gray whales in terms of abundance, distribution and stock structure;

(b) information on the critically endangered North Pacific right whale population in the eastern Pacific;

(c) completion of coverage of the northern range of fin whales following on from the IWC-POWER cruises in 2010-12;

(d) baseline information on distribution, stock structure and abundance for a poorly known area for several large whale species/ populations, including those that were known to have been depleted in the past but whose status is unclear;

(e) essential information for the development of the medium-long term international programme in the North Pacific in order to meet the Commission's long-term objectives.

1.2 Research area and cruise track design

Originally, it was planned that the 2021 IWC-POWER would be conducted East of the Kuril archipelago within the Russian EEZ (IWC 2021b; 2021d) and Japan submitted the research application to Russia in December 2020. However, the Russia sent the Note Verbal to Japan in April 2021 stating that the government could not accept the application without mentioning the reason. Therefore, the 2021 IWC-POWER was conducted according to the back-up plan for the eastern north Pacific (IWC 2021b; 2021d). The research area for the 2021 IWC-POWER was decided to be between 40°00'N and US and Canadian EEZ boundaries, 135°00'W and 155°00'W, comprised entirely of the High-Sea (Figure 1a). The research area was established considering the following suggestions made by the Technical Advisory Group (TAG) in 2020 (IWC, 2021b):

(1) it had not been surveyed within 9 years;

(2) it represented an important information gap for several large whale species;

(3) IO mode data were not available for the area;

(4) COVID-19 might limit port calls and or the travel of researchers.

A randomised start point for survey tracks was used based on the IWC/SC survey guidelines (IWC, 2012c). Every location within the study area had an equal probability of being sampled, as calculated by the software "DISTANCE (Ver. 6.2)" (Thomas *et al*., 2010). The lines were reviewed in the light of the guidelines for good track design included in the Requirements and Guidelines for Surveys under the Revised Management Procedure (IWC, 2012c), and in particular the need to take into account the distribution of priority species and the objectives of the survey, the need to ensure that lines did not follow features that might result in a bias (e.g., by following a coastline where the density of whales decreased with distance from the coast), as well as practical considerations such as time that would need to be spent on transit. Figure 1b shows the cruise track design in the designated research area and Table 1c shows Waypoints (WP) for the pre-determined tracklines. Research hours during the cruise were set at a maximum of 12 hours per day. Following advice from the SC and TAG, the 2021 survey alternated modes between Passing with abeam closing mode (NSP) and Independent Observer Mode (IO) (ca., every 80 n.miles).

1.3 Priority of the cruise

Priority was given to the sightings survey of the research area. Research was conducted in 'Passing with abeam closing mode' and 'IO mode' with the associated distance and angle experiments. Priority on this cruise shall be given to IO survey mode with 50% of effort being undertaken in that mode. The Cruise Leader (CL) and the Captain had responsible for deciding how to obtain the necessary increase in IO mode survey. Sufficient time must also be allocated to the other priority items (Photo-ID and biopsy sampling); this was determined by the CL. The priority species for biopsy sampling during the 2021 cruise were North Pacific right whales, blue, fin, sei and humpback whales. Medium-priority species included sperm and killer whales. Priority species for photo-ID were North Pacific right blue and humpback whales, although photos of all other species, including killer whales were obtained opportunistically.

2. SHORT DESCRIPTIONS OF SURVEY METHODOLOGIES

The survey methodologies are briefly described here, and the details can be found in the Information for Researchers for the cruise (2021e).

2.1 The 2021 cruise itinerary

Date (ship's time)	Event
1 August 2021	Pre-cruise meeting at Shiogama

2 August	Vessel departs Shiogama
17 August	Vessel starts the survey in the research area
16 September	Vessel completes the survey in the research area
30 September	Vessel arrives Shiogama
1 October	Post-cruise meeting at Shiogama

2.2 Research vessel

The R/V *Yushin-Maru No.2* (YS2, 747GT) was contracted for this cruise. The vessel is a sister ship of the *Yushin-Maru No.3* which was contracted in previous years (2011-2016). Ship specifications, photo, and the crew list for this cruise are provided in Appendix A.

2.3 Attending scientists and responsibilities

Three international researchers were nominated by the IWC steering group for IWC-POWER. Researchers for the cruise were Hiroto Murase (Tokyo University of Marine Science and Technology (TUMSAT), Japan, [CL]), James W. Gilpatrick, Jr. (NOAA Fisheries, Southwest Fisheries Science Center (SWFSC), US) and Isamu Yoshimura (IWC-nominated researcher, Japan).

Hiroto Murase (Japan) - Cruise Leader (CL) /Chief Scientist James W. Gilpatrick, Jr. (US) - Photo-ID Isamu Yoshimura (Japan) – sighting data, marine debris and biopsy sample managements

Alexander Somov (VINRO, Russia) was also nominated as an international researcher of this cruise. However, it was unfortunate that he could not participate in the survey at the last minute because of his personal reason. If he had joined the cruise, he would be the first Russian researcher in the history of the survey. Russia and the IWC worked cooperatively in the process of the nomination. The researchers thanked their effort and hoped that Russian researcher would participate in next year's survey.

2.4 Management Authority Permits for Cetacean Research Activities and International Export and Import of Cetacean Biopsy Tissue Samples.

All cetacean research activities (i.e., the approach of cetaceans for species identification, school size estimates, digital photography, and biopsy sample collection) conducted on the high seas in international waters by Japanese researchers aboard the YS2 were authorized under permit SUIKAN 3-1162 (dated 21 July 2021) issued by Fisheries Agency, Government of Japan. The CITES (Convention on International Trade in Endangered Species) certificate for introduction of specimens of CITES-listed species into Japan from the high seas would be issued by Japan Management Authority, the Office of Trade Licensing for Wild Animals and Plants, Ministry of Economy, Trade and Industry (METI), soon after the completion of the samplings

2.5 Pre- and post-cruise meetings

On 1 August 2021, a pre-cruise meeting was held at the Tohoku Dock yard at Shiogama, chaired by Kato on behalf of the steering group. Meeting participants were: Matsuoka (chair), Kato (acting representative for the 2021 IWC POWER survey), Moronuki (Fisheries Agency of Japan), Eguchi (captain), Takamatsu (chief officer), Mizobuchi (chief engineer), Semii (chief operator), Katase (bosun), Murase (CL), Gilpatrick (researcher) and Yoshimura (researcher), Ohta (interpreter). The meeting discussed and confirmed priorities and strategies for the cruise based on relevant IWC-SC papers and IWC research manual (IWC, 2021e). The pre-cruise meeting report was distributed to the steering group after review by the chair (IWC, 2021f).

On 1 October 2021, a post-cruise meeting was held at the Hotel Grand Palace Shiogama at Shiogama, chaired by Matsuoka. Meeting participants were: Matsuoka (chair), Kato, Iida (Fisheries Agency of Japan), Katsumata (ICR), Mori (Kyodo Senpaku Co. LTD), Murase, Gilpatrick, Yoshimura, Eguchi and Ohta. All the samples and data collected during the survey and a draft of the cruise report was thoroughly reviewed at the meeting.

2.6 Research hours

The schedule for research hours was consistent with previous the IWC-SOWER (Southern Ocean Whale and Ecosystem Research) and the IWC-POWER cruises. Research effort began 60 minutes after sunrise and ended 60 minutes before sunset, with a maximum 12-hour research day (maximum 06:00-19:00, including 30 minutes for meal time for lunch and supper, when surveying in IO mode; see below). There were occasions when it was beneficial to extend the research day beyond the normal research hours. This decision was made with the mutual agreement of the Captain and CL. In such cases, there was an allocation of equivalent time-off on the following day for crew and scientists aboard the vessel.

Time-zone changes were made in either 30-minute or 1 hour increments, effective from 01:00 hrs. Work schedules adhered to local ship time (or ship mean time (SMT)) which ranged between +9.0 hours (i.e., Japanese Standard Time (JST)) and +15.0 hours UTC throughout the cruise depending on the ship's geographic location (Table 1b) although the date had remained the same as JST regardless of the time. Data collected during the cruise and all associated reporting are provided in local ship time.

2.7 Survey mode and number of observers on effort

Following advice from the SC and TAG, the 2021 survey alternated between NSP and IO modes. It was suggested that at least 50% of effort be in IO mode.

Passing with abeam closing mode (NSP): This was in effect Passing Mode. Two topmen were on effort from the TOP barrel at all times. There was open communication between the upper bridge and the barrel. The observers on the upper bridge communicated with the topmen only to clarify sighting information. The upper bridge observers did not distract the topmen from their normal search procedure unless they were directed to do so by the CL.

Independent Observer Mode (IO): This is also in effect Passing Mode. Two topmen were observing from the TOP barrel and two from the IO barrel at all times. Communications were essentially one-directional, with topmen from the TOP and IO platforms reporting information to the upper bridge in isolation from each other to ensure that no sighting information was exchanged between the TOP and IO barrel observers. The observers on the upper bridge would communicate with the topmen only to clarify sighting information and would not direct the topmen to disrupt their normal search procedure unless directed to do so by the CL.

Sighting effort was conducted by the topmen from the TOP barrel (crow's nest: always two primary observers) and typically, two primary observers (the helmsman and captain) and at least four secondary observers from the upper bridge (three researchers, and the chief engineer or deputy). Sighting activities aboard the ship were classified into two principal types: On-effort and Off-effort. On-effort activities were times when full search effort was executed and conditions (such as weather and sea state) were within acceptable parameters to conduct research. Off-effort activities were all activities that were not On-effort when no primary observers were in the TOP barrel (e.g. during drifting), Top down (TD) or transiting along the trackline due to bad weather conditions. All sightings recorded during On-effort were classified as Primary sightings. All other sightings were considered to be Secondary sightings.

Immediately after a sighting was detected from the barrel, the topman relayed information to observers on the upper bridge. Details of the estimated distance and angle to the sighting (and when possible, the species and number of animals present) were relayed. After the sighting information was relayed to the upper bridge observers, the topman responsible for the sighting continued his normal searching pattern. Observers on the upper bridge located the sighting made by the topman and decided whether it would be possible to confirm species and conduct a school size count before the sighting passed abeam of the vessel. The topmen gave no further information to the upper bridge unless the whale group resurfaced within their normal searching pattern area. A designated researcher on the upper bridge recorded the species and estimated number of whales in the school when the sighting passed abeam of the vessel; this was in consultation with other upper bridge observers/researchers. When the sighting location was abeam of the vessel, the ship altered course to approach the whale, and speed was increased to 15 knots to hasten the closure. Ship speed was decreased when the group was near, usually within 0.2 to 0.4 n.miles from the initial sighting position. After the sighting was approached, the species, number of animals in the group, estimated length(s), number of calves present, and behaviour were determined and recorded. Following this, other activities would normally be conducted (time allowing and at the discretion of the CL), such as photography for natural marking (Photo-ID) studies and biopsy sampling. Until the ship resumed full search effort on the trackline, any sightings detected after initial departure from the trackline were classified as secondary sightings.

2.8 Identification of species

Guidelines for species identification were based on the IWC-SOWER and the IWC-POWER methods for classification of identification. Positive identification of species was based on multiple cues and usually required clear observation of the whale's body. Occasionally, repeated observations of the shape of the blow, surfacing and other behavioural patterns were sufficient to identify whales; this judgement was made only by the CL or other designated researcher. Identification of species was recorded as 'probable' based on multiple cues, which were nevertheless insufficient to be absolutely confident of identification (recorded as "like"). This usually occurred when blows and surfacing patterns could be confirmed, but the whale's body could not be clearly seen.

2.9 Determination of group size

The following guidelines were used in determining group size: Schools where the number of animals, or an accurate estimated range of the number of animals was determined, were classified as confirmed schools. Data from the confirmed schools can be used to determine a mean school size. Therefore, it is critical that the confirmed schools

accurately represent the size of schools in the survey area. Normally, schools believed to be confirmed for school size were approached to within 1 n.mile for large whales and to within 0.3 n.miles for minke whales. Allowing for context-specific differences (i.e., environmental conditions and animal behaviour), every effort was made to be consistent with regard to the maximum time spent on identification of species and confirmation of numbers. Normally, no more than 20 minutes (after closure has been completed) was spent on confirmation; this reduces the potential for confusion with other whale sightings in the vicinity.

2.10 Searching conditions

Primary search effort was conducted in acceptable weather conditions. These guidelines for acceptable conditions applied: visibility > 2.0 n.miles; wind speed < 20 knots and a sea state < Beaufort 6. These guidelines were followed during previous research cruises.

It should be noted that the upper limits of wind speed and sea state have been considered as acceptable conditions for large whales as their main sighting cue is relatively large and strong blow. However, the conditions are not suitable for cryptic small species, such as common minke whales, as their main sighting cues are small and weak blow and/or body above sea surface.

2.11 Data entry system and analysis

Throughout the cruise, research data collected during the survey (weather, effort, sighting and distance experiment data) were entered by researchers using the 'onboard data collecting system' developed by ICR (ICR, 2013).

2.12 Experiments

2.12.1 Distance and angle estimation experiment

This calibration experiment was conducted in the survey area using two buoys and three portable GPS units. A training exercise was conducted near the beginning of survey in the research area.

The experiment was conducted following suggestions from the IWC/SC and the TAG (IWC, 2017). They were: (1) use of relatively inexpensive GPS technology (a durable waterproof model) on the buoy to improve detectability (a) at greater distances and (b) in more realistic sea/weather conditions than may be possible using the present radar system; (2) use of two buoys which can (a) reduce the potential lack of independence while using only one buoy with the correct experimental protocols and (b) allow increased efficiency which will assist when having a greater distance range and when the crew in the experiment using the recommended buoys (to simulate a whale's body in addition to the blow).

2.12.2 Biopsy sampling

As appropriate and decided by CL, research time was dedicated to biopsy sampling of North Pacific right, blue, fin, sei, bowhead, humpback and common minke whales, with high priority given to the first 5 species listed above. Biopsy of sperm and killer whales were attempted on an opportunistic basis. The following equipment were available by courtesy of ICR: two Larsen biopsy guns (Larsen, 1998), ammunitions, biopsy darts and laboratory equipment for biopsy sample processing. All samples for molecular genetics analyses were kept frozen. Samples were divided in half during the cruise, with one half of the samples designated for IWC research and the other half for analyses in Japan (ICR). These biopsy skin samples will enable genetic studies on stock structure to be conducted and samples of blubber will be analysed for contaminants, hormones and fatty acids.

As in past years, biopsy darts were numbered and color-coded and each biopsy shooter used either red or black labelled darts. This allowed us to track which whale was sampled. At the commencement of each biopsy sampling encounter, effort code "BX" was recorded, and after a sample was collected, effort code "EX" was recorded by the researcher on the upper bridge.

2.12.3 Photo-ID data collection

Target species for photo-ID are North Pacific right, blue, gray and humpback whales although photos of all other species including killer whales were obtained opportunistically. Generally, large whales were approached within 15-20 m. Adults, juveniles, and females accompanied by calves were approached for photo-identification. Photo-ID experiments involved a photographer. The main camera used was a Canon EOS 5D Mark II with 100-400 mm lens (courtesy of SWFSC) and the backup was a Canon EOS 7D Mark II with 100-400 mm lens (courtesy of ICR). Because it was identified that the SWFSC's lens was not properly functioned, the ICR's lens was attached to the SWFSC's camera from the beginning of the cruise. The cameras are GPS compatible.

Two 3 TB external hard drives were purchased for daily backups and a spare SD card with a 64 GB capacity was also prepared by the ICR. This provided adequate storage for this cruise.

All digital photographs were processed using the Adobe Lightroom software (LR) installed on a PC provided by the IWC. This has been the designated IWC photo-database management program. Gilpatrick processed the photos during the cruise according to the guideline prepared by the IWC (IWC, 2021g).

Images of photo-ID species were reviewed at the end of each survey day in order to confirm the number of unique individuals per sighting. Individuals were reviewed for images that documented identification features and met catalogue-quality criteria, e.g., perpendicular angle for dorsal fins. Primary ID features are species-specific: ventral flukes for humpbacks; left or right head for right whales; laterals (left or right) or flukes (dorsal or ventral) for gray whales; dorsal fin or right head blazed chevron for fin whales; and dorsal fin or saddle patch for killer whales. Individuals that had one or more image(s) of a Primary ID feature that adhered to catalogue-quality criteria, were considered photo-identified for the purpose of this report. Secondary ID features were useful for photo-identification but not sufficient alone (e.g. humpback whale dorsal fins or scars anywhere on the body).

The IWC LR database is not a photo-identification catalogue but is designed to categorise images for contribution to various research interests, including photo-identification. During the 2021 IWC-POWER cruise, the best primary ID feature image(s) and the best secondary feature image(s) of individuals were coded 'Photo-identification' in LR. If no images of primary features met the criteria, the individual was not considered photo-identified for the purpose of this report, and no images were coded 'Photo-identification' in LR.

The logic: species-specific catalogues are based on primary ID features; therefore, even if a secondary feature (e.g., scar) is well documented making the whale easy to match, this whale could potentially never be matched to catalogue primaries that do not show the distinct mark (or to images of the whale prior to acquiring the scar). All images 'useful for photo-identification' are labelled green in LR, regardless of whether the whale is photo-identified or not.

For the purpose of this report, individuals were considered photo-identified if they were documented with one or more image(s) that met species-specific identification criteria and catalogue-quality standards. These data should be considered preliminary and are subject to change with the further processing of database and catalogue curators.

2.12.4 Video recording

A digital video camera recorder, Sony FDR-AX60, 4K Handycam was used to conduct opportunistic video recording.

2.12.5 Acoustic data collection

Acoustic survey was not conducted in this cruise.

2.12.6 Marine debris observation

As in past years, data on floating marine debris were collected to document the type and extent of marine debris present in the North Pacific. High priority was given to the whale sighting survey and that marine debris observations and recordings were done as time allows. Systematic data collection of marine debris was limited to the first 15 minutes of each hour, as time permitted (not to interfere with cetacean observations). In addition, opportunistic marine debris data were recorded and photographed if items were particularly large and/or could potentially lead to large whale entanglements. For all recorded marine debris items, observers recorded angle, distance and time of initial sighting, IWC code and a description. Photographs of items were archived and will be available to those interested in these data. In the case of large marine debris (which present a possible hazard to navigation), photographs were obtained and the location reported as appropriate. Marine debris information was summarized in paragraph form in the cruise weekly report as in previous years.

2.12.7 Other

During the 2021 IWC-POWER planning meeting, the potential of carrying out satellite tagging studies was considered and agreed that it may be a way to address specific questions in the future, and voluntarily done by Japan (IWC, 2021b). According to the agreement, satellite linked dive behavior tags were experimentally deployed during the cruise at the discretion of Japan. The details are shown in Appendix C.

3. SHORT NARRATIVE OF THE CRUISE

3.1 Weather conditions and expected versus realised effort

Low-pressure systems intermittently moving over the research area resulted in frequent intervals of poor visibility, rain conditions, and heavy storms. Moderate to strong wind (c.a., 11 knots <) prevailed this year in comparison with previous cruises (Appendix B).

A total of 1,562.5 n.miles (NSP:833.7 n.miles, IO: 728.8 n.miles) of original trackline were surveyed in the research area. Survey trackline coverage in the entire research area was 77.2 % (1,562.5 n.miles of a planned distance of 2,022.4

n.miles). A total of 315.2 n.miles was surveyed during transit surveys between the port and the research area. NSP and IO was conducted for 79 and 68 hrs, respectively while YS2 drifted 115 hrs out of a total of 346 research hrs because of bad weather conditions (Figure 3).

3.2 Narrative, and summary of sighting and experiments

Tabulations of cruise itinerary, ship time, trackline WPs, area codes, leg number codes, search effort, and sightings recorded in the research area by species and by survey modes are presented in Tables 1a-1e and 2a, respectively. Table 2b summarises all sightings observed throughout the cruise including those recorded during transit to and from the research area. Table 2c shows the identification of duplicate sightings observed when surveying in IO mode. Table 3 shows the sea surface temperature (minimum, maximum and range) for species sighted in the research area and provides quartile analysis for species sighted on multiple occasions. Table 4a show the summary of the number of biopsy samples collected by each species. Table 4b shows the summary of photographed sightings with Photo-ID results for individuals. Tables 4c to 4g summarise blue, fin, sei, Bryde's and killer whale sightings, photography and biopsy effort during the cruise. Tables 5 provides sighting-specific details for photographed sightings and biopsy results. Table 6 shows the summary of marine debris observations during the cruise. Table 7 shows the summary of the feasibility experiment of dive behavior tagging.

Figure 1a illustrates the research area and transit between Japan and the research area. Figure 1b illustrates the pre-determined trackline design and start/end points of tracklines in the research area. Figure 1c illustrates the waypoint locations along the trackline. Figures 2a through 2e illustrate locations of the main species sighted and search effort in the research area. Figure 3 shows the breakdown of research time, in hours by effort code in the research area. Appendix A lists the ship specifications and crew list. Appendix B compares weather conditions (wind speed / visibility) in the research area among past cruises.

Transit to the research area (2–17 August)

YS2 departed the port of Shiogama on schedule at 09:20 hrs (+9:00 UTC) on 2 August. Time-zone was changed in 1-hour increments at 1:00 on 4, 6, 8, 10, 14 and 16 Augst, and the local ship time was adjusted to +15:00 UTC in the end. Air temperature ranged between 12.6˚C and 28.5˚C and sea surface temperature ranged between 10.8˚C and 23.9˚C. A total searching distance of 315.3 n.miles (NSP: 220.5 n.miles, IO: 94.8 n.miles) was surveyed. Sightings included fin (2/2), sei (2/3) and sperm (5/8) whales. A total of 5 items of marine debris was observed during the transit. The Estimated Angle and Distance Experiment was conducted on 14 August.

Research area (17 August–16 September)

17–21 August:

YS2 commenced survey at 12:43 hrs on 17 August in the research from the starting point (WP101, 45˚47.3'N 135˚00.0'W) to the northwest. Air temperature ranged between 13.8˚C and 18.2˚C and sea surface temperature ranged between 16.2˚C and 20.3˚C. A total searching distance of 375.2 n.miles (NSP: 226.6 n.miles, IO: 148.6 n.miles) was surveyed. Sightings include fin (9/12) and sperm (2/2) whales. Biopsy samples were taken from 2 fin whales while Photo-ID photographs were collected for fin whales. One dive behavior tag was attached to 1 fin whale. No marine debris was observed in this period.

22–28 August:

YS2 continued the research area survey. YS2 arrived at WP109 (55˚53.4'N 141˚38.4'W) at 13:50 hrs on 25 August and completed the first northwestward trackline. YS2 continued surveying southwestward from WP110 (55˚58.3'N 141˚44.7'W) at 14:25 hrs on 25 August. Water depths along the tracklines were deep (over 3,000 meters). Air temperature ranged from 14.8˚C to 19.9˚C, and sea temperature ranged between 13.0˚C and 13.8˚C. Time-zone was changed in 30-minutes decrement at 1:00 on 27 August, and the local ship time was adjusted to +14:30 UTC. Wind speeds were mostly moderate (ca., wind speed 10–15 knots). YS2 was in drifting for most of the day on 26 August and for the entire day on 28 August due to bad weather conditions (fog, rain, strong wind and high seas). A total searching distance of 303.8 n.miles (NSP: 130.8 n.miles, IO: 173.0 n.miles) was surveyed in acceptable weather condition. Sightings included blue (4/4), fin (42/67), sperm (1/1) and killer (1/4) whales. Biopsy samples were taken from 3 blue, 6 fin and 1 killer whales while Photo-ID photographs were collected for the same species. One dive behavior tag was attached to 1 fin whale. No marine debris was observed in this period.

29 August–4 September:

YS2 continued the research area survey. Water depths along the tracklines were deep (over 3,000 meters). Air temperature ranged from 14.7˚C to 18.2˚C, and sea temperature ranged between 12.7˚C and 14.1˚C. Time-zone was changed in 30-minutes decrement at 1:00 on 4 September, and the local ship time was adjusted to +14:00 UTC. YS2 was in drifting for four days (29 August, and 1, 2 and 4 September) because of bad weather (e.g., fog, rain, strong wind and high seas) associated with moving low-pressure systems from west to east over the research area. The survey on

the rest of days were mostly conducted in moderate weather conditions (e.g., wind speed less than 15 knots). A total searching distance of 184.7 n.miles (NSP: 103.1 n.miles, IO: 81.6 n.miles) was surveyed in acceptable weather condition. Planned tracklines and searching effort are shown in Fig. 1. Sightings include blue (2/3), fin (24/31), sei (16/30) and sperm (2/2) whales. Biopsy samples were taken from 1 fin and 2 sei whales while Photo-ID photographs were collected for the blue, fin and sei whales. Dive behavior tags were attached to 1 fin and 1 sei whales. No marine debris was observed in this period.

5–11 September:

YS2 continued the research area survey. Water depths along the tracklines were deep (over 3,000 meters). Air temperature ranged from 16.3˚C to 20.1˚C, and sea temperature ranged between 14.7˚C and 19.6˚C. YS2 was in drifting on 9 and 10 September because of bad weather conditions (e.g., rain, strong wind and high seas) associated with moving low-pressure systems from west to east over the research area. Weather conditions were moderate for the rest of the days. A total searching distance of 325.0 n. miles (NSP: 163.9 n.miles, IO: 161.1 n.miles) was surveyed in acceptable weather condition. Sightings include fin (1/2), sei (7/7) Bryde's (5/5) and sperm (1/1) whales. Biopsy samples were taken from 2 sei and 1 Bryde's whales while Photo-ID photographs were collected for the fin, sei and Bryde's whales. Dive behavior tags were attached to 1 sei whales. A total of 2 marine debris was observed in this period. The distance and angle estimation experiment was successfully conducted on 7 September.

12–16 September:

YS2 continued the research area survey by 16 September. YS2 arrived at the southernmost waypoint, WP124 (40˚00.0'N 151˚42.5'W), at 13:06 hrs on 13 September. YS2 finished the research area survey at the last waypoint, WP128 (44˚57.8'N 155˚00.0'W), at 13:54 hrs on 16 September. Water depths along the tracklines were deep (over 3,000 meters). Air temperature ranged from 16.7˚C to 24.3˚C, and sea temperature ranged between 15.8˚C and 22.3˚C. The research area survey was mostly conducted in moderate weather conditions (e.g., wind speed less than 15 knots) although it was occasionally interrupted by bad visibility due to fogs and strong wind. A total searching distance of 373.9 n. miles (NSP: 209.4 n. miles, IO: 164.5 n. miles) was surveyed in acceptable weather condition. Sightings include fin (1/1), Bryde's (15/17) and sperm (4/4) whales. A biopsy sample was taken from 1 Bryde's whales while Photo-ID photographs were collected for the fin and Bryde's whales. A total of 81 marine debris was observed in this period.

Transit to Shiogama (16–30 September)

YS2 departed from westernmost waypoint of the research area (WP128, 44˚57.8'N 155˚00.0'W) at 13:54 hrs on 16 September and started the transit. No sighting effort was allocated during the transit. Time-zone was changed in 1-hour decrement at 1:00 on 18, 20, 22, 24 and 25 September, and the local ship time was adjusted to +9:00 UTC (i.e,. JST) in the end. The vessel arrived at Port of Shiogama on schedule at 8:30 hrs, 30 September.

3.3 Sighting and experiment information by each whale species

Blue whale (*Balaenoptera musculus*)

A total of 6 schools (7 individuals) of blue whales were sighted (Tables 2a and 2b). Blue whales were mainly distributed in the northern part of the research area (Figure 2a). Sea surface temperatures of the sighting positions were between 12.7˚C and 13.6˚C (25th to 75th quartiles: 13.1–13.4˚C) (Table 3). Photo-ID photographs were taken for 7 indivisuals and biopsy samples were collected from 3 individuals (Table 4c).

Fin whale (*Balaenoptera physalus*)

A total of 79 schools (115 individuals, including 4 mother & calf pairs) of fin whales were sighted (Tables 2a and 2b). Fin whales were mainly distributed in the northern part of the research area (Figure 2b). Sea surface temperatures of the sighting positions were between 12.7°C and 19.7°C (25th to 75th quartiles: 13.3–13.6˚C) (Table 3). Photo-ID photographs were taken for 31 individuals and biopsy samples were collected from 9 individuals (Table 4d).

Sei whale (*Balaenoptera borealis*)

A total of 25 schools (40 individuals) of sei whales were sighted (Tables 2a and 2b). Sei whales were distributed in mid-latitudes of the research area (Figure 2c). Sea surface temperatures of the sighting positions were between 13.0°C and 16.1°C (25th to 75th quartiles: 13.5–14.8˚C) (Table 3). Photo-ID photographs were taken for 15 individuals and biopsy samples were collected from 4 individuals (Table 4e).

Bryde's whale (*Balaenoptera edeni*)

A total of 20 schools (22 individuals, including 1 mother & calf pair) of Bryde's whales were sighted (Tables 2a and 2b). Bryde's whales were distributed in the southern part of the research area (Figure 2d). Sea surface temperatures of

the sighting positions were between 17.4°C and 21.3°C (25th to 75th quartiles: 19.4–20.6˚C) (Table 3). Photo-ID photographs were taken for 13 individuals and biopsy samples were collected from 2 individuals (Table 4f).

Sperm whale (*Physeter macrocephalus*)

A total of 19 schools (22 individuals) of sperm whales were sighted (Tables 2a and 2b). Sperm whales were widely distributed in the research area (Figure 2e). Sea surface temperatures of the sighting positions were between 12.7°C and 20.0°C (25th to 75th quartiles: 14.7–19.3˚C) (Table 3). Neither photo-ID nor biopsy samples were collected.

Killer whale *(Orcinus Orca)*

A total of 1 school (4 individuals) of killer whales were sighted in the northern part of the research area with sea surface temperature 13.1˚C (Tables 2a, 2b and 3). Killer whales were distributed in the northern part of the research area (Figure 2e). Photo-ID photographs were taken for 3 individuals and biopsy samples were collected from 1 individuals (Table 4g).

3.4 Resighting During IO Mode

Resight data were recorded for a total of 108 sightings during IO Mode. Table 2c shows the identification of duplicate sightings observed during survey in IO mode. Duplicate status was based on the number of sightings made by the Independent Observer Platform (IOP) that also were observed by the Topmen in the Standard TOP Barrel. For blue whales, there were 6 school sightings made by TOP and IOP and 2 schools made by IOP. A breakdown of the numbers of the 2 schools include 2 “Definite duplicate”. For fin whales, there were 60 school sightings made by TOP and IOP and 26 schools made by IOP. A breakdown of the numbers of the 26 schools include 23 “Definite duplicate” and 3 “Not duplicate”. For sei whales, there were 12 school sightings made by TOP and IOP and 6 schools made by IOP. A breakdown of the numbers of the 6 schools sighted by IOP include 4 “Definite duplicate”, and 2 “Not duplicate”. For Bryde’s whales, there was 14 school sighting made by TOP and IOP and 8 school made by IOP. A breakdown of the numbers of the 8 schools include 5 “Definite duplicate” and 3 “Not duplicate”. For sperm whales, there were 8 school sightings made by TOP and IOP and 4 schools made by IOP. A breakdown of the numbers of the 4 schools include 4 “Definite duplicate”.

4. RESULT OF EXPERIMENTS

4.1 Estimated Angle and Distance Experiment

4.1.1 Training Exercise

The Estimated Angle and Distance Training Exercise was conducted on 14 August for a total duration of 4 hours 2 minutes whilst in the transit. During the exercise, observers familiarised themselves with distance estimates from the top barrel and upper bridge.

4.1.2 Experiment

The Estimated Angle and Distance Experiment was conducted on 7 September for 6 hours 40 minutes whilst in the research area. A total of 84 trials (12 trials/set times 7 sets) were conducted for each platform (TOP and IO barrels and upper bridge). Details of the results will be analysed and reported to the TAG after the conclusion of the cruise.

4.2 Biopsy sampling

Biopsy samples were collected for 19 individual whales: 3 blue, 9 fin, 4 sei, 2 Bryde’s and 1 killer whales (Table 4a and c-g). All individual biopsies were cut in half on board. All biopsy samples were catalogued and stored in cryo-vials frozen at a temperature of -30ºC on the vessel. All biopsy samples collected in the cruise were sent to ICR after arrival at Shiogama, Japan under the responsibility of the CL. This provided two equivalent biological samples for separate analysis at the respective laboratories noted above. Samples for IWC will be sent to the SWFSC laboratory as soon as possible from ICR under the responsibility of a ICR genetic scientist (Taguchi). The samples will be transported to SWFSC legally after the cruise under Matsuoka’s supervision, under the CITES Japan Management Authority, the Office of Trade Licensing for Wild Animals and Plants, METI.

Biopsy duration times were evaluated to examine biopsy efficiency. Success rates for each species were 60.0% (n=5) for blue, 47.4% (n=19) for fin, 80.0% (n=5) for sei, 50.0% (n=4) for Bryde’s and 50.0% (n=2) for killer whales. Median time of biopsy effort duration from setup to sample retrieval when sampling each species was 44 minutes for blue, 21 minutes for fin, 12 minutes for sei, 12 minutes for Bryde’s, and 4 minutes for killer whales. Biopsy sampling was attempted as often as time permitted under acceptable weather conditions.

4.3 Photo-ID data collection

Six different photo-ID species were photographed during the 2021 IWC-POWER. A total of 131 schools were approached close enough to obtain photo-identification images. Of those, 69 were photo-identified within schools; not all have been inter-matched to check for duplicates. Photo-ID species encountered included: blue (6 schools approached / 7 individuals photo-ID'd), fin (79/31), sei (25/15), Bryde's (20/13) and killer (1/3) whales (Tables 4b, 4c-h and 5) .

Images collected during the cruise were uploaded to the IWC master photographic database in Adobe Lightroom (LR). Preliminary coding was completed for all cetacean images, including the allocation of species name, sighting number, school size and biopsy effort. Full coding involved analysing each image in LR for various health, behaviour and unique identification parameters, which were written to the image metadata as keywords.

Star ratings will be allocated for image quality and colours will be assigned for photo-identification purposes. Photo-identification results are preliminary and subject to change after further processing by catalogue curators. Images will be made available for incorporation into respective catalogues.

4.4. Video-recording

85 separate video clips (30 schools) were recorded for a total time of 01:30:44, including 00:25:46 of blue (6 schools), 0:27:32 of fin (12 schools), 00:30:35 of sei (7 schools), 00:05:38 of Bryde's (4 schools), and 00:01:13 of killer (1 schools) whales surfacing and experiment events.

4.5 Acoustic data collection

No acoustic data were collected in this cruise.

4.6 Marine debris observations

A total of 88 marine debris objects were recorded "on effort" (Table 6).

4.7 Other

Results of feasibility experiment of dive behavior tagging are shown in Appendix C.

9. OTHER TECHNICAL MATTERS AND RECOMMENDATIONS

9.1 Stratification of the research area

The 2021 IWC-POWER was conducted from the middle of August to the middle of September which was assumed to be the end of their northbound migration season. It covered three different waters: subarctic and subtropical waters, and the transition zone between them (subarctic–subtropical transition zone). It appeared that distributions of four baleen whale species were related to these waters: blue and fin whales in the subarctic water, sei whales in the transition zone and Bryde's whales in the subtropical water. Allocation of the planned tracklines in each water zone was apparently limited in this cruise given the size of the survey area. It is **recommended** that the survey designers reconsider the survey timing and stratification of the research areas when formulating a medium-term plan, taking into account the objectives, target species, season, oceanography and the past results of the IWC-POWER cruises. In 68C IWC/SC, it was pointed out that the research area of the 2021 IWC-POWER might be too large to obtain a good estimate given the number of days available (IWC, 2021c).

9.2 Schedule of the survey

Initially, there was an option that YS2 called to Kodiak, US for refuelling and joining/leaving researchers (IWC, 2021b). However, it was decided that the 2021 IWC-POWER would be conducted for 60 days without refuelling considering the COVID-19 pandemic situation at the time of departure from Japan. This decision limited the total research days to 30 days. Furthermore, YS2 reduced the ship's research speed to 10.5 knots to conserve fuel although it was in the range of accepted speed for the sighting survey. Reducing the ship's speed affected the total searching distance. It was **recommended** that port calls outside of Japan should made in the future survey to maximize survey effort in the research area if the situations allow. This consideration is especially important when the research area is considerably distant from Japan.

9.3 Photographic database processing in Lightroom (LR)

As in the case of 2021 cruise, images collected during the cruise were uploaded to LR and preliminarily coded. By processing images directly in LR, post-cruise processing time is greatly reduced. Furthermore, it allows for real-time photo-analysis summaries and expedites image access/sharing. It is **recommended** that researchers on future cruises continue LR processing. However, processing images would overwhelm researchers if a large number of images are taken in a high-speed consecutive shot mode. It is **recommended** that photographers try to take only "high-quality

images" as much as possible to minimize number of images for LR processing. It is **recommended** that guidance documents specific for photo-processing during the cruise and the IWC LR Photographic Database Manual are kept up-to-date and that hard and electronic copies are made available on future cruises. It is **recommended** that newest version of LR at the beginning the survey is installed on the IWC-POWER laptop with an up-to-date catalogue prior to future IWC-POWER cruises. It is **recommended** that the IWC secretariat holds a workshop of LR for researchers in advance of each cruise so that database manager and researchers can have mutual understanding on management of images in LR.

9.4 Camera equipment

A Canon EOS 5D Mark II camera with 100-400 mm lens (courtesy of SWFSC) was used as one of the primary cameras for photo-identification during the 2021 IWC-POWER survey. However, because it was identified that the SWFSC's lens was not functioned properly, the ICR's lens was used in conjunction with the SWFSC's camera. It is **recommended** that the cameras be carefully checked well before the survey.

9.5 Assessment of feasibility of photo identification for fin, sei and Bryde's whales

Target species for photo-ID are North Pacific right, blue, gray and humpback whales although photos of all other species were obtained opportunistically. Generally, it is believed that photo identifications of fin, sei and Bryde's whales are extremely difficult one because they do not have unique features for the identifications and the other because matching is difficult considering their abundance. Their photos have taken since the beginning of this programme without assessment of the feasibility. It is **recommended** that the feasibility of their photo identifications be assessed before continuing this practice in the future cruises. This is also important consideration on workload of researchers.

10. CONCLUSIONS

The 12th annual IWC-POWER cruise was successfully conducted using the Japanese R/V *Yushin-Maru No.2* under approved international status. The crews and researchers successfully prevented COVID-19 infection with appropriate measures (e.g., measurement of body temperature and wearing surgical masks). Shiogama was used for shipping, refuelling and boarding of international researchers. All equipment and survey methods were consistent with previous IWC international cetacean sighting surveys. Sighting procedures were in accordance with guidelines agreed upon by the IWC/SC. Survey objectives, methods and procedures were discussed and agreed upon by the Captain, officers, crew and international researchers prior to survey operations. Throughout the cruise, all participants worked collaboratively to meet overall research objectives. Data collected, including sighting records, photographic, video data and biopsy samples have been provided to the IWC secretariat by the Chair of the steering group (Matsuoka) and confirmed on 15 December 2021. This cruise provides critical information on the distribution, abundance and stock structure of large whales which will contribute to an improved understanding of species/population movements in areas of the North Pacific where there has been little to no survey effort in recent decades. These results contribute to the objectives of IWC-POWER and whale management research in near future.

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Tables and Figures

Table 1a. The 2021 cruise itinerary of the 2021 IWC-POWER.

Date (UTC) y/m/d	Time (UTC)	Date (SMT) y/m/d	Time (SMT)	Area code	Ttack Line	Leg No	Position		Remark
2021/8/2	0:20	2021/8/2	9:20	-	-	-	-	-	Departed Shiogama Japan
2021/8/2	21:00	2021/8/3	6:00	1	1	001	39° 24.2'N	145° 30.5'E	Started transit survey to Research Area (R.A).
2021/8/16	21:43	2021/8/17	12:43	1	1	001	45° 47.1'N	135° 00.3'W	Finished transit survey to R.A.
2021/8/16	21:43	2021/8/17	12:43	84	1	101	45° 47.1'N	135° 00.3'W	Started R.A between longitude 150°W and 135°W
2021/9/11	0:27	2021/9/11	14:27	84	1	121	43° 06.2'N	150° 00.0'W	Finished R.A between longitude 150°W and 135°W
2021/9/11	0:27	2021/9/11	14:27	85	1	121	43° 06.2'N	150° 00.0'W	Started R.A between longitude 155°W and 150°W
2021/9/15	23:54	2021/9/16	13:54	85	1	127	44° 57.9'N	155° 00.0'W	Finished R.A between longitude 155°W and 150°W
2021/9/15	23:54	2021/9/16	13:54	2	1	002	44° 57.9'N	155° 00.0'W	Started transit survey from R.A to Shiogama
2021/9/28	3:00	2021/9/28	12:00	2	1	002	38° 31.1'N	144° 51.5'E	Finished transit survey from R.A to Shiogama
2020/9/29	23:15	2021/9/30	8:15	-	-	-	-	-	Arrived Shiogama Japan

Table 1b. Summary of the “Ship's Time Adjustment” Schedule during the 2021 IWC-POWER. JST: Japan time.

Date	Ah'd/Ab'k	Balance	Ship's time	Remarks
2021/8/2	-	UTC+9.0h	JST	Departed Japan (Shiogama)
2021/8/4	Ah'd 1hour	UTC+10.0h	JST+1.0h	-
2021/8/6	Ah'd 1hour	UTC+11.0h	JST+2.0h	-
2021/8/8	Ah'd 1hour	UTC+12.0h	JST+3.0h	-
2021/8/10	Ah'd 1hour	UTC+13.0h	JST+4.0h	-
2021/8/14	Ah'd 1hour	UTC+14.0h	JST+5.0h	-
2021/8/16	Ah'd 1hour	UTC+15.0h	JST+6.0h	-
2021/8/27	Ab'k 0.5hour	UTC+14.5h	JST+5.5h	-
2021/9/4	Ab'k 0.5hour	UTC+14.0h	JST+5.0h	-
2021/9/18	Ab'd 1hour	UTC+13.0h	JST+4.0h	-
2021/9/20	Ab'd 1hour	UTC+12.0h	JST+3.0h	-
2021/9/22	Ab'd 1hour	UTC+11.0h	JST+2.0h	-
2021/9/24	Ab'k 1hour	UTC+10.0h	JST+1.0h	-
2021/9/25	Ab'k 1hour	UTC+9.0h	JST	-
2021/9/30	-	UTC+9.0h	JST	Arrived Japan (Shiogama)

Table 1c. Way Points (WP) and each survey mode in the 2021 IWC-POWER research area. See also Figure1c.

WP	Latitude	Longitude	Course	Distance (n.mile)	Mode
101	45°47.3'N	135°00.0'W	338°	82.0	NSP
102	47°03.2'N	135°45.4'W	338°	81.9	IO
103	48°19.0'N	136°31.9'W	338°	82.1	NSP
104	49°34.9'N	137°19.6'W	338°	82.0	IO
105	50°50.7'N	138°08.5'W	338°	82.0	NSP
106	52°06.5'N	138°58.8'W	338°	82.0	IO
107	53°22.3'N	139°50.5'W	338°	82.0	NSP
108	54°38.1'N	140°43.8'W	338°	81.5	IO
109	55°53.4'N	141°38.4'W	-	-	OE
110	55°58.3'N	141°44.7'W	202°	74.0	NSP
111	54°49.9'N	142°34.4'W	202°	73.9	IO
112	53°41.6'N	143°22.8'W	202°	74.0	NSP
113	52°33.2'N	144°09.9'W	202°	74.0	IO
114	51°24.8'N	144°55.8'W	202°	74.0	NSP
115	50°16.4'N	145°40.5'W	202°	74.1	IO
116	49°07.9'N	146°24.2'W	202°	74.0	NSP
117	47°59.5'N	147°06.9'W	202°	74.0	IO
118	46°51.0'N	147°48.6'W	202°	74.0	NSP
119	45°42.5'N	148°29.5'W	202°	73.9	IO
120	44°34.1'N	149°09.6'W	202°	74.0	NSP
121	43°25.6'N	149°48.9'W	202°	74.1	IO
122	42°17.0'N	150°27.4'W	202°	74.0	NSP
123	41°08.5'N	151°05.3'W	202°	74.0	IO
124	40°00.0'N	151°42.5'W	334°	83.0	NSP
125	41°14.7'N	152°30.6'W	334°	83.0	IO
126	42°29.4'N	153°19.6'W	334°	83.0	NSP
127	43°44.1'N	154°09.6'W	334°	81.9	IO
128	44°57.8N	155°00.0'W	-	-	-
			Total	**2,022.4**	

Table 1d. List of area code and leg number code used for the effort record during the 2021 IWC-POWER.

Area Code	Definition
1	Transit survey from Shiogama to research area
84	Research area between longitude 150°W and 135°W (original track)
85	Research area between longitude 155°W and 150°W (original track)
2	Transit survey from research area to Shiogama

Leg.No	Definition
001	Transit survey from Shiogama to research area (WP101)
101-127	Research area (original track line)
002	Transit survey from research area (WP128) to Shiogama
999	Off-effort transit from WP109 to WP110

Table 1e. Summary of the searching effort (time and distance) and experimental time (hours) by each survey with the area code conducted during the 2021 IWC-POWER.

Area	Area Code	Leg No.	Start	End	NSP		IO		NSP+IO		Photo-ID, Biopsy, TDR tag	Estimated angle and distance training / experiment
		Start	Date	Date	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time	Time
		End	Time	Time								
Shiogama to R.A (Leg 001)	1	001	3-Aug.	17-Aug.	21:27:12	220.46	9:14:01	94.78	30:41:13	315.24	0:00:00	4:02:11
	High Sea	-	6:00	12:43								
Research Area (between 150°W and 135°W)	84	101	17-Aug.	11-Sep.	59:04:25	624.30	52:33:36	552.83	111:38:01	1177.13	14:08:44	6:40:47
	High Sea	121	12:43	14:27								
Research Area (between 155°W and 150°W)	85	121	11-Sep.	16-Sep.	19:45:13	209.44	16:26:07	175.99	36:11:20	385.43	0:24:46	0:00:00
	High Sea	127	14:27	13:54								
R.A to Shiogama (Leg 002)	2	002	16-Sep.	28-Sep.	0:00:00	0.00	0:00:00	0.00	0:00:00	0.00	0:00:00	0:00:00
	High Sea	-	13:54	12:00								
Total			3-Aug.	28-Sep.	100:16:50	1,054.20	78:13:44	823.60	178:30:34	1,877.80	14:33:30	10:42:58
			6:00	12:00								

Table 2a. Number of sightings for all species observed in the research area (Original tracklines) by effort mode during the 2021 IWC-POWER. NSP: Normal Passing with abeam closing Mode; IO: Independent Observer Mode (IO), OE: Top down (TD) and drifting (DR). Numbers of Individuals includes the number of calves.

Species	NSP			IO			OE			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Blue whale	2	3	0	4	4	0	0	0	0	6	7	0
Fin whale	39	58	1	37	54	3	1	1	0	77	113	4
Like fin whale	0	0	0	1	1	0	0	0	0	1	1	0
Sei whale	14	26	0	8	10	0	1	1	0	23	37	0
Like sei whale	1	2	0	0	0	0	0	0	0	1	2	0
Bryde's whale	11	13	1	9	9	0	0	0	0	20	22	1
Sperm whale	9	9	0	5	5	0	0	0	0	14	14	0
Baird's beaked whale	1	3	0	0	0	0	0	0	0	1	3	0
Ziphiidae	1	2	0	3	6	0	0	0	0	4	8	0
Killer whale	1	4	0	0	0	0	0	0	0	1	4	0
Striped dolphin	0	0	0	1	74	0	0	0	0	1	74	0
Common dolphin	1	84	2	3	410	8	0	0	0	4	494	10
Pacific white-sided dolphin	3	85	3	1	157	7	0	0	0	4	242	10
Northen right whale dolphin	1	107	4	0	0	0	0	0	0	1	107	4
Dalli type Dall's porpoise	10	55	0	5	42	0	0	0	0	15	97	0
Unid. type Dall's porpoise	3	11	0	2	2	0	0	0	0	5	13	0
Unid. dolphin	2	13	0	0	0	0	0	0	0	2	13	0
Unid. small cetacean	1	1	0	1	1	0	0	0	0	2	2	0
Unid. cetacean	2	2	0	3	3	0	0	0	0	5	5	0
Unid. large baleen whale	7	7	0	5	6	0	0	0	0	12	13	0

Table 2b. Number of sightings for all species observed during the entire 2021 IWC-POWER. Numbers of Individuals includes number of calves.

Species	Transit to research area (All High-Sea, area code 1, leg 001)			Research Area, between longitude 150°W and 135°W (All High Sea, area code 84)			Research Area, between longitude 155°W and 150°W (All High Sea, area code 85)			Transit to Shiogama (All High Sea, area code 2, leg 002)			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Blue whale	0	0	0	6	7	0	0	0	0	0	0	0	6	7	0
Fin whale	2	2	0	76	112	4	1	1	0	0	0	0	79	115	4
Like fin	8	8	0	1	1	0	0	0	0	0	0	0	9	9	0
Sei whale	2	3	0	23	37	0	0	0	0	0	0	0	25	40	0
Like sei	15	21	0	1	2	0	0	0	0	0	0	0	16	23	0
Bryde's whale	0	0	0	2	2	0	18	20	1	0	0	0	20	22	1
Like minke	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0
Sperm whale	5	8	0	6	6	0	8	8	0	0	0	0	19	22	0
Baird's beaked whale	0	0	0	1	3	0	0	0	0	0	0	0	1	3	0
Ziphiidae	0	0	0	2	6	0	2	2	0	0	0	0	4	8	0
Killer whale	0	0	0	1	4	0	0	0	0	0	0	0	1	4	0
Striped dolphin	0	0	0	0	0	0	1	74	0	0	0	0	1	74	0
Common dolphin	0	0	0	1	16	2	3	478	8	0	0	0	4	494	10
Pacific white-sided dolphin	1	23	2	4	242	10	0	0	0	0	0	0	5	265	12
Northern right whale dolphin	0	0	0	1	107	4	0	0	0	0	0	0	1	107	4
Dalli type Dall's porpoise	5	38	0	15	97	0	0	0	0	0	0	0	20	135	0
Unid.type Dall's porpoise	5	19	0	5	13	0	0	0	0	0	0	0	10	32	0
Unid. dolphin	1	45	0	2	13	0	0	0	0	0	0	0	3	58	0
Unid. cetacean	0	0	0	3	3	0	2	2	0	0	0	0	5	5	0
Unid. large baleen whale	10	15	0	10	11	0	2	2	0	0	0	0	22	28	0
Unid. small cetacean	0	0	0	1	1	0	1	1	0	0	0	0	2	2	0
Total	**55**	**183**	**2**	**161**	**683**	**20**	**38**	**588**	**9**	**0**	**0**	**0**	**254**	**1,454**	**31**

Table 2c. Identification of duplicate sightings (main species) observed during survey in Independent Observer (IO) mode (original trackline) during the 2021 IWC-POWER. Duplicate status was based on the number of sightings made by the Independent Observer Platform (IOP) that were observed also by the Topmen in the Standard TOP Barrel. Status codes: D - Definite duplicate, P - Possible duplicate, R - Remote duplicate, N - Not duplicate.

Species	Number of all schools sighted made by TOP & IOP	Number of schools made by IOP	Duplicate Status			
			D	P	R	N
Blue whale	6	2	2	0	0	0
Fin whale	60	26	23	0	0	3
Sei whale	12	6	4	0	0	2
Bryde's whale	14	8	5	0	0	3
Sperm whale	8	4	4	0	0	0

Table 3. Minimum, maximum range, and 25th to 75th quartiles of sea surface temperatures in degrees Celsius for each species sighted in the 2021 IWC-POWER research area (original trackline). Also noted are the number of sightings for each species.

Species	Number of sightings	Minimum SST	Maximum SST	Temperature range	25th to 75th Quartile
Blue whale	6	12.7	13.6	0.9	13.1–13.4
Fin whale	77	12.7	19.7	0.5	13.3–13.6
Sei whale	23	13.0	16.1	3.1	13.5–14.8
Bryde's whale	20	17.4	21.3	3.9	19.4–20.6
Sperm whale	14	12.7	20.0	7.3	14.7–19.3
Killer whale	1	13.1	-	-	-
Common dolphin	4	18.1	20.2	2.1	19.2–19.8
Pacific white-sided dolphin	4	13.6	18.1	4.5	13.8–15.7
Ziphiidae	4	13.0	20.6	7.6	13.7–20.0
Dalli type Dall's porpoise	15	12.8	14.8	2.0	13.3–13.8

Table 4a. Summary of the number of biopsy samples collected by each species in the 2021 IWC-POWER.

Biopsy samples	Blue	Fin	Sei	Bryde's	Humpback	Killer	Total
Transit from Japan to Research Area (All High Sea, area code 1)	0	0	0	0	0	0	0
R.A between longitude 150°W and 135°W (All High Sea, area code 84)	3	9	4	1	0	1	18
R.A between longitude 155°W and 150°W (All High Sea, area code 85)	0	0	0	1	0	0	1
Transit from Research Area to Japan (All High Sea, area code 2)	0	0	0	0	0	0	0
Total	**3**	**9**	**4**	**2**	**0**	**1**	**19**

Table 4b. Summary of the number of Photo-ID'd individuals by each species in the 2021 IWC-POWER.

Photo-ID	Blue	Fin	Sei	Bryde's	Killer	Total
Transit from Japan to Research Area (All High Sea, area code 1)	0	0	0	0	0	0
R.A between longitude 150°W and 135°W (All High Sea, area code 84)	7	31	15	2	3	58
R.A between longitude 155°W and 150°W (All High Sea, area code 85)	0	0	0	11	0	11
Transit from Research Area to Japan (All High Sea, area code 2)	0	0	0	0	0	0
Total	**7**	**31**	**15**	**13**	**3**	**69**

Table 4c. Summary of blue whale sightings, photography (unique individuals) and biopsy effort in the 2021 IWC-POWER.

Blue whale	Total Sightings		Ind.	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.	Biopsy			
Transit from Shiogama to Research Area (High Sea)	0	0	0	0	0	0
R.A between longitude 150°W and 135°W (High Sea)	6	7	3	6	7	7
R.A between longitude 155°W and 150°W (High Sea)	0	0	0	0	0	0
Transit from Research Area to Shiogama (High Sea)	0	0	0	0	0	0
Total	**6**	**7**	**3**	**6**	**7**	**7**

Table 4d. Summary of fin whale sightings, photography (unique individuals) and biopsy effort in the 2021 IWC-POWER.

Fin whale	Total Sightings		Ind.	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.	Biopsy			
Transit from Shiogama to Research Area (High Sea)	2	2	0	0	0	0
R.A between longitude 150°W and 135°W (High Sea)	76	112	9	29	42	31
R.A between longitude 155°W and 150°W (High Sea)	1	1	0	1	0	0
Transit from Research Area to Shiogama (High Sea)	0	0	0	0	0	0
Total	**79**	**115**	**9**	**30**	**42**	**31**

Table 4e. Summary of sei whale sightings, photography (unique individuals) and biopsy effort in the 2021 IWC-POWER.

Sei whale	Total Sightings		Ind.	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.	Biopsy			
Transit from Shiogama to Research Area (High Sea)	2	3	0	0	0	0
R.A between longitude 150°W and 135°W (High Sea)	23	37	4	12	15	15
R.A between longitude 155°W and 150°W (High Sea)	0	0	0	0	0	0
Transit from Research Area to Shiogama (High Sea)	0	0	0	0	0	0
Total	**25**	**40**	**4**	**12**	**15**	**15**

Table 4f. Summary of Bryde's whale sightings, photography (unique individuals) and biopsy effort in the 2021 IWC-POWER.

Bryde's whale	Total Sightings		Ind.	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.	Biopsy			
Transit from Shiogama to Research Area (High Sea)	0	0	0	0	0	0
R.A between longitude 150°W and 135°W (High Sea)	2	2	1	2	2	2
R.A between longitude 155°W and 150°W (High Sea)	18	20	1	13	13	11
Transit from Research Area to Shiogama (High Sea)	0	0	0	0	0	0
Total	**20**	**22**	**2**	**15**	**15**	**13**

Table 4g. Summary of killer whale sightings, photography (unique individuals) and biopsy effort in the 2021 IWC-POWER.

Killer whale	Total Sightings		Ind.	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.	Biopsy			
Transit from Shiogama to Research Area (High Sea)	0	0	0	0	0	0
R.A between longitude 150°W and 135°W (High Sea)	1	4	1	1	4	3
R.A between longitude 155°W and 150°W (High Sea)	0	0	0	0	0	0
Transit from Research Area to Shiogama (High Sea)	0	0	0	0	0	0
Total	**1**	**4**	**1**	**1**	**4**	**3**

Table 5. Summary of photographed whale sightings with information on photo-identification, biopsy sampling and the attachment of Time and Depth Recording (TDR) satellite tags in the 2021 IWC-POWER. TDR tags also record the whale's location over time.

Sighting Number: daily cetacean sighting number. **School Size:** number of whales grouped together and encountered by the ship during the sighting. **Photographed**: number of whales photographed in the group**. Photo-Identified**: number of whales photographed in the group and showing good features for potential photo-identification study. **Letter(s) of Whale(s) Photo-Identified:** unique letter assigned to a photographed whale that presents photo-identifiable features. **ID features**: identification morphology i.e., **DF**=Dorsal Fin, **FL** = Flukes, **LD** = Left DF, **RD** = Right DF, **HD** = Head and/or Rostral photo. **Photographs**: initials of the photographer and the numerical series of photographs taken for the whale sighting. Photographs are also catalogued with the IWC using the Adobe Lightroom software application. **Biopsied**: the number of whales in the group that were biopsied for DNA analysis**. Letter of Biopsied Whale**: unique letter assigned to a biopsied whale. **ID Form Number**: Identification Form Number continuous for the annual survey. **Biopsy Form number**: Biopsy Form Number continuous for the annual survey. **Biopsy Sample Number**: Year (2021), Species code (e.g., Fin whale is "05") and Ship code (YS2) identifying the biopsy biological sample. **Encounter Duration (mins):** The ship's encounter duration in minutes with the whale(s) for the purpose of taking photographs and biopsy samples and the attachment of satellite tags. **Photo-Identification Notes:** All other information/observations associated with the sighting.

Survey Date (Y/M/D)	Sighting Number	Species Common Name	School Size	Photographed	Photo Identified	Letters of whales Photo-identified	Identification Features	Photographs	Number Biopsied	Letter of Biopsied whale	ID Form No.	BY Form No.	Biopsy Sample Number	Encounter Duration (min)	Photo-Identification Notes
2021/08/18	002	Fin Whale	1	1	1	A	RD, Medium tall DF	JWG-494-507	0	-	ID001	BY001	No sample	47	Many cookie-cutter shark scars. JWG00013 07:57 AM) Whale no.1; whale letter A
2021/08/21	003	Fin Whale	1	1	1	A	RD, LD, Medium tall DF	JWG-0551- 0610 JWG-0625- 0631	0	-	ID003	BY002	No sample	28	Many cookie-cutter shark scars, Tall erect DF.
2021/08/21	009	Fin whale	2	1	1	A	RD, Medium Tall DF	JWG-002-003	2	A & B	ID004	BY003	21051001 21051002	46	Many cookie-cutter shark scars, Tall erect DF.
2021/08/23	001	Fin whale	2	2	1	A, B	RD	JWG-0662-0669	0	-	ID008	BY004	No sample	55	Mother obviously large, Medium tall DF; Calf is small.
2021/08/23	012	Fin whale	1	1	1	A	LD	JWG-0695-0698	0	-	ID010	-	No sample	-	Many ecto-parasites on the DF, small, numerous cookie cutter shark scars on dorsum.
2021/08/23	011	Fin Whale	2	2	2	A, B	LD, RD	JWG-0700-0740	1	A	ID011	BY005	21051003	12	Tall DF, 1 DF rounded other DF more pointed, Satellite tag (TDR-005) attached.
2021/08/23	013	Fin whale	5	3	3	A, B, C	RD, LD	JWG-0752-0771	1	A	ID012	BY006	21051004	42	Chevron pattern visible, moderate number of cookie cutter scars on dorsum.
2021/08/23	015	Fin whale	2	2	2	A, B	LD, RD	JWG-781-791	0	-	ID013	-	No sample	-	"A" whale pointed DF," B" whale rounded DF with a large notch, moderate load cc shark scars.
2021/08/24	003	Fin whale	3	2	1	A, B	LD, RD	JWG-0794-0808	1	A	ID014	BY007	21051005	19	Fin, TL approx.:19.6 m, RD, Notch in DF of whale A. TL estimates approx.:19.6m,18.8m,20.4m, many cc shark scars.
2021/08/24	006	Fin whale	1	1	0	A	Dorsum	JWG-811-813	0	-	ID015	-	No sample	-	Fast moving, Fin Whale. .TL approx..:17.7m.
2021/08/24	021	Blue whale	1	1	1	A	RD, LD,FL, Flanks mottled, Gray and white mottling, small DF	JWG-816-856	0	-	ID016	BY008	No sample	45	1 Blue whale with very small dorsal fin bump (A). Unusual fluke morph: Long, thin pointed right fluke with white spot. Left fluke blunt, rounded and short. Some mottling on flanks. TL approx. 22.7 m JWG-816-856. Much time attempted for biopsy; deep diver and sun when down.
2021/08/25	012	Fin whale	4	4	4	A	RD, Dorsum	JWG-0861-0903	1	A	ID017	BY009	21051006	29	Biopsied. Moderate cookie- cutter shark bite scars.TL approx.20.6. Photo frames: JWG-0861-0903.
2021/08/25	012	Fin whale	4	4	4	B	LD, Dorsum	JWG-0861-0903	Only whale A	-	ID017	Only whale A	See above Fin Whale A	29	Erect DF, Dark, Slightly Falcate, moderate cookie-cutter shark bites. No biopsy…too fast. TL approx.:19.8 m.
2021/08/25	012	Fin whale	4	4	4	C	RD	JWG-0861-0903	Only whale A	-	ID017	Only whale A	See above Fin Whale A	29	Notch posterior of dorsal fin. Pointed shape DF, Slightly Falcate. Moderate cookie cutter shark scars..No biopsy…too fast. TL.approx.:19.7 m.

Survey Date (Y/M/D)	Sighting Number	Species Common Name	School Size	Photographed	Photo Identified	Letters of whales Photo-identified	Identification Features	Photographs	Number Biopsied	Letter of Biopsied whale	ID Form No.	BY Form No.	Biopsy Sample Number	Encounter Duration (min)	Photo-Identification Notes
2021/08/25	012	Fin whale	4	4	4	D	LD, RD,	JWG-0861-0903	Only whale A	-	ID017	Only whale A	See above Fin Whale A	29	DF strongly Falcate. Moderate cookie cutter shark scars. No biopsy…too fast. TL.approx.:18.8 m
2021/08/25	021	Blue whale	1	1	1	A	LD,RD, Fluke, Dorsum	JWG-0926-1022 96 Frames.	1	A	ID018	BY010	21061007	43	High number of cookie cutter shark bite scars. White worm-like ecto-parasites on dorsum. Brown diatoms on rostrum and around mouth and attached slightly beyond blow holes. Scarring on the DF-small hump. BW is moderately thin w/ vertebrae protruding out under skin/blubber layers.TL approx.: 23.5 m.
2021/08/25	025	Killer whale	4	4	3	A	LD	JWG-1026-1059	1	A	ID019	BY011	21271008	9	Large dominate male w/ tall triangular DF.TL approx. 6.8 m (22.31 ft.).
2021/08/25	025	Killer whale	4	4	3	B	LD	JWG-1026-1059	0	-	ID019	-	No sample	9	Mature female likely. TL approx. 6.0 m. Interesting color pattern. Tall falcate DF of mature female "B".
2021/08/25	025	Killer whale	4	4	3	C	LD	JWG-1026-1059	0	-	ID019	-	No sample	9	Smaller female; located on R side of dominate male. Color pattern interesting. TL approx.: 4.3 m. Could be an immature Male. Photos.
2021/08/25	025	Killer whale	4	4	3	D	TL approximated by the Top Man, Chief Bosun.	JWG-1026-1059	0	-	ID019	-	No sample	9	No definitive photos for the smallest Killer Whale. Viewed by JWG and the Chief Bosun. approx.: 3.8 m. (12.5 ft. Orca). Probable calf..
2021/08/27	001	Blue whale	1	1	1	A	RD, Dorsum	JWG-1071-1093	1	A	ID020	BY012	21061009	57	DF and RD photos. Small falcate DF. +14.5 UTC. Moderate number of cc shark scars.
2021/08/27	002	Fin whale	1	1	1	A	Dorsal Chevron	JWG-1096-1126	1	A	ID021	BY013	21051010	6	Fin Whale. TL approx.19.2 m. +14.5 UTC Chevron visible. Medium level of cc shark scars. Satellite Tag no. TD-006.
2021/08/27	008	Fin whale	1	1	0	-	Dorsal Chevron	JWG-1148-1156	1	A	ID022	BY014	21051011	24	TL approx.17.8 m. +14.5 UTC No DF photo.
2021/08/28	001	Fin whale	1	1	0	-	Dorsum	JWG-1164-1167	0	-	ID023	-	No sample	-	+14.5 UTC. Spent little time w/ this Fin whale. TL approx.18.9m. No DF photo.
2021/08/28	003	Blue whale	1	1	1	A	LD, RD	JWG-1170-1223	1	A	ID024	BY015	21061012	13	Highly mottled coloration, small triangular DF. TL approx.22.5 m. Medium level of cookie cutter shark scars. Frames.
2021/08/30	007	Blue whale	2	2	2	A & B	LD, RD	JWG-1240-1324	0	-	ID025	-	No sample	-	Both BW's w/ small Falcate DF's. No flukes up. Lg. swell; no Biopsy or Tag effort.
2021/08/30	013	Fin whale	1	1	1	A	LD, HD	JWG-1335-1337	0	-	ID026	-	No sample	-	No Biopsy or Sat. tag due to large swell. DF notch good for ID. Tall Falcate DF. UTC+14.5 hrs. TL approx. 18.4 m.
2021/08/31	001	Fin whale	1	1	1	A	RD	JWG-1340-1360	0	-	ID027	BY016	No sample	40	Some cookie cutter shark scars; none fresh. Tall rounded DF with scalloped looking posterior edge TL approx.: 17.6m. UTC+14.5. No biopsy.
2021/08/31	003	Sei whale	1	1	1	A	LD, RD	JWG-1371-1397	1	A	ID028	BY017	21041013 (A)	52	High level of cc shark scars; none fresh. Tall triangular DF, black coloration on DF. Biopsied and TDR (TD-007) satellite tagged.TL approx.:14.3m.
2021/08/31	005	Blue whale	1	1	1	A	LD, RD, HD	JWG-1405-1494	0	-	ID029	BY018	No sample	61	Black spot on Dorsal Fin Medium level of cookie cutter shark scars. None fresh. Vertebrae protruding up below blubber and skin levels.TL.approx.18.2m. Fast moving whale; no biopsy.
2021/08/31	011	Fin whale	1	1	1	A	Tall DF, RD	JWG-1499-1504	0	-	ID030	-	No sample	-	Relatively tall, falcate DF. TL approx..: 16.2m. No biopsy or TDR.

Survey Date (Y/M/D)	Sighting Number	Species Common Name	School Size	Photographed	Photo Identified	Letters of whales Photo-identified	Identification Features	Photographs	Number Biopsied	Letter of Biopsied whale	ID Form No.	BY Form No.	Biopsy Sample Number	Encounter Duration (min)	Photo-Identification Notes
2021/08/31	013	Fin whale	1	1	1	A	Tall DF, RD	JWG-1506-1526	0	-	ID031	-	No sample	-	Many cc shark scars. Tall triangular, slight falcate DF TL approx.:20.3m.
2021/08/31	014	Sei whale	1	1	1	A	LD	JWG-1530-1550	0	-	ID032	-	No sample	-	TL approx.:14.2 m.
2021/09/03	002	Sei whale	3	2	2	A & B	LD	JWG-1557-1594	1	A	ID033	BY019	21041014	23	High number of cc shark scars; short, pointed, slightly falcate DF photos; TL :"A"14.0m. & "B"14.3m. Biopsied and TDR (TD-008) satellite tagged.
2021/09/03	004	Sei whale	4	2	2	A & B	LD	JWG-1597-1604	0	-	ID034	-	No sample	-	DF Photos, 1 whale falcate wide DF, other whale with a sickle shaped DF.
2021/09/03	006	Fin whale	3	2	2	A & B	LD	JWG-1607-1659	0	-	ID035	-	No sample	-	Many cc shark scars; No Biopsy TLapprox.: 20.5m,19.2m, 17.8 m.
2021/09/03	007	Fin whale	1	1	1	A	LD	JWG-1662-1664	0	-	ID036	-	No sample	-	Tall Falcate Dorsal Fin. TLapprox.: 28.4 m.
2021/09/03	014	Sei whale	2	1	1	A	LD, RD	JWG-1671-1684	0	-	ID037	-	No sample	-	Rounded DF, no biopsy. TL approx.: 13.7m & 14.0 m.
2021/09/03	016	Sei whale	1	1	1	A	Dorsum, RD	JWG-1689-1701	0	-	ID038	-	No sample	-	Nick on anterior edge of DF. TL approx.:14.3m. Tall Falcate DF.
2021/09/03	017	Fin whale	1	1	1	A	RD	JWG-1704-1717	0	-	ID039	-	No sample	-	Many cc shark scars. Tall, Falcate DF. TL est. 18.7m.
2021/09/03	019	Fin whale	2	1	1	A	RD	JWG-1720-1724	0	-	ID040	-	No sample	-	Many cc shark scars, TL est. 19.0 m & 18.2 m.
2021/09/03	020	Fin whale	2	2	2	A & B	LD, RD, Dorsum	JWG-1815-1869	1	A	ID042	BY020	21051015	47	TL est.:19.6m, 18.9m.
2021/09/03	021	Sei whale	3	2	2	A & B	RD	JWG-1729-1750	0	-	ID041	-	No sample	-	TL est.:12.8 m,14.2 m,14.6 m. Tall DF, wide base, 1 whale with DF posterior nick. UTC+14.5.
2021/09/03	022	Sei whale	1	1	1	A	LD, RD, Dorsum	JWG-1753-1809	0	-	ID043	-	No sample	-	Falcate DF, many cc shark scars, white spot on DF.
2021/09/06	001	Sei whale	1	1	1	A	RD	JWG-1876-1877	0	-	ID044	-	No sample	-	Falcate DF.
2021/09/06	002	Sei whale	1	1	1	A	LD, Dorsum	JWG-1883-1888 JWG-1894-1937	1	A	ID045	BY021	21041016	58	TDR satellite tag form.009, Sat. tag bounced off whale. Tall, erect, black, sickle shaped DF, many cc shark scars, TL est.:13.8m.
2021/09/06	006	Fin whale	2	1	1	A	RD	JWG-1945-1962	0	-	ID046	BY022	No sample	24	UTC+14 hrs. ecto-parasites, falcate DF, TL est.: 19.2m, 15.2 m. many cc shark scars, Nick at tip of DF.
2021/09/06	007	Sei whale	1	1	1	A	LD	JWG-1968-1979	0	-	ID047	-	No sample	-	Tall, Falcate DF, TL est.:13.2m.
2021/09/08	001	Sei whale	1	1	1	A	LD	JWG-1984-1995	1	A	ID048	BY023	21041017	8	Tall, erect, sickle shaped DF, many cc shark scars, none fresh, no ridges on Rostrum, Biopsy taken, TDR satellite tag form:010. TL approx.:13.2m.
2021/09/11	001	Bryde's whale	1	1	1	A	Rostral ridges	JWG-2029-2046	1	A	ID049	BY024	21031018	30	Tall, black, falcate DF. Many cc shark scars; some fresh. TL est.: 13.2 m.
2021/09/11	002	Bryde's whale	1	1	1	A	Rostral ridges	JWG-2049-2069	0	-	ID050	BY025	No sample	24	Tall, black, falcate DF. Many cc shark scars; some fresh. TL est.:13.6 m.
2021/09/11	005	Bryde's whale	1	1	0	-	Rostral ridges	JWG-2073-2077	0	-	ID051	-	No sample	-	Dorsum photo. No good for Photo-ID. TL est.:12.8 m.
2021/09/12	002	Bryde's whale	1	1	1	A	Rostral ridges, LD	JWG-2087-2115	0	-	ID052	-	No sample	-	Rounded DF, LD, small knobs at tip of DF, many cc shark scars, TL est.: 13.7 m.
2021/09/12	006	Bryde's whale	1	1	0	-	Rostral ridges	JWG-2153-2154	0	-	ID053	-	No sample	-	DF Photo only. TL est.: 12.9 m. No biopsy or Sat. tag. No good for photo-id study.

Survey Date (Y/M/D)	Sighting Number	Species Common Name	School Size	Photographed	Photo Identified	Letters of whales Photo-identified	Identification Features	Photographs	Number Biopsied	Letter of Biopsied whale	ID Form No.	BY Form No.	Biopsy Sample Number	Encounter Duration (min)	Photo-Identification Notes
2021/09/12	008	Bryde's whale	2	2	2	A & B	Rostral ridges, LD, RD	JWG-2179-2208	1	A	ID054	BY026	21031019	4	Some differences in DF morphology between A and B whales. TL est. A: 13.0 m, TL est. B: 13.7 m, many cc shark scars some fresh.
2021/09/12	010	Bryde's whale	2	2	2	A & B	Rostral ridges, LD, RD	JWG-2211-2244	0	-	ID055	-	No sample	-	Mother/calf pair, TL est. A: 13.7 m, TL est. B: 7.8 m, many cc shark scars some fresh.
2021/09/12	012	Bryde's whale	1	1	1	A	Rostral ridges, RD	JWG-2256-2267	0	-	ID056	-	No sample	-	TL est.:14.0 m, many cc shark scars some fresh.
2021/09/14	001	Bryde's whale	1	1	1	A	Rostral ridges, LD	JWG-2361-2363	0	-	ID057	-	No sample	-	TL est.:12.7, UTC+14.0, many cc shark scars, some fresh, Pointy, Falcate DF w/ serrations along post. Edge.
2021/09/14	003	Bryde's whale	1	1	1	A	Rostral ridges, RD	JWG-2367-2375	0	-	ID058	-	No sample	-	TL est.: 13.1 m, RD photos, DF black colour, erect, slightly falcate.
2021/09/14	004	Bryde's whale	1	1	1	A	Rostral ridges, RD	JWG-2386-2392	0	-	ID059	-	No sample	-	DF is black, many cc shark scars some fresh, Notch at posterior edge of DF, Tall falcate DF, TL est. : 13.1 m.
2021/09/14	005	Bryde's whale	1	1	0	-	Rostral ridges, RD	JWG-2394-2395	0	-	ID060	-	No sample	-	Only tip of DF photographed, not good for photo-ID study.
2021/09/15	007	Bryde's whale	1	1	1	A	Rostral ridges, LD	JWG-2435-2464	0	-	ID061	-	No sample	-	Tall black DF, Notches in DF. Many cc shark scars, some bites fresh. TL est.: 13.4m.
2021/09/15	008	Bryde's whale	1	1	1	A	Rostral ridges, RD	JWG-2477-2484	0	-	ID062	-	No sample	-	DF black with posterior edge notch. Falcate and pointed. TL est.: 12.9 m. moderate number of cc shark scars.
2021/09/15	011	Bryde's whale	1	1	0	-	Rostral ridges, RD	JWG-2488-2489	0	-	ID063	-	No sample	-	DF black. Photos of DF only. Likely not good for photo-id study.

Table 6. Summary of marine debris observations during the entire 2021 IWC-POWER. On-effort observations were made only during the first 15 minutes of each hour while on survey. Off-effort observations were strictly opportunistic.

IWC code	Description	ON Effort	OFF Effort	Total
120	Unidentified net, piece of net, white	3	0	3
134	Single fishing float	15	0	15
148	Styrofoam board, less than 1 square meter	45	0	45
151	Styrofoam box (at least 2 sides)	3	0	3
161	Plastic, unidentified	4	0	4
162	Plastic, less than 1 square meter	9	0	9
165	Plastic bag, small	1	0	1
199	Other, pet bottle, clear, 500ml-2,000ml	5	0	5
199	Other, plastic bottle, white, 2,000ml	1	0	1
199	Other, wooden log (natural)	1	0	1
199	Urethane foam, yellow color	1	0	1
	Total	88	0	88

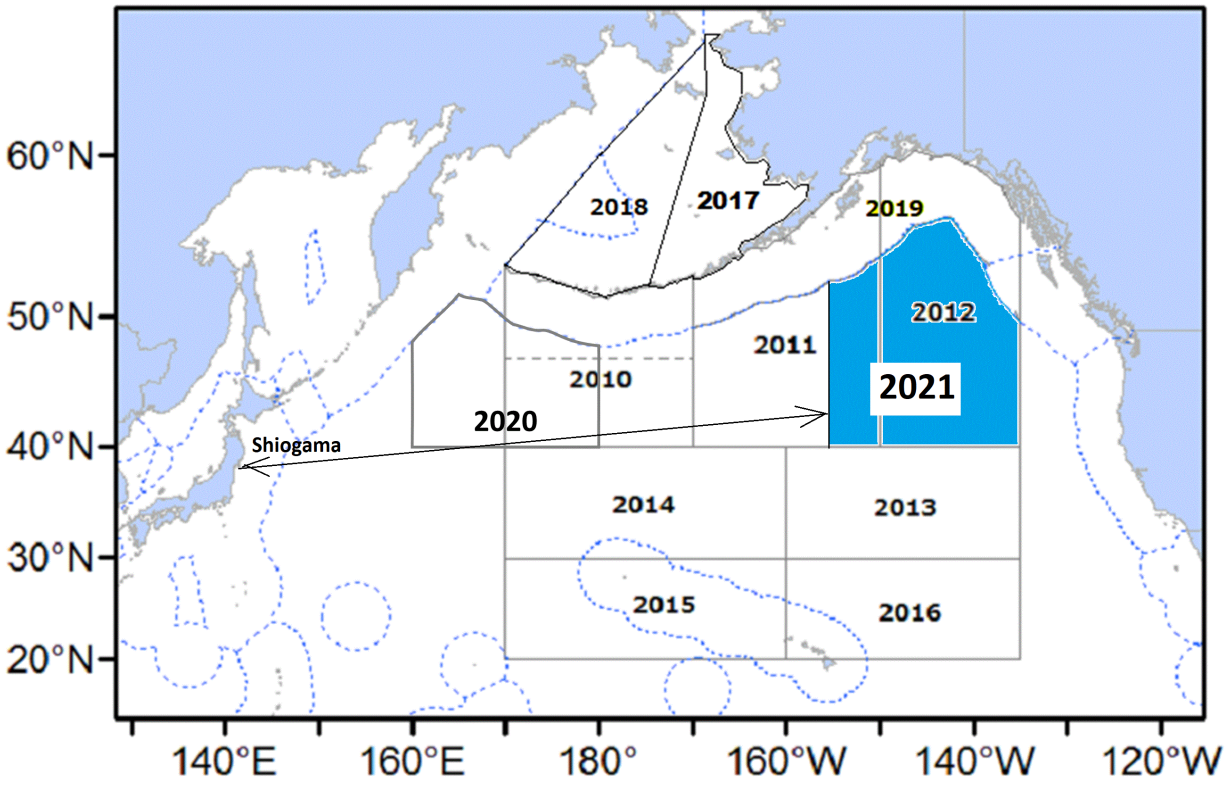

Figure 1a. Research area, transit and survey track lines with start and end points for the 2021 IWC-POWER.

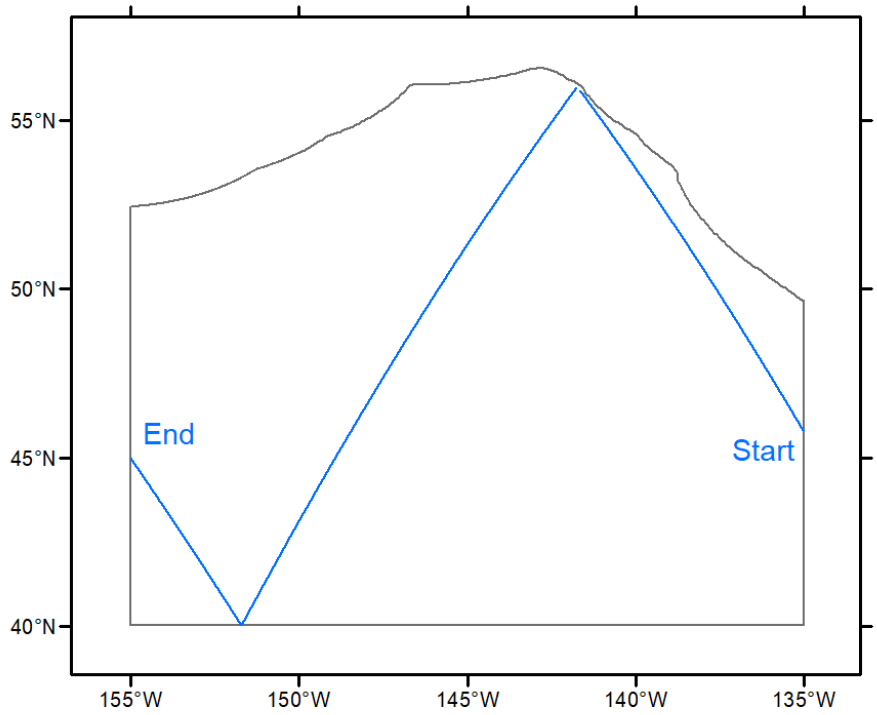

Figure 1b. Predetermined cruise track lines and start and end points within the main survey area for the 2021 IWC-POWER.

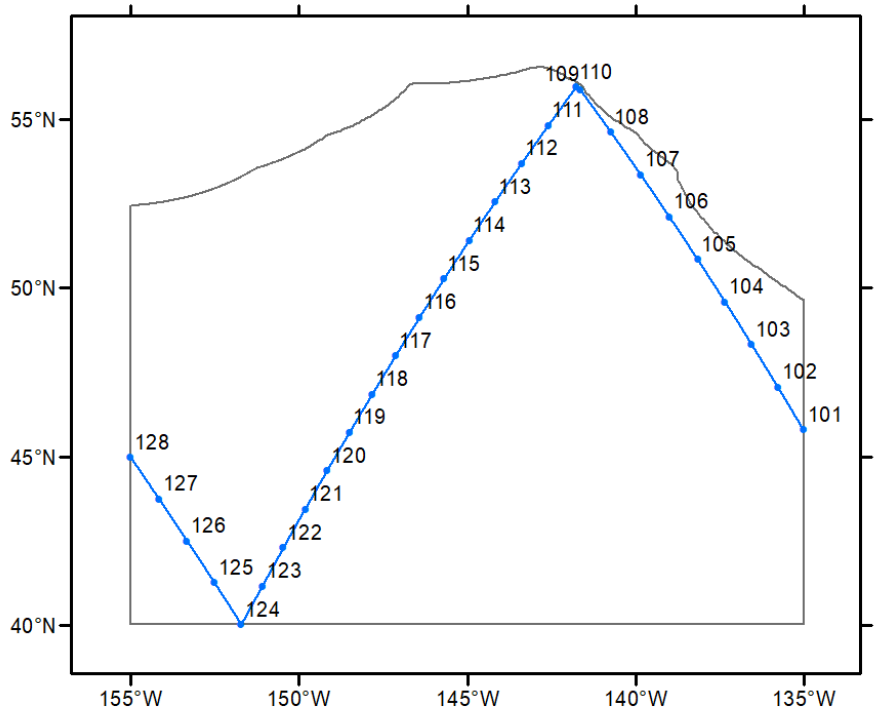

Figure 1c. The waypoint number within the main survey area for the 2021 IWC-POWER.

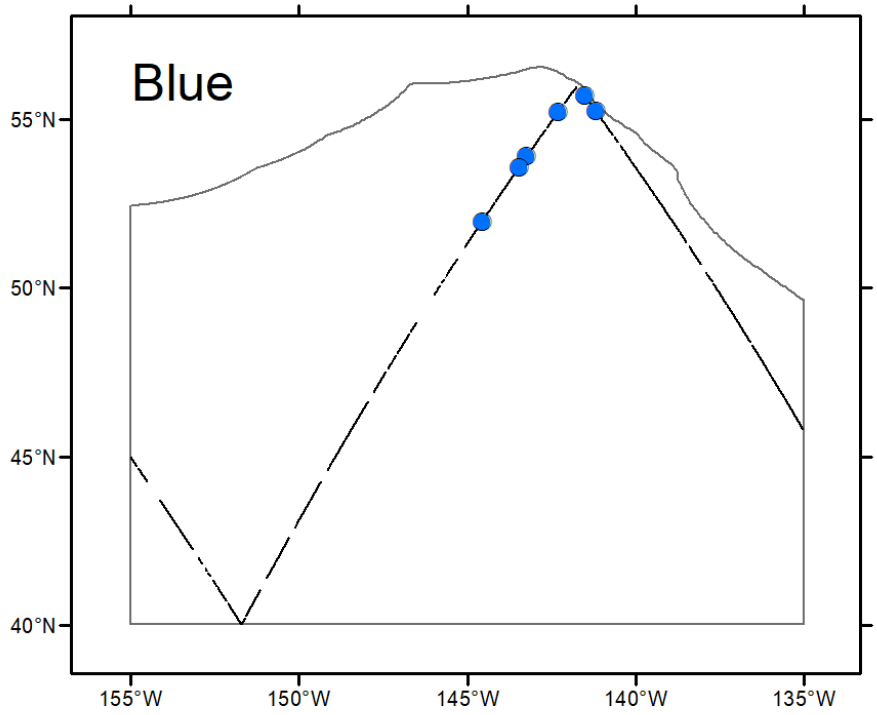

Figure 2a. The searching effort (black lines) and sighting positions (blue circles) of blue whales during the 2021 IWC-POWER

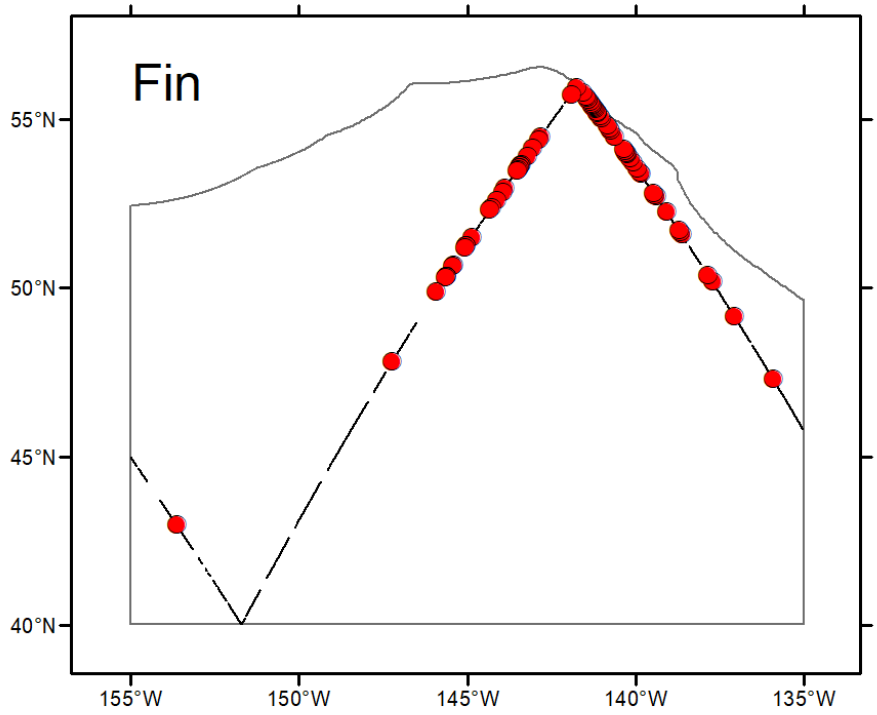

Figure 2b. The searching effort (black lines) and sighting positions (red circles) of fin whales during the 2021 IWC-POWER

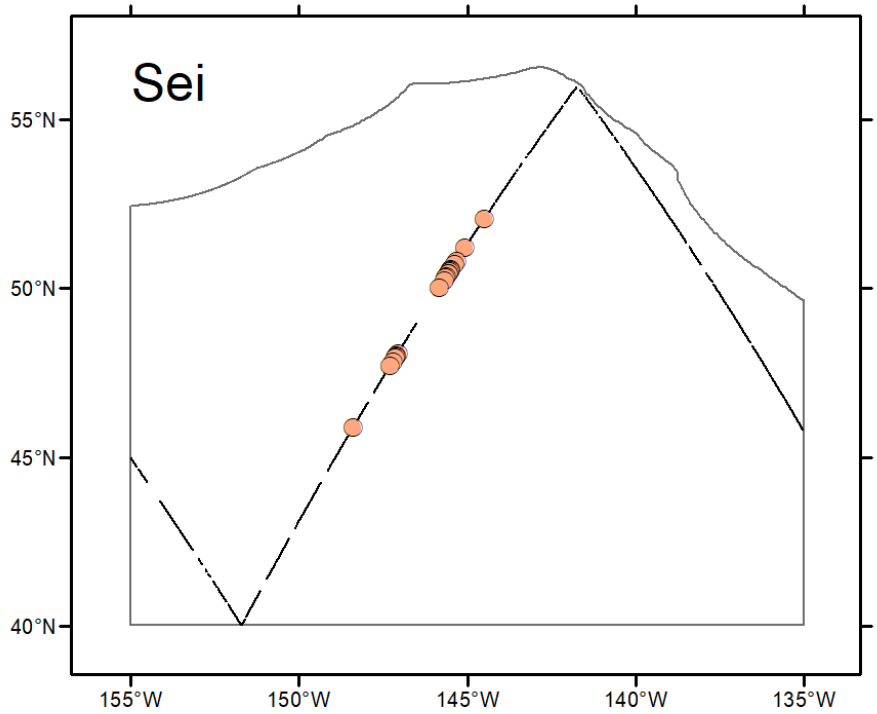

Figure 2c. The searching effort (black lines) and sighting positions (yellow circles) of sei whales during the 2021 IWC-POWER .

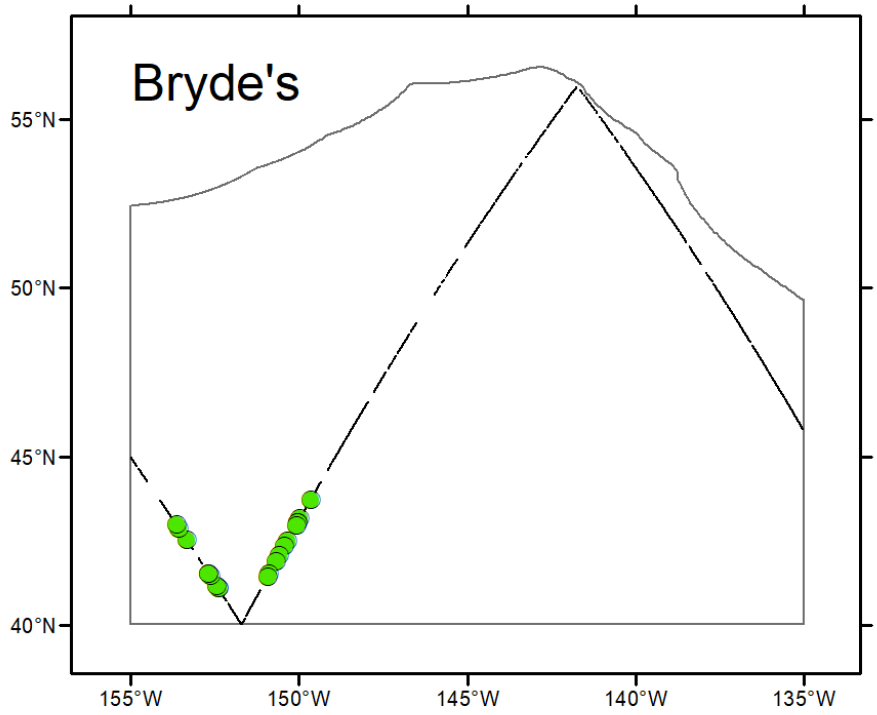

Figure 2d. The searching effort (bkack lines) and sighting positions (green circles) of Bryde's whales during the 2021 IWC-POWER .

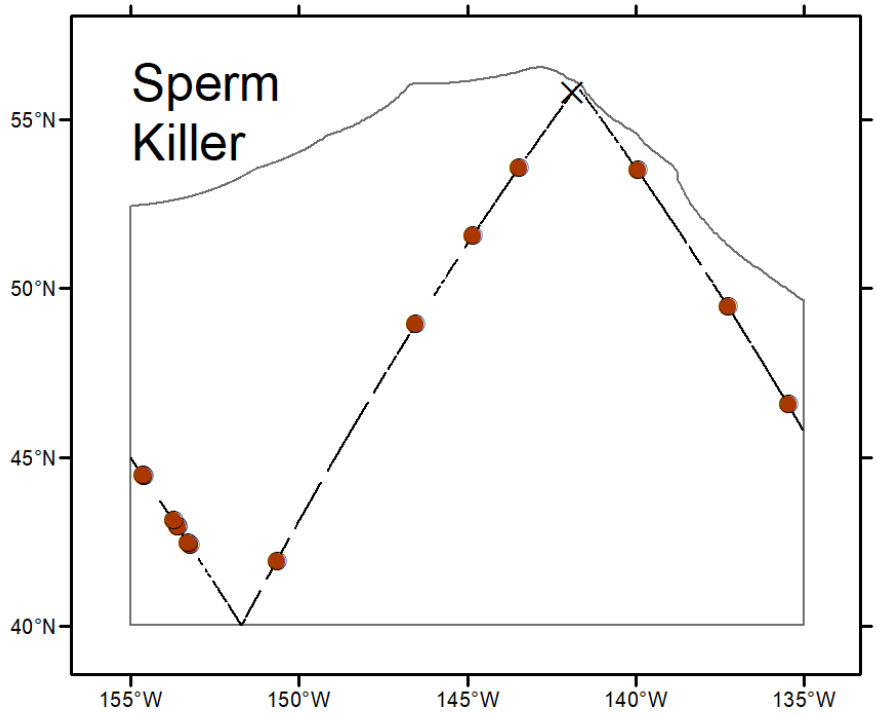

Figure 2e. The searching effort (thin line) and sighting positions (brown circles) of sperm and killer (black cross) whales the 2021 IWC-POWER .

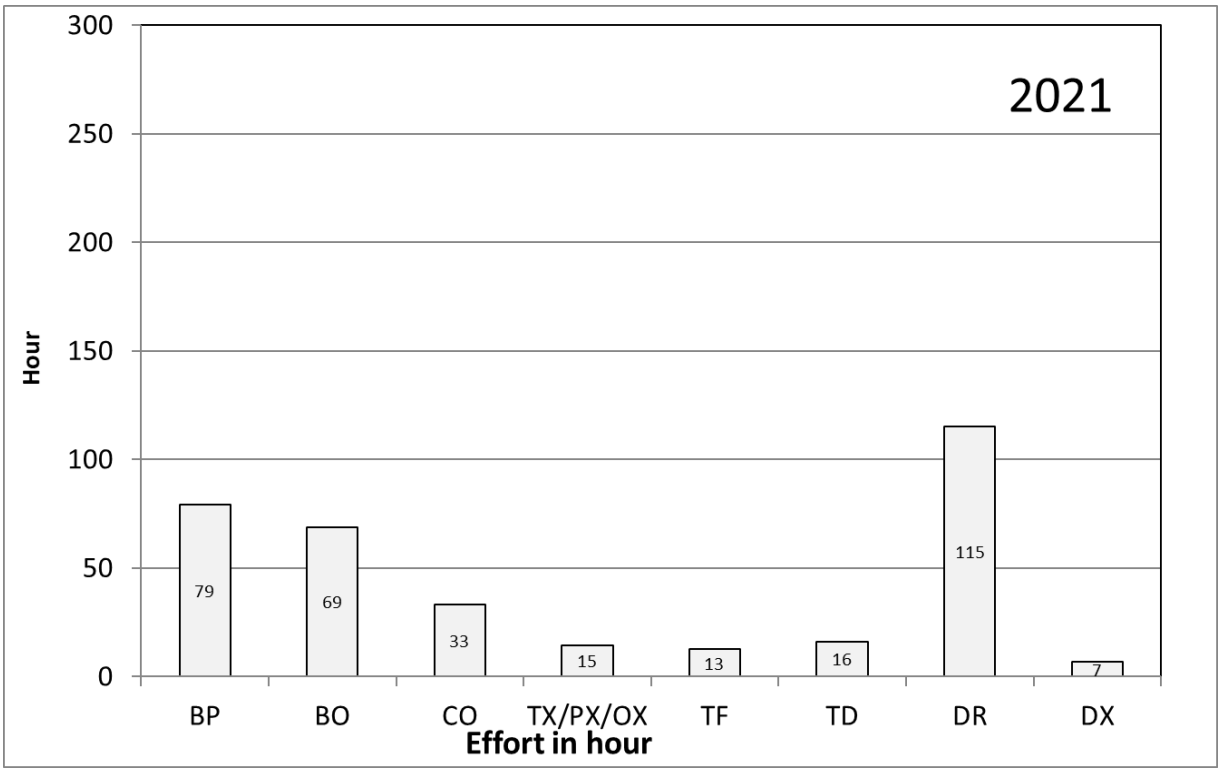

Figure 3. Breakdown of research time in hours, by effort code in the research area during the 2021 IWC-POWER (Original tracklines, Area code: 84 and 85). P: Passing mode searching, BO: Independent Observer mode, CO: Confirmation of school, TX/PX: Biopsy / Photo-ID experiments, TF: Time back to trackline, TD: Top down steaming, DR: Drifting (including 16 hours between northern and southern off-effort steaming), DX: Distance and angle estimate experiment.

APPENDICES

Appendix A. Ship specifications and crew list of *Yushin-Maru No.2*.

Ship photo:

Ship specifications:

	Yushin-Maru No.2
Call sign	JPPV
Length overall [m]	69.61m
Molded breadth [m]	11.5m
Gross tonnage (GT)	747
Barrel height [m]	19.5m
IO barrel height [m]	13.5m
Upper bridge height [m]	11.5m
Bow height [m]	6.5m
Engine power [PS / kW]	5303/3900 (PS/kW)

Crew list:

Title	***Yushin-Maru No.2***
Captain	Hiroshi Eguchi
Chief Officer	Toru Takamatsu
Second Officer	Masahiro Yamazaki
Chief Engineer	Keisuke Mizobuchi
First Engineer	Kazuhito Abe
Second Engineer	Hayato Seki
Third Engineer	Yuki Fukagawa
Chief Operator/Purser	Takeshi Semii
Boatswain	Hisashi Katase
Quartermaster	Kazuyuki Sugiyama
Quartermaster	Takato Sawabe
Sailor	Kenta Kato
Sailor	Ryota Kamekura
Sailor	Hiroto Konishi
Chief Steward	Akihiko Toyomura
Steward	Junya Oguchi

Appendix B. Comparison of weather conditions (wind speed / visibility) among past cruises (2010-2020).

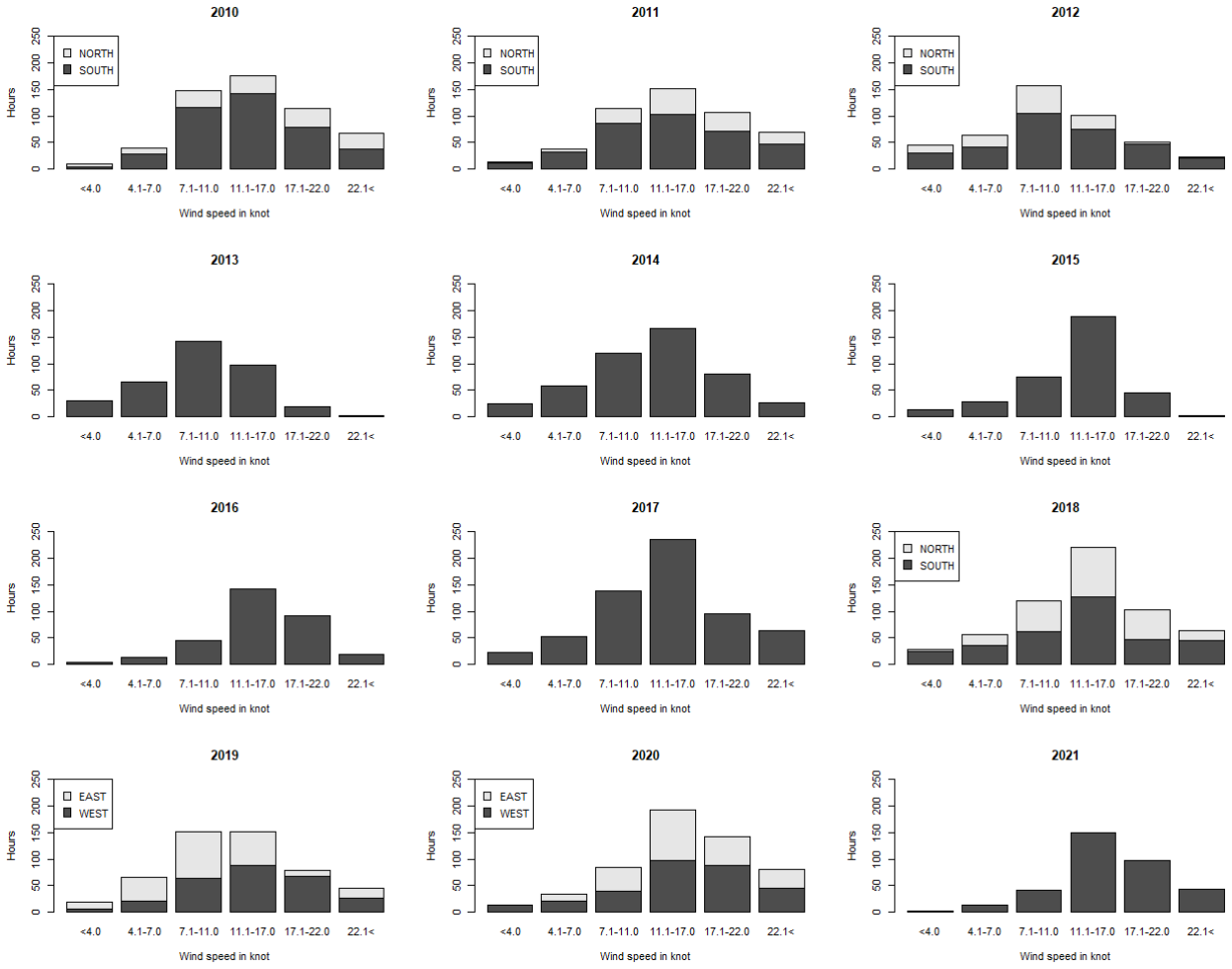

Figure B1. Breakdown of research time in hours during 2010 to 2021 surveys in research area by wind speed (in knots).

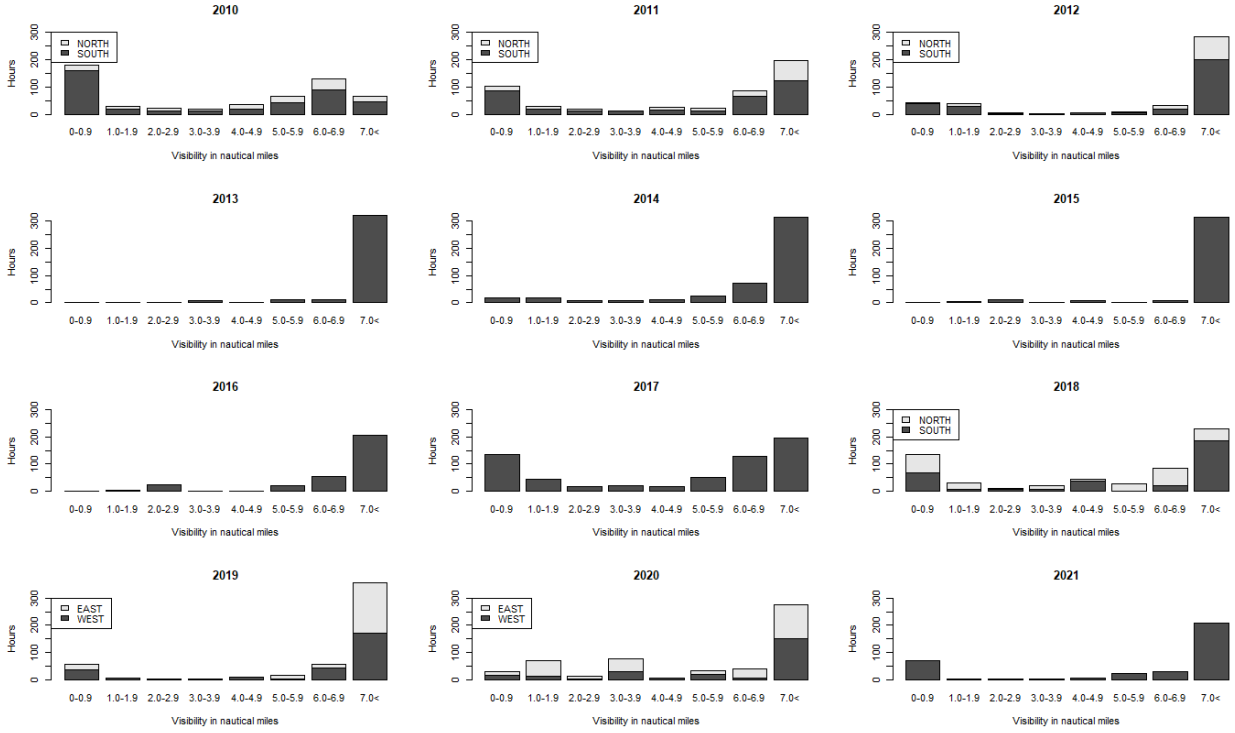

Figure B2. Breakdown of research time in hours during 2010 to 2021 surveys in research area by visibility (in nautical miles).

Appendix C. Feasibility experiment of dive behavior tagging

BACKGROUND

During the 2021 IWC-POWER planning meeting, a possibility of carrying out a feasibility study on diving with a satellite tagging was considered and agreed to be voluntarily conducted by Japan with an understanding that it might be a way to address specific questions in the future (IWC, 2021b). According to this agreement, satellite linked dive behavior tags were experimentally deployed during the cruise at the discretion of Japan. The obtained data could be used to correct availability bias in the future abundance estimation.

SHORT DESCRIPTIONS OF THE METHODOLOGY

Target species were fin, sei and humpback whales. High priority given to the first two species, but humpback whales were also selected assuming that the species is suitable for this feasibility experiment as they swim relatively slow. The following equipment was available: ten dive behavior tags (SPLASH10-F-333, Wildlife Computers, US), one Aerial Rocket Transmitter System (LK-ARTS) and darts (courtesy of ICR). Tagging and biopsy experiments were conducted simultaneously. One shooter used a LK-ARTS for the tagging while the other shooter used a Larsen biopsy gun. This experiment was conducted at the cruise leader's discretion with the understanding that the line transect survey was the highest priority.

RESULTS AND DISCUSSION

The results of feasibility experiment of dive behavior tagging is summarized in Table C1. The tags were attached to 2 fin and 3 sei whales and the data were obtained via satellite. Success rates for each species were 33.3% (n=6) for fin and 75.0% (n=4) for sei whales. A total experiment time targeting 10 schools (6 fin and 4 sei whale schools) was 5 hours 47 minutes although the time was overlapped with biopsy experiment. The preliminary results will be presented to the TAG/planning meetings in reference to the future work of this programme. Detailed analysis will be conducted by Japanese scientists and the results will be reported relevant scientific communities.

Feasibility experiment of dive behavior tagging was successfully conducted. This was the first attempt of this kind of experiment in IWC-POWER. The satellite linked dive behavior tags, SPLASH10-F-333 was used in the experiment. Some dive behavior data were obtained via satellite although the detailed analysis is yet to be conducted. Data throughput of transmitting tags is limited by the availability of satellite coverage. Mote (Wildlife Computers, US) is stationary listening station and can continuously log telemetry data from satellite tags on animals within reception range (distances over 207 km). Installation of Mote to the vessel will be considered at the description of Japan taking account of comments from the TAG and planning meetings.

Table C1. Summary of the feasibility experiment of dive behavior tagging in the 2021 IWC-POWER.

Date	Sighting #	Species	School size	Serial #	PTT ID	Attachment	Letters attached of ind.	Data acquisition	Biopsy (sample #)	Experiment duration	Remarks
2021/8/18	2	Fin whale	1	-	-	-	-	-	-	0:46:09	No chance to shoot
2021/8/21	3	Fin whale	1	-	-	-	-	-	-	0:27:40	No chance to shoot
2021/8/21	9	Fin whale	2	20A0501	207834	Yes	A	Yes	Yes 21051001	1:02:52	-
		Fin whale	2	20A0247	207831	No	-	-	-		Hit but bounced on the body. Lost the tag in the water.
2021/8/23	1	Fin whale	2	20A0211	207829	No	-	-	-	0:54:39	Miss but lost the tag in the water.
2021/8/23	11	Fin whale	2	20A0201	207823	Yes	A	Yes	Yes 21051003	0:11:13	-
2021/8/27	2	Fin whale	1	20A0200	207822	No	-	-	-	0:05:25	Hit but bounced on the body. Lost the tag in the water.
2021/8/31	3	Sei whale	1	20A0214	207832	Yes	A	Yes	Yes 21041013	0:51:34	-
2021/9/3	2	Sei whale	3	20A0502	207835	Yes	A	Yes	No	0:22:44	-
2021/9/6	2	Sei whale	1	-	-	-	-	-	-	0:57:31	No chance to shoot
2021/9/8	1	Sei whale	1	20A0207	207825	Yes	A	No	Yes 21041017	0:07:39	-

END