

# Cruise report of the 2023 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER)

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## ABSTRACT

IWC-POWER cruises in the North Pacific follow the series of IWC/IDCR-SOWER (Southern Ocean Whale and Ecosystem Research) cruises that were conducted in the Antarctic since 1978. The 14<sup>th</sup> annual IWC-POWER cruise was conducted between 28 July and 5 October 2023 in the eastern North Pacific (between 40°00'N and US EEZ boundary, 180°00'W and 155°00'W, comprised entirely of the high seas). This area was surveyed in 2010 and 2011, but the survey was conducted from mid-July to mid-August while the 2023 survey will be conducted from mid-August to mid-September. The survey was conducted aboard the Japanese research vessel *Yushin-Maru No. 2*. The cruise was organized as a joint project between the IWC and Japan. The cruise plan was endorsed at the 69A IWC/Scientific Committee (IWC/SC) meeting. Researchers from the IWC, the U.S., and Japan participated in the survey. The cruise had four main objectives: (a) obtain information for the in-depth assessments of sei, humpback, gray and sperm whales in terms of abundance, distribution and stock structure; (b) obtain information on the critically endangered North Pacific right whale population in the Pacific; (c) obtain 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.g., blue and fin whales); (d) obtain essential information for the development of the medium-long term international programme in the North Pacific in order to meet the Commission's long-term objectives. At the pre-cruise meetings in Shioyama and Dutch Harbor, the crew of the vessel and international researchers agreed on the procedures and objectives of this survey. The survey was conducted using methods based on the guidelines of the IWC/SC. Survey trackline coverage in the research area was 84.6 % (1,476.57 n.miles of a planned distance of 1,745.00 n.miles), with a total of 742.29 n.miles in Passing with abeam closing mode (NSP) and 734.18 n.miles in Independent Observer passing mode (IO). Additionally, 172.80 n.miles were surveyed during transit between Japan to and from Dutch Harbor, and Dutch Harbor to and from the research area. During the entire cruise, sightings of: North Pacific right (4 schools / 5 individual), blue (9/9), fin (116/193), sei (66/85), common minke (2/2), humpback (1/1), sperm (25/26) and killer (7/16) whales. Blue, fin and sei whales were mainly distributed in the northern part of the research area. Fin whales were the most frequently sighted large whale species. Photo-identification data were collected for: 4 right, 7 blue, 30 fin and 9 sei whales. These data are preliminary, pending further processing and photo-identification confirmation. A total of 19 biopsy (skin and sometimes blubber) samples were collected from 4 blue, 8 fin and 7 sei whales. The Estimated Angle and Distance Training Exercise and Experiment were completed. The acoustic survey was included for the 5th time to acoustically monitor for the presence of marine mammals, with particular importance for detecting and locating North Pacific right whales. A total of 146 sonobuoys were deployed, of which 143 were successful, for a total of over 538.28 monitoring hours. Species detected include sperm whales (107 buoys, 74.8%), fin whales (81, 56.6%), killer whales (53, 37.1%), blue whales (33, 23.1%), common dolphins (10, 6.9%), humpback whales (8, 5.6%), North Pacific right whales (7, 4.9%), Pacific white-sided dolphins (6, 4.2%), and sei whales (4, 2.8%). Other signals detected include northern right whale dolphins (2, 1.4%), Baird's beaked whales (1, 0.7%), unidentified dolphins (2, 1.4%), and earthquakes (2, 1.4%). A total of 4 SPOT 177S tags were deployed on 4 blue whales. Five SPLASH-f-333 tags each were deployed on fin and sei whales. Two drifting buoy recorders (Long-term Drifting Buoy Recorder, LT-DBR) were deployed during the cruise on behalf of Barlow, with an expectation that acoustic data of beaked whales could be recorded. A seabird sighting survey was conducted as a feasibility study based on a proposal by Brownell. A total of 115 survey blocks along tracklines up to 15 minutes long was covered with sightings of 27 species of seabirds (466 individuals). This cruise was successfully completed and provided important information on cetacean distribution, in particular blue, fin and sei whales, in an area where limited survey effort had been conducted in recent decades, in a poorly known and logistically difficult area. These results will contribute to the aforementioned objectives of the IWC/SC.

KEY WORDS: NORTH PACIFIC RIGHT WHALE, BLUE WHALE, FIN WHALE, SEI WHALE, COMMON MINKE WHALE, HUMPBACK WHALE, SURVEY VESSEL, NORTH PACIFIC, ALEUTIAN ISLANDS, IWC-POWER, PASSIVE ACOUSTICS

## 1. INTRODUCTION

### 1.1 Research objectives

The cruise was organised as a joint project between the International Whaling Commission (IWC) and Japan (IWC, 2012a, 2012b, 2013, 2014, 2016a, 2016b, 2017a, 2017b, 2019a, 2019b; 2020a; 2020b; 2021a; 2021b, Kato *et al.*, 2011). The 2023 cruise plan was discussed at the IWC-POWER Planning Meeting in 2022 and endorsed at the 69A IWC/Scientific Committee (IWC/SC) meeting (IWC 2024a, 2024b). The cruise had four main objectives: (a) obtain information for the in-depth assessments of sei, humpback, gray and sperm whales in terms of abundance, distribution and stock structure; (b) obtain information on the critically endangered North Pacific right whale (hereafter NPRW) population in the Pacific; (c) obtain 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.g., blue and fin whales); and (d) obtain essential information for the development of the medium-long term international programme in the North Pacific in order to meet the Commission's long-term objectives. The research area for 2023 cruise was surveyed in 2010 and 2011, but these surveys were conducted from mid-July to mid-August while the 2023 survey was conducted from mid-August to mid-September.

### 1.2 Research area, cruise track design and priority of the cruise

The research area for POWER 2023 was off the southern Aleutian Islands bounded by 40°00'N, the US exclusive economic zone (EEZ) boundary to the north, 180°00'W and 155°00'W, comprised entirely of the high seas (Figure 1a). 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 (see section 2.5). Primary search effort was conducted only in acceptable weather conditions, as per guidelines for prior cruises; visibility greater than 2.0 nautical miles (n.miles), wind speed <21 knots and sea state <Beaufort 6.

Following advice from the SC and the Technical Advisory Group (TAG), the 2023 survey alternated modes between Normal Closing Mode (NSP) and Independent Observer Mode (IO) (ca. every 60 n.miles).

Two primary observers were in the TOP barrel throughout periods of NSP and IO modes and an additional 2 observers were in the IO platform during IO mode (see section 2.5). Sighting survey procedures are detailed in "Information for Researchers" (Anon. 2023a). For encounters of rare species (e.g., blue and NPRW), it was decided that the vessel would approach whales immediately in order to avoid losing the sighting due to a delay in closing.

The priority species for biopsy sampling during the 2023 cruise were NPRW, blue, fin, sei, common minke, humpback, and gray whales, with highest priority for the first two species. Biopsy sampling of killer, Brydes, and sperm whales was attempted opportunistically. The Larsen sampling system was used to collect samples (Larsen, 1998). Target species for photo-ID were blue, NPRW, gray, and humpback whales. Photos of fin, sperm, and killer whales were also obtained opportunistically.

## 2. SHORT NARRATIVE OF THE CRUISE

### 2.1 The 2023 cruise itinerary

Date (ship's time)	Event
27-Jul-2023	Pre-cruise meeting at Shiogama
28-Jul	Vessel departs from Shiogama
5-Aug	Vessel arrives at Dutch Harbor
7-Aug	Vessel departs from Dutch Harbor
7-Aug	Pre-cruise meeting on YS2 off Dutch Harbor
9-Aug	Vessel starts the survey in the research area
13-Sep	Vessel completes the survey in the research area
22-Sep	Vessel arrives at Dutch Harbor
24-Sep	Post-cruise meeting at Dutch Harbor
25-Sep	Vessel departs from Dutch Harbor
5-Oct	Vessel arrives at Shiogama
6-Oct	Post-cruise meeting at Shiogama

### 2.2 Research vessel

The R/V *Yushin-Maru No.2* (YS2, 747GT) was contracted for this cruise. Ship specifications, photo, and the crew list for this cruise are provided in Appendix A.

### 2.3 Attending scientists and responsibilities

Four international researchers were nominated by the IWC steering group for the POWER programme. Researchers were Hiroto Murase (Tokyo University of Marine Science and Technology (TUMSAT), Japan, Cruise Leader), Jessica Crance (National Oceanic and Atmospheric Administration (NOAA) Fisheries, Alaska Fisheries Science Center (AFSC), Marine Mammal Laboratory (MML), USA), Bernardo Alps (contracted by MML through WildSEA, Inc., USA), and Isamu Yoshimura (IWC-nominated researcher, Japan). Isamu Yoshimura was on board for the entirety of the cruise from Shiogama to Shiogama, and therefore participated in transit surveys, whereas the other researchers were on board from Dutch Harbor to Dutch Harbor and were not involved in transit surveys to/from Japan.

Hiroto Murase (Japan): Cruise Leader (CL)
Jessica Crance (USA): Acoustics, photo-ID
Bernardo Alps (USA): Photo-ID data management, seabird sighting
Isamu Yoshimura (Japan): sighting data, marine debris and biopsy sample management

### 2.4 Pre- and post-cruise meeting

On 27 July, the first pre-cruise meeting was held at the Tohoku dock Co., Ltd., Shiogama, Miyagi, Japan. Meeting participants were: Matsuoka (chair, Institute of Cetacean Research (ICR)), Kawai (Fisheries Agency of Japan (FAJ)), Kato and Miyashita (IWC-POWER/SOWER Steering Group) Katsumata (ICR), Murase (Cruise Leader (CL)), Yoshimura (researcher), Okoshi (Captain), Miyamoto (Chief Engineer), Kuwaoka (Chief Operator), Nagamine (Chief Officer) and Abe (Bosun). The meeting discussed and confirmed priorities and strategies for the cruise based on the IWC Scientific Committee's planning report (IWC, 2024a), and IWC research manual (Anon, 2023a). The meeting confirmed that the YS2 has all necessary Japanese and US research permits to operate on the high seas and US EEZ as well as Japanese CITES Introduction from the Sea permits. The pre-cruise meeting report was distributed to the steering group after review by the Convenor (Anon, 2023b).

On 7 August, the second pre-cruise meeting was held on YS2 off Dutch Harbor, Alaska, US. Meeting participants were: Murase (CL/chair), Crance, Alps and Yoshimura (researchers), Okoshi (Captain) and Kuwakoa (Chief Operator). The meeting primarily followed a draft report of the pre-cruise meeting for the 2023 IWC-POWER Cruise in Shiogama on 27 July 2023 (Anon, 2023b) with a few additions. The second pre-cruise meeting report was distributed to the steering group after review by the Convenor (Anon, 2023c).

On 24 September, the first post-cruise meeting was held at the Grand Aleutian Hotel, Dutch Harbor, Alaska. Meeting participants were: Murase (CL/chair), Crance, Alps and Yoshimura (researchers) and Okoshi (Captain). The first draft of the cruise report was reviewed in the meeting.

On 6 October, the second post cruise meeting was held at the Tohoku dock Co., Ltd. Meeting participants were: Matsuoka (chair, ICR), Kato and Miyashita (IWC-POWER/SOWER Steering Group), Katsumata (ICR), Murase (cruise leader), Yoshimura (researcher) and Okoshi (Captain). The second draft of the cruise report was reviewed during the meeting.

## 2.5 Research hours, survey mode and number of observers on effort

The schedule for research hours was consistent with previous SOWER (Southern Ocean Whale and Ecosystem Research) and 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 mealtime 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 60-minute increments, effective from 01:00 hrs. Work schedules adhered to local ship time which ranged between -13.0 hours and +12.0 hours UTC throughout the cruise depending on the ship's geographic location (Table 1b). Data collected during the cruise and all associated reporting are provided in local ship time, with the exception of acoustic data, which were collected in Alaska Daylight Time (ADT). Relative UTC has been noted for reference in raw data.

Sighting effort was conducted by the bosun and topmen from the TOP barrel (crow's nest: always two primary observers) when in NSP mode, as well as two topmen in the IO platform during IO survey, and typically, two primary observers (the helmsman and captain) and at least three secondary observers from the upper bridge (officer-on-watch, two 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; i.e., when no primary observers were in the TOP barrel (e.g., during drifting (DR), 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.

Following advice from the SC and TAG, the 2023 survey alternated between NSP and IO modes. It was suggested that at least 50% of effort be in IO mode (see section 2.6 for expected versus realised survey effort).

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 as recommended by the TAG. 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.

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 sample collection experiments. Until the ship resumed full search effort on the trackline, any sightings detected after initial departure from the trackline were classified as secondary sightings.

The 2023 POWER cruise again utilized the monitor with the sighting "map" that was recommended to use in 2020 POWER cruise and installed in 2021 POWER cruise in the upper bridge and available for the CL and other researchers to view. This provided additional information that allowed researchers to more easily track and differentiate multiple sightings.

## 2.6 Weather conditions and expected versus realised effort

In the research area, sea surface conditions were generally good throughout, although we sometimes skipped short sections in off effort or drifted due to fog and/or strong wind. A total of 1,476.57 n.miles (NSP: 742.29 n.miles, IO: 734.18 n.miles) of original planned trackline (1,745.00 n.miles) were surveyed in the survey area. Survey trackline coverage in the research area was 84.6 %. Additionally, 172.80 n.miles were surveyed during transit between Japan to and from Dutch Harbor, and Dutch Harbor to and from the research area. A comparison of weather conditions among past cruises is shown in Appendix B.

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

Cetacean research activities conducted on the high seas in international waters by Japanese researchers aboard the YS2 were authorized under permit SUIKAN 5-1123 (dated 24 July, 2023) issued by Ministry of Agriculture, Forestry and Fisheries (MAFF), Government of Japan (GOJ) through Fisheries Agency of Japan (FAJ).

All research activities (i.e., the approach of cetaceans for species identification, school size estimates, digital photography, and biopsy sample collection but not satellite tagging) that were carried out within the U.S. EEZ were permitted under U.S. National Marine Fisheries Service (NMFS) Permit no. 25563 (issued to AFSC, Marine Mammal Laboratory), Letter of Acknowledgement (LOA) 2023-04 issued by National Oceanic and Atmospheric Administration (NOAA), the United States Department of Commerce, and a consent letter responding to the application listed in the Research Application Tracking System by Government of Japan as U2023-003 by Bureau of Oceans and International Environmental and Scientific Affairs, the United States Department of State. Research did not take place within 3 n.miles of the coastline and was conducted in accordance with LOA 2023-04. Researcher Jessica Crance (U.S., NOAA/AFSC) was listed as the co-investigator (CI) on the NMFS permit aboard the research vessel.

Cetacean tissue biopsy samples obtained during the survey in the research area (i.e., 4 blue, 8 fin and 7 sei whale samples) were divided in half during cruise, with one half of the samples designated for IWC research and the other half for analyses in Japan (ICR). The IWC samples were legally transported to the Southwest Fisheries Science Center (SWFSC/NOAA) after the cruise under Crance's supervision, under the CITES (Convention on International Trade in Endangered Species) U.S. Management Authority (U.S. Fish and Wildlife Service) Permit. The Japanese samples were kept on YS2 and imported to Japan (ICR, Tokyo) under the CITES Japan Management Authority, the Office of Trade Licensing for Wild Animals and Plants, Ministry of Economy, Trade and Industry (METI).

## 2.8 Photo-ID data collection

As appropriate and decided by the CL, research time was allocated for photo-identification and /or video recording of large whales, with the same priority species as for biopsy sampling (section 1.2). 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 minimum of one photographer (maximum three) on the bow, with additional photographers in the IO barrel or upper bridge.

Four cameras were used throughout the survey: (1) The main camera was a Canon EOS R6 Mark II DSLR with a Canon RF 100-500mm f/4.5-7.1 L IS USM lens, and a Canon GPS Receiver GP-E2 (courtesy of ICR), (2) The secondary camera was a Canon 60D with a Canon 100-400 f/4.5-5.6 L IS lens (owned by Crance), (3) A Nikon D850 DSLR camera with an AF-S Nikkor 500mm f5.6E PF ED lens was the backup camera (owned by Alps) and (4) A Nikon D610 DSLR with an AF Nikkor 20-35mm 1:2.8 D was for activities on board that require a wide angle lens (owned by Alps). The camera date and clock were synchronized to the second with the ship's clock and kept updated. All images were shot in RAW format.

Alps used cameras 1, 3, and 4. Camera 1 was always at hand during surveys, and an attempt was made to photograph every cetacean sighting. Additionally, seabirds were photographed opportunistically to confirm ID and for documentation. Marine debris were also photographed opportunistically to aid with classification and for documentation. Life and work on board was documented when possible. Camera 3 was used on one occasion when a wrong setting on camera 1 could not be quickly corrected. Camera 4 was used to document activities like sonobuoy and LT-DBR deployment. Crance used camera 2, mainly during attempts to obtain biopsy samples and deploy satellite tags, and attempts to obtain ID photos, but also opportunistically for other marine mammal and seabird sightings. The photos were named as follows: (1) Camera 1: BAL for images up to #9999, (2) Camera 1: B2A for images up to #9999 in another sequence of file number (3) Camera 2: JLC, (4) Camera 3: BEA and (5) Camera 4: B1A

During biopsy and tagging attempts, Alps photographed from the bow pulpit (height 6.5 m), positioned just behind and to the side of the two shooters, and Crance photographed from the IO barrel (height 13.5 m). For blue, fin, sei, and minke whales, it was always attempted to photograph the animals from as close as possible to a perpendicular to the body axis, showing the dorsal fin and as much of the flank of the animal as possible.

Two 2 TB external hard drives (courtesy of ICR) were purchased for daily backups and a spare SD card with a 32 GB capacity was also prepared by the ICR. This was more than adequate storage for the 2023 cruise, particularly when combined with daily back up of photographs, allowing for nightly deletions of photos on the cameras' SD cards in preparation for photo-ID data collection the following day.

Images were uploaded to the IWC master photographic database in Adobe Lightroom (LR) version 6.0 on the laptop computer (MSI GE72 7RE Apache Pro, courtesy of ICR), backed up, and preliminarily analysed at the close of each survey day. Images from camera 1 and camera 3 were converted to DNG file format prior to being imported into Lightroom using the Adobe Digital Negative Converter because the raw formats used in these cameras were not compatible with the older version of LR. Preliminary photo-analysis involved: linking photographic data to relevant sighting information (i.e., sighting number, school size and species) and biopsy records (i.e., sample number, no sample obtained or no attempt to obtain sample); identifying number of individuals photographed in each sighting; and assessment for photo-identification (Anon, 2023d). Additionally, photos were marked as taken under the US ESA/MMPA permit (Permit No. 25563) with the associated permit number when they were taken within US EEZ. Photographic data with associated information saved to the metadata were organised into daily folders and sighting subfolders. Keywords were attached to all images, and captions where appropriate, and images were sorted into folders. A daily folder (20230901\_GMT-11) was created for each effort day. All photos in each cetacean sightings were moved into individual folders inside the daily folder. The sighting folders were numbered consecutively throughout the day and named with the sighting number and species name (e.g., G1\_003\_Fin). Non-cetacean images were moved into general folders like Other Sightings, Marine Debris, Scientific Work, and Ship Life. Images that were severely out of focus or missed the subject completely were discarded during the editing process.

Copies of photographic data were submitted to the CL and delivered to the IWC Secretariat shortly after the conclusion of the cruise. 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 (section 4.1). These data should be considered preliminary and are subject to change with the further processing of database and catalogue curators.

## 2.9 Data entry system

Throughout the cruise, research data collected during the survey (weather, effort and sighting) were entered by researchers using the 'onboard data collecting system' developed by ICR (ICR, 2013) and were duplicated in IWC standardized written forms.

## 2.10 Acoustic data collection

Passive acoustic monitoring for marine mammals was conducted using sonobuoys. A sonobuoy is a free-floating, expendable, short-term passive acoustic listening device that transmits signals in real time via VHF radio waves to a receiver on a vessel. Each sonobuoy consists of an outer tube (approx. 14 cm in diameter, 110 cm long), and an inner sonobuoy. Total weight of one sonobuoy (including outer tube) is approximately 30-35 lbs; the weight of one crate of 48 sonobuoys is approximately 1,300 lbs. Prior to the start of the survey, the sonobuoys were removed from their crates, brought on board individually, and stored in the lower hold of the vessel. A total of 192 sonobuoys were brought on board in Dutch Harbor. Two types of sonobuoys were used during the survey: AN-SSQ 53F and 53G. Two antennas (one omnidirectional and one yagi directional) were installed and tested on the vessel on 6 August 2023 in Dutch Harbor prior to the start of the survey. Sonobuoys were deployed approximately every 25 nm along the trackline. In addition, one sonobuoy was deployed in the evenings so it could be monitored for the full 8 hour lifespan. Sonobuoys were monitored either in real-time or post-processed the following morning by the acoustician, and presence of species-specific call types was noted (Crance *et al.*, 2017). When in/near high density areas or high priority areas (e.g., Aleutian Passes), additional buoys were deployed. During the right whale survey at the end of the cruise, sonobuoys were deployed continuously during daylight hours to maximize the potential for detecting a right whale (Crance *et al.*, 2017; IWC, 2019a). Handheld radios allowed the acoustic technician to interact with a member of the visual observation team to groundtruth the acoustic detections with the visual sightings. The acoustic technician did not disclose the species detected on the sonobuoys to the observers to avoid biasing the visual surveys.

# 3. SUMMARY OF SIGHTINGS

## 3.1 Identification of species

Guidelines for species identification were based on the IWC-SOWER and IWC-POWER methods for classification of identification (IWC, 2023a). 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. Details of recording procedures during sightings can be found in the ‘Information for Researchers’ document (IWC, 2023a).

### 3.2 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 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. Counts of individual cetaceans found for each sighting are provided in the Sighting summary (section 3.3). The summary provides best estimates of school sizes in the research area, except when indicated otherwise.

### 3.3 Sighting summary

Tables of the 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–e and 2a. 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 shows the summary of photographed sightings with Photo-ID results for individuals and biopsy results for each sighting. Table 4b show the summary of the number of biopsy samples collected by each species. Tables 4c–f summarise North Pacific right, blue, fin and sei whale sightings, photography and biopsy effort during the cruise. Table 5 provides sighting-specific details for all sightings during the cruise, including photo-ID and biopsy information. Tables 6a and 6b show the summary of all sonobuoy deployments, success rates, recording hours, and species detected. Table 7 show the summary of marine debris observations during the cruise.

Figure 1a illustrates the research area and transit course 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–g 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. Figures 4a–4h show the location of all sonobuoy deployments and species detected. Appendix A lists the ship specifications and crew list. Appendix B compares weather conditions (wind speed / visibility) in the research area among past cruises. Appendix C shows all sonobuoy deployments and species detected during the entire cruise. Appendix D summarises the results of the satellite tagging study conducted in the research area. Appendix E summarises the deployment of Long-term Drifting Buoy Recorder (LT-DBR). Appendix F summarises the results of the feasibility study of the seabird sighting survey. Appendix G lists cetacean sightings within US EEZ.

#### *Transit survey to Dutch Harbor (28 July–5 August)*

YS2 departed Shioyama on 28 July on schedule and started transit to Dutch Harbor. Yoshimura boarded the YS2 with all equipment excepting acoustics. Water depths along the trackline were deep (over 4,000 m). Air temperature ranged from 9.4°C to 33.2°C, and sea surface temperature ranged between 5.4°C and 26.5°C. Time-zone was changed in a 23-hour decrement at 1:00 on 29 July, and 1-hour increments at 1:00 on 29, 31 July and 1, 2, 3, 4 August. The local ship time was adjusted to -8:00 UTC. The researcher and crews engaged in preparation for the survey. No survey effort was allocated this week due to poor visibility caused by dense fog and low-pressure systems. YS2 arrived at the Crowley dock at Captain's Bay, Dutch Harbor, Alaska, on 5 August as scheduled. All researchers boarded YS2 with all of the necessary equipment.

#### *The research area*

Details of each week are below.

#### 6–12 August (including transit from Dutch Harbor to the research area)

YS2 departed Dutch Harbor at 09:00 on 7 August, transited to WP101, and commenced surveying on 9 August. YS2 started the survey in the research area from WP101 (52°12.7'N, 155°00.0'W) on 9 August to the northwestward. No survey effort was allocated between Dutch Harbor and WP101. YS2 completed the first northwestward trackline at WP103 (52°25.9'N, 155°12.6'W) at 07:21 hrs on 9 August and continued surveying southwestward on the second trackline from WP104 (52°25.9'N, 155°12.8'W) to the southwest. The water depths along the tracklines were deep (over 3,000 m). Air temperature ranged from 11.9°C to 18.9°C, and sea surface temperature ranged between 7.5°C and

12.7°C. The ship's time was changed by a 1 hour decrement at 1:00 on 8 and 9 August (UTC -10:00 hours). YS2 surveyed in generally good weather conditions although occasionally skipped short sections in off effort due to strong winds. A total searching distance of 207.7 n.miles (NSP: 99.4 n.miles, IO: 108.3 n.miles) was surveyed in acceptable weather conditions. Sightings include fin (6 schools/17 individuals), sei (3/3) and sperm (2/2) whales. A biopsy sample was taken from 1 fin whale. A SPLASH type satellite tag was deployed to a fin whale. The estimated angle and distance training exercise was conducted on the morning of 10 August for a total duration of 3 hours and 40 minutes. A total of 18 sonobuoys were deployed, all of which were successful, for a total of 56.95 hours of monitoring time. Species detected include sperm whales (15 buoys, 83.3%), fin whales (8 buoys, 44.4%), killer whales (8 buoys, 44.4%), and humpback whales (3 confirmed, two possible buoys, 16.7%). The first day of sonobuoy deployments was spent troubleshooting antenna issues. After replacing the omni antenna, the system is now working well. Only one buoy was deployed on 11 August due to inclement weather. A total of 2 items of marine debris were observed.

#### 13–19 August

YS2 continued surveying southwestward on the second trackline covering from WP106 to WP113. The water depths along the tracklines were deep (over 3,000 m). Air temperature ranged from 13.5°C to 21.3°C, and sea surface temperature ranged between 11.6°C and 18.0°C. The ship's time was changed by a 1 hour decrement at 1:00 on 14 August (UTC -11:00 hours). YS2 surveyed in generally good weather conditions although occasionally skipped short sections in off effort or drifted due to fog. A total searching distance of 272.6 n.miles (NSP: 132.4 n.miles, IO: 140.2 n.miles) was surveyed in acceptable weather conditions. Sightings include fin (12 schools/14 individuals), sei (12/15), common minke (1/1), sperm (1/1) and killer (1/1) whales. Biopsy samples were taken from 1 fin and 1 sei whale. A SPLASH type satellite tag was deployed on a sei whale. A total of 21 sonobuoys were deployed, all of which were successful, for a total of 94.47 hours of monitoring time. Species detected include sperm whales (15 buoys, 71.4%), fin whales (8 buoys, 38.1%), killer whales (11 buoys, 52.4%), blue whales (2 confirmed, one possible buoy, 9.5%), and Baird's beaked whales (1 buoy, 4.7%). A total of 7 items of marine debris were observed.

#### 20–26 August

YS2 continued surveying covering from WP113 to WP121. YS2 completed the second southwestward trackline at WP118 (40°00.0'N, 165°42.0'W) on 23 August and continued surveying northwestward on the third trackline from there. The water depths along the tracklines were deep (over 3,000 m). Air temperature ranged from 18.9°C to 26.1°C, and sea surface temperature ranged between 17.9°C and 23.3°C. YS2 surveyed in generally good weather conditions although occasionally skipped short sections in off effort or drifted due to fog and/or strong winds. A total searching distance of 445.6 n.miles (NSP: 245.0 n.miles, IO: 200.6 n.miles) was surveyed in acceptable weather conditions. Sightings include fin (1 school/1 individual) and sperm (3/3) whales. Biopsy samples were taken from 1 fin whale. A SPLASH type satellite tag was deployed on a fin whale. The estimated angle and distance experiment was conducted on 22 August for a total duration of 6 hours and 32 minutes. A total of 23 sonobuoys were deployed, all of which were successful, for a total of 76.56 hours of monitoring time. Acoustic detections were generally in good agreement with visual sightings. Species detected include sperm whales (16 buoys, 69.6%), killer whales (6 buoys, 26.1%), common dolphins (6 buoys, 26.1%), and fin whales (1 buoy, 4.3%). Only one buoy was deployed on 25 August due to inclement weather. Two long-term drifter buoys were deployed on behalf of Barlow. A total of 59 items of marine debris were observed.

#### 27 August–2 September

YS2 continued surveying covering from WP121 to WP125. The water depths along the tracklines were deep (over 3,000 m). Air temperature ranged from 14.6°C to 23.0°C, and sea surface temperature ranged between 13.7°C and 20.0°C. YS2 surveyed in generally good weather conditions, although drifted on 28, 29 and 30 August due to strong winds. A total searching distance of 254.6 n.miles (NSP: 126.8 n.miles, IO: 127.8 n.miles) was surveyed in acceptable weather conditions. Sightings include blue (3 schools/3 individuals), fin (18/29), sei (5/5) and sperm (8/9) whales. Biopsy samples were collected from 3 blue, 5 fin and 4 sei whales. SPOT type satellite tags were deployed on 3 blue whales. SPLASH type satellite tags were deployed on 3 fin and 2 sei whale. A total of 17 sonobuoys were deployed, of which 16 were successful, for a total of 59.68 hours of monitoring time. Acoustic detections were generally in good agreement with visual sightings. Species detected include sperm whales (16 buoys, 100%), fin whales (10 buoys, 62.5%), Pacific white-sided dolphins (4 buoys, 25%), common dolphins (4 buoys, 25%), northern right whale dolphins (2 buoys, 12.5%), killer whales (1 buoy, 6.25%), and earthquakes (1 buoy, 6.25%). Only one buoy was deployed on 28 August, and no buoys were deployed on 29 and 30 August, due to inclement weather. A total of 19 items of marine debris were observed.

#### 3–9 September

YS2 continued surveying covering from WP125 to WP127. The water depths along the tracklines were deep (over 3,000 m). Air temperature ranged from 13.0°C to 20.0°C, and sea surface temperature ranged between 11.4°C and 15.4°C. YS2 surveyed in good weather conditions between 3 and 5 September although skipped short sections in off



effort or drifted due to fog and strong winds between 6 and 8 September. Considering the weather forecast, YS2 transited within the research area from the middle of Leg 127 (47°39.4'N, 175°07.9'W) to westernmost waypoint, WP133 (45°39.4'N, 180°00.0'W), on 8 and 9 September. A total searching distance of 93.6 n.miles (NSP: 41.1 n.miles, IO: 52.5 n.miles) was surveyed in acceptable weather conditions. Sightings include blue (3 schools/3 individuals), fin (9/12), sei (29/37), common minke (1/1), humpback (1/1) and sperm (4/4) whales. Biopsy samples were taken from 1 blue and 1 sei whale. A total of 20 sonobuoys were deployed, of which 19 were successful, for a total of 101.87 hours of monitoring time. Acoustic detections were generally in good agreement with visual sightings. Species detected include sperm whales (19 buoys, 100%), fin whales (13 buoys, 68.4%), blue whales (12 buoys, 63.2%), sei whales (2 buoys, 10.5%), killer whales (10 buoys, 52.6%), Pacific white-sided dolphins (2 buoys, 10.5%), and unidentified dolphins (2 buoys, 10.5%). A total of 2 items of marine debris were observed.

10–16 September (including some portion of transit from the research area to Dutch Harbor)

YS2 continued surveying covering from WP133 to WP129 in that order. YS2 also surveyed from WP128 to the middle of Leg 127 (47°57.8'N, 175°18.0'W). The survey in the research area was completed at 13:38 on 13 September. YS2 commenced transit to Dutch Harbor because there was no hope that YS2 would be able to carry out additional surveys even if YS2 stayed in the research area. The water depths along the tracklines were deep (over 3,000 m). Air temperature ranged from 10.3°C to 17.1°C, and sea surface temperature ranged between 9.9°C and 14.7°C. The ship's time was changed by a 0.5 hour increment at 1:00 on 15 and 16 September (UTC -10:00 hours). YS2 surveyed in generally good weather conditions in the research area. A total searching distance of 202.5 n.miles (NSP: 97.5 n.miles, IO: 105.5 n.miles) was surveyed in acceptable weather conditions. Sightings include blue (3 schools/3 individuals), fin (24/36), sei (14/22) and sperm (6/6) whales. Biopsy samples were taken from 1 sei whale. A SPLASH type satellite tag was deployed on 1 sei whale. A total of 27 sonobuoys were deployed, of which 26 were successful, for a total of 65.26 hours of monitoring time. Species detected include sperm whales (24 buoys, 92.3%), fin whales (21 buoys, 87.5%), blue whales (19 buoys, 79.2%), sei whales (2 confirmed, 1 possible, 8.3%), killer whales (8 buoys, 33.3%), earthquakes (2 buoys, 8.3%), and unknown grunts (1 buoy, 4.2%). Only one buoy was deployed on 16 September due to inclement weather. Overnight transits beginning 13 September meant sonobuoys were not deployed or monitored overnight, resulting in fewer monitoring hours for the remainder of the week. A total of 6 items of marine debris were observed.

17–22 September (transit from the research area to Dutch Harbor including a small scale survey targeting NPRW)

YS2 continued surveying during the transit from the research area to Dutch Harbor. YS2 arrived at the Crowley dock at Captain's Bay, Dutch Harbor at 14:30 on 22 September as scheduled. Three researchers (Murase, Crance and Alps) disembarked, and acoustic equipment and the IWC biopsy samples were offloaded. The water depth along the tracklines ranged from 50 to 500 m. Air temperature ranged from 9.9°C to 13.3°C, and sea surface temperature ranged between 7.8°C and 10.9°C. The ship's time was changed by a 0.5 hour increment at 1:00 on 17 (UTC -9:30) and 21 September (UTC -9:00 hours), and 1 hour increment at 1:00 on 22 September (UTC -8:00). The weather during the transit was a mixture of good and bad conditions. As a part of the transit survey, a small scale opportunistic sighting survey mainly targeting NPRW was conducted south of the Alaska Peninsula between 155°00.0'W and 157°24.0'W (all within the US EEZ) from 17 to 20 September. Given the parameters of the scientific research permit, surveys could not be conducted within the Bering Sea or Gulf of Alaska Critical Habitats; however, the permitted research area extended up to the western side of Kodiak Island. The tracklines were opportunistically set within the area considering past sightings and detected NPRW calls by sonobuoys. A total searching distance of 101.7 n.miles (all in NSP) during the transit was surveyed in acceptable weather conditions. Sonobuoys were deployed continuously to maximize the potential for detecting NPRW calls. Attempts were made to take Photo-ID photographs of NPRW even in off effort if the weather conditions allowed. Sightings include fin (45 schools/83 individuals), right (4/5) and killer (3/8) whales. A total of 20 sonobuoys were deployed, all of which were successful, for a total of 83.99 hours of monitoring time. Species detected include North Pacific right whales (7 buoys, 35.0%), fin whales (20 buoys, 100%), humpback whales (5 confirmed, 2 possible buoys, 25.0%), killer whales (9 buoys, 45%), and sperm whales (2 buoys, 10.0%). When right whales were detected, multiple buoys were deployed simultaneously to localize on the caller's position. As a result, the total monitoring hours are overly inflated.

*Transit survey to Shiogama (25 September–5 October)*

YS2 departed Dutch Harbor at 13:05 on 25 September as scheduled. YS2 left the US EEZ on 28 September and commenced transit survey in the high seas. The water depths along the tracklines were over 3,000 m. Air temperature ranged from 10.7°C to 19.8°C, and sea surface temperature ranged between 7.4°C and 26.6°C. The time-zone was changed on 26, 27, 28, 29, 30 September and 1, 2 October in 1-hour decrements and 4 October in a 24-hour increment. YS2 arrived at the Tohoku dock Co., Ltd., Shiogama at 8:30 on 5 October as scheduled. Yoshimura disembarked, and all the equipment and the Japanese biopsy samples were offloaded. The transit survey was conducted only on 28 September. No survey was conducted between 29 September and 2 October because of poor weather conditions. A total searching distance of 71.1 n.miles in NSP was surveyed in acceptable weather conditions. Sightings include fin (1

school/1 individual), sei (3/3) and killer (1/3) whales. Biopsy, Photo ID and satellite tagging experiments were not attempted. No marine debris was observed.

*Detailed main sightings by each species during the 2023 cruise are as follows:*

#### North Pacific right whale (NPRW, *Eubalaena japonica*)

A minimum of 4 NPRW (potentially 5) in 4 schools were observed approximately 55 n.miles south of Sutwik Island in the Aleutian Islands chain. On 19 September, gunshot calls were detected. After deploying additional buoys, an approximate position was obtained and approximately 20 minutes later, a NPRW was sighted at 55°36.2'N, 157°15.7'W (SST: 9.9°C). Photo-ID photographs were obtained of the left and right sides of the head. The following day, at least 4 NPRW in 3 schools were sighted using acoustic localization. It is unknown whether the animal sighted on 19 September was one of the animals sighted on the 20 September. Their sighting positions and SSTs were 55°42.5'N, 157°19.9'W (10.0°C), 55°43.1'N, 157° 21.6'W (10.1°C) and 55°43.3'N, 157°24.1'W (10.1°C). Although the conditions were adverse (strong winds, big swells and long dive times), three distinct NPRW were photographed. Photo-ID photographs were taken for 4 NPRW in total and no biopsy sample was collected (Table 4c). Efforts to match these individuals to the Photo-ID catalog will be conducted.

#### Blue whale (*Balaenoptera musculus*)

Blue whales were the third most frequently sighted baleen whale in the research area (Table 2a). A total of 9 schools (9 individuals) of blue whales were sighted. Blue whales were mainly distributed in the northern part of the area to the west of 165°W (Figure 2a). Sea surface temperatures of the sighting positions were between 12.9 and 18.5°C (25<sup>th</sup> to 75<sup>th</sup> quartiles: 13.1-14.8°C) (Table 3). Photo-ID photographs were taken for 7 blue whales and biopsy samples were successfully collected from 4 individuals (Table 4d).

#### Fin whale (*Balaenoptera physalus*)

Fin whales were the most frequently encountered baleen whale species in the research area (Table 2a). A total of 70 schools (109 individuals, of which 5 were calves) of fin whales were observed, primarily in the northern part of the research area (Figure 2b). Sea temperatures ranged from 11.6 to 23.1°C (25<sup>th</sup> to 75<sup>th</sup> quartiles: 12.9-14.8°C) (Table 3). Photo-ID photographs were taken for 30 fin whales and biopsy samples were successfully collected from 8 individuals (Table 4e).

#### Sei whale (*Balaenoptera borealis*)

Sei whales were the second most frequently sighted baleen whale in the research area (Table 2a). A total of 63 schools (82 individuals) of sei whales were observed. Sei whales were mainly distributed in the northern part of the area (Figure 2c). Sea surface temperatures ranged from 11.3 to 17.4°C (25<sup>th</sup> to 75<sup>th</sup> quartiles: 11.8-14.5°C) (Table 3). Photo-ID photographs were taken for 9 sei whales and biopsy samples were successfully collected from 7 individuals (Table 4f).

#### Common minke whale (*Balaenoptera acutorostrata*)

A total of 2 schools (2 individuals) were observed (Table 2a, Figure 2d). Sea temperature at sighting locations ranged from 11.8 to 12.0°C (25<sup>th</sup> to 75<sup>th</sup> quartiles: 11.8-12.0°C) (Table 3). In some cases, acceptable sighting conditions were not suitable for cryptic common minke whales. No individuals were photographed, and no biopsy samples were collected.

#### Humpback whale (*Megaptera novaeangliae*)

A total of 1 school (1 individual) was observed (Table 2a, Figure 2e). Sea temperature at the sighting position was 12.9°C (Table 3). The individual was not photographed, and no biopsy samples were collected.

#### Sperm whale (*Physeter macrocephalus*)

Sperm whales were widely distributed throughout the research area (Table 2a, Figure 2f). A total of 25 schools (26 individuals) were sighted. Sperm whales were recorded in waters with SST ranging from 11.6 to 23.3°C (25<sup>th</sup> to 75<sup>th</sup> quartiles: 12.8-17.4°C) (Table 3). No individuals were photographed, and no biopsy samples were collected.

#### Killer whale (*Orcinus Orca*)

A total of 3 schools (5 individuals) were sighted (Table 2a, Figure 2g). Killer whales were recorded in waters with SST ranging from 11.8 to 20.7°C (25<sup>th</sup> to 75<sup>th</sup> quartiles: 16.3-20.7°C) (Table 3). No individuals were photographed, and no biopsy samples were collected.

### 3.4 Resighting During IO Mode

Resight data were recorded for a total of 117 sightings during IO Mode. Table 2c shows the identification of duplicate sightings observed during the 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 8 school sightings made by TOP and IOP and 4 schools made by IOP. A breakdown of the 4 schools includes 2 “Definite duplicate” and 2 “Not duplicate”. For fin whales, there were 57 school sightings made by TOP and IOP and 26 schools made by IOP. A breakdown of the 26 schools includes 18 “Definite duplicate” and 8 “Not duplicate”. For sei whales, there were 32 school sightings made by TOP and IOP and 14 schools made by IOP. A breakdown of the 14 schools sighted by IOP include 6 “Definite duplicate” and 8 “Not duplicate”. For humpback whales, 1 school sighting was made by IOP. For sperm whales, there were 19 school sightings made by TOP and IOP and 10 schools made by IOP. A breakdown of the 10 schools sighted by IOP include 8 “Definite duplicate” and 2 “Not duplicate”.

## 4. PHOTOGRAPHIC DATABASE

Four different species were photographed during the 2023 IWC-POWER cruise. A total of 49 schools were approached close enough to obtain photo-identification images. Of those, 31 were photo-identified within schools; not all have been inter-matched to check for duplicates (see section 4.1). Photo-ID species encountered included: NPRW (4 schools approached / 4 individuals photo-ID’ed), blue (9/7), fin (115/30), sei (63/9) whales (Table 4a, 4c–f). These schools were targeted for biopsy and satellite tagging experiments. Other schools/individuals of fin and sei whales were also photographed but not analysed for unique individuals. A summary of photographed sightings is shown in Table 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.

### 4.1 Individual Identification

Images of photo-ID species were reviewed at the end of each survey day to confirm 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 were species-specific: ventral flukes for humpbacks; left or right head for NPRW; 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 (Tables 4a, c–f). 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 2023 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, not even excellent-quality secondaries.

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.

Photo-identification results are **preliminary** and subject to change after further processing by catalogue curators. Individuals that were documented during the entire cruise including transits, to meet catalogue-quality standards were provisionally identified, including: 2 NPRW (the other 2 individuals could be identified by features other than left or right head), 7 blue, 30 fin, and 9 sei whales (Tables 4a, 4c–f). Images will be made available for incorporation into respective catalogues.

## 5. BIOPSY SAMPLING

Biopsy samples were collected during the entire cruise including transits for 19 individual whales: 4 blue, 8 fin and 7 sei whales (Table 4b). An attempt was made to collect a biopsy sample from a NPRW. Every biopsy encounter was documented photographically. The 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) so that replicate genetic analyses can take place (i.e., an IWC study to take place at the SWFSC genetics laboratory in the USA and a separate, concurrent study

to be conducted by the ICR laboratory). All biopsy samples were catalogued and stored in cryo-vials frozen at a temperature of -30°C on the vessel. All IWC biopsy samples collected in the research area were sent to SWFSC post cruise after arrival at Dutch Harbor under the responsibility of the CL and U.S. researcher, Crance. Samples for Japan remained on the vessel during the return transit and were imported under the CITES permit. 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.

### 5.1 Biopsy data management

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. The time of each biopsy hit was captured photographically, and the exact biopsy time of each biopsy hit was written on the foil wrap for each sample before it was taken to the biopsy lab.

### 5.2 Biopsy efficiency

Biopsy duration times were evaluated to examine biopsy efficiency. Success rates for each species were 80.0% (number of obtained samples (n) =4) for blue, 44.4% (n=8) for fin, 77.8% (n=7) for sei whales, and 0% for NPRW. Median time of biopsy effort duration from setup to sample retrieval when sampling each species was 54 minutes for blue, 23 minutes for fin, and 13 minutes for sei whales. While an effort was made to collect a sample from a NPRW, long dive times and rough seas made attempts difficult, and no sample was collected. Biopsy sampling was attempted as often as time permitted under acceptable environmental conditions.

## 6. VIDEO-RECORDING

Opportunistic video data were collected during the 2023 POWER cruise when biopsy sampling or satellite tagging activities were attempted. These video recordings will not be used in any formal analysis, therefore no data form was recorded.

## 7. ACOUSTIC DATA COLLECTION

A total of 146 sonobuoys were deployed during the cruise (Appendix C). Of these, 143 deployed and transmitted successfully for an overall success rate of 97.98%, the highest of any survey (Table 6a). A total of 538.28 hours of acoustic monitoring occurred during the survey (Table 6b). The location of sonobuoy deployments and species detected are shown in Figures 4 a-h. The most common species detected were sperm and fin whales, detected on 107 (74.8%) and 81 (56.6%) buoys, respectively. Killer whales were the next most common, detected on 53 buoys (37.1%), followed by blue whales (33, 23.1%), common dolphins (10, 6.9%), humpback whales (8, 5.6%), North Pacific right whales (7, 4.9%), Pacific white-sided dolphins (6, 4.2%), and sei whales (4, 2.8%). Other signals detected include northern right whale dolphins (2, 1.4%), Baird’s beaked whales (1, 0.7%), unidentified dolphins (2, 1.4%), and earthquakes (2, 1.4%).

Acoustic detections generally were in good agreement with visual sightings. Sperm and fin whales were the most commonly detected species, and were detected throughout the entire survey area (Figures 4b, e). Killer whales were the third most commonly detected species and were also detected throughout the survey area (Figure 4f). Blue whales were detected more commonly in the northern and western portions of the survey area, similar to the visual sightings (Figure 4a). While there were more acoustic detections than there were visual sightings, the high amplitude and low frequency of blue whale calls results in long propagation distances, and therefore a greater detection range. NPRW were only detected on a handful of buoys, but these corresponded to their exact location and sighting positions (Figure 4g). Humpbacks were relatively uncommon and only detected close to the coast within the US EEZ (Figure 4d).

Species where acoustic detections did not align with visual sightings were sei, sperm, killer whales, and dolphins. Surprisingly, very few sei whale calls were detected, and only in the western portion of the survey area, despite the high number of sei whale sightings (Figure 4c). Sei whale downsweeps and blue whale D calls (downsweeps) share many acoustic characteristics and are very difficult to tell apart. As such, caution was used when positively attributing these calls to species. Future cruises that can obtain focal follow data of vocalizing sei whales would be extremely beneficial in helping to distinguish between calls of these two species. Sperm whales are more easily detected acoustically than visually, due to extremely long dive times and their highly vocal nature. Killer whales are likewise very vocal and are therefore often a better candidate for acoustic monitoring. Conversely, dolphins often occur in large groups that are easily seen, and their high frequency vocalizations do not propagate as far. As such, they are more frequently sighted than they are acoustically detected (Figure 4h). Finally, there were zero minke whale acoustic detections despite two visual sightings. The acoustic results, which nicely complement the visual results, in particular the localization and subsequent sighting of at least four NPRW, again show the benefit of including passive acoustics in a vessel survey.

## 8. OTHER EXPERIMENTS

### 8.1 Estimated Angle and Distance Training Exercise

The Estimated Angle and Distance Training Exercise was conducted in the morning of 10 August for a total duration of 3 hours 40 minutes. During the exercise, observers familiarised themselves with distance estimates from the top barrel and upper bridge. Following advice from the SC and the TAG, the 2023 survey adopted several improvements for this experiment as in the cases of previous surveys (IWC, 2017a). The improvements 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 including researchers as well as the crew in the experiment using the recommended buoy (to simulate a whale's body rather than the blow).

### 8.2 Estimated Angle and Distance Experiment

The Estimated Angle and Distance Experiment was conducted on 22 September for 6 hours 33 minutes whilst in the research area. A total of 84 trials were conducted for each platform (TOP and IO barrels and upper bridge). Both the Estimated Angle and Distance Training Exercises and Experiments were performed using the improved protocol (IWC, 2017b, see also above). Details of the results will be analysed and reported to the TAG after the conclusion of the cruise.

### 8.3 Marine debris observations

During this cruise 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. As agreed during the pre-cruise meetings, systematic data collection of marine debris was limited to the first 15 minutes of each hour, as time permitted (not to interfere with marine mammal 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.

A total of 95 marine debris objects were observed. 56 items were recorded "on effort" (i.e., during the first 15 minutes of each hour) and 39 items were recorded during "off effort" (Table 7).

### 8.4 Satellite tagging studies

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 recognition in 2023 IWC-POWER planning meeting (IWC, 2024a), satellite tags were deployed during the survey in the research area (all in the high seas) at the discretion of the Cruise Leader and Captain. The details are shown in Appendix D.

### 8.5 Deployment of Long-term Drifting Buoy Recorder (LT-DBR)

At the planning meeting in 2022, the potential of using drifting buoy recorders to collect beaked whale acoustic data was discussed and agreed that this was possible (IWC, 2024a). Two drifting buoy recorders (Long-term Drifting Buoy Recorder, LT-DBR) were deployed during the cruise to record acoustic data from beaked whales in the central North Pacific. LT-DBRs can record higher frequency sounds and remain deployed for considerably longer (months vs hours) than sonobuoys. The details are shown in Appendix E.

### 8.6 Feasibility study of seabird sighting survey

On 3 August 2023, Brownell circulated an e-mail to the steering group to propose recording of seabirds observed during the survey, considering Alps's expertise, and hoping to collect more information on the changing oceanographic conditions in North Pacific. The steering group generally agreed to the proposal by the time of the pre-cruise meeting in Dutch Harbor. However, the decision on the detailed survey methods was left to the researchers to be finalized because an instruction manual was not provided. The meeting considered the amount of workload for Alps, given his duties as photo database manager, and decided that writing down every sighting and every time could be too labour intensive and agreed that the seabird sighting survey be conducted as a feasibility study (Anon, 2023c). Instead, the researcher wrote down the summary of species and approximate numbers seen within 300 m from the vessel, from 0° to 90° on the starboard side for the first 15 min. of each effort hour (except during off-effort) in a similar manner to marine debris, rather than recording each individual sighting. The seabird sighting survey was conducted only in the research area. This was the first attempt to conduct a seabird sighting survey within the framework of POWER programme. The details are shown in Appendix F.

## 9. TECHNICAL MATTERS OF DATA AND RECOMMENDATIONS

### 9.1 Radios for onboard communications by researchers

Previously, it has been recommended that VHF marine radios be purchased for use by the acoustician and photographers. On the 2023 cruise, the researchers used specified low power radios provided by the vessel to communicate during the survey day as a test case. The radios may also be used in the future for coordination between the acoustician and upper bridge when localizing on whales and for researchers on separate platforms to ensure they photograph different individuals/groups, in order to maximise the number of individuals that are photographed. It is **recommended** that the researchers be able to use VHF radios provided by the vessel on future cruises.

### 9.2 Photographic database processing in Lightroom (LR)

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. 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 with the date created and that hard and electronic copies are made available on future cruises. In advance of the cruise, a short virtual workshop on the usage of LR was held on 6 August. Jess Taylor (IWC) acted as the instructor of the workshop and Murase and Alps participated. The workshop was informative for the researchers, especially Alps who joined the POWER cruise for the first time. The researchers thanked Taylor and **recommended** that the workshop be held in the future cruises. 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” where possible to minimize the number of images for LR processing. For 2023, a 27 inch touch screen monitor was provided by the ICR. This was a welcome upgrade and considerably improved the efficiency of photographic data processing. It is **recommended** that this monitor be available to researchers in future POWER cruises. Finally, it is **recommended** that the newest version of LR is installed on the IWC-POWER laptop with an up-to-date catalogue prior to the 2024 POWER cruise.

### 9.3 Computer Data entry

ICR has developed and implemented an electronic data entry program. This system is extremely helpful for rapid processing of data and day to day summaries of effort. The system is currently only in Japanese. It is **recommended** that ICR continues the maintenance of the data entry system. Currently, the monitor with the sighting “map” input by the officers in the bridge are used in the upper bridge and available for the CL and other researchers to view. It is very helpful for distinguishing resightings, especially during IO mode or high density areas. However, it would be more useful if the map is linked to the data entry system (i.e., mapping function is integrated to the data entry system and sighting data input in the system are displayed on the map). It is **requested** that development of such function be considered as a part of the mid-long term plan. It is suggested that another 27 inch touch screen monitor for data management be provided to enhance working efficiency of data management in the laboratory onboard the YS2.

### 9.4 Reconsideration and consolidation of data recording forms

Weather, effort and sighting data during the survey have been recorded using the ‘onboard data collecting system’ developed by ICR since the 2010 POWER cruise. Some of these items have also been duplicated in the IWC standardized written forms as backups. The electronic data system has been in operation for 14 years without critical failure. While planning the medium-long term IWC-POWER programme, it is **recommended** that the paper records for weather, effort and sighting data be abolished and that consideration be given to moving to paperless data recording.

Following the formats of previous IDCR/SOWER surveys, the researchers of POWER still use separate data recording forms for three types of experiments (i.e., biopsy, natural marking and satellite tagging). However, many of the items recorded on these forms overlap (e.g., form numbers, date, time, sighting number and species) because these experiments are conducted simultaneously and targeted on the same school. Recording duplicate information is labor intensive for researchers and is likely to lead to recording errors. While planning of the medium-long term IWC-POWER programme, it is **recommended** that these three types of recording forms be combined into one recording form.

It is **recommended** a small group be established consider reorganization of data recording forms led by Yoshimura with a decade of his experience in the POWER programme.

### 9.5 Feasibility study of seabird sighting survey

This was the first attempt to determine the feasibility of conducting a seabird sighting survey within the framework of the POWER programme. The decision to conduct this study was made just before the start of the 2023 POWER survey without a detailed instruction manual. The survey methodology was discussed and agreed upon at the pre-cruise meeting

in Dutch Harbor. Post-survey discussions determined that while potentially feasible in future surveys, it would be easier to note presence/absence of species on a daily basis, rather than attempting to get individual counts for the first 15 minutes of each effort hour. Continuation of seabird sighting for first 15 minutes of each effort hour could be difficult when whales occur in high densities because of frequent approaching to whale sightings. However, it must be noted that Alps was uniquely qualified to conduct this survey, given his extensive knowledge of both marine mammals and seabirds. Future researchers would need to demonstrate a similar level of expertise for this survey to be possible. Additionally, in this survey, one researcher was responsible for both the seabird sighting survey and the photo-ID database management. For this reason, the amount of work for opportunistic photographing (e.g., fin and sei whales) was reduced in comparison with previous years, while the time spent organizing the LR database increased due to the addition of seabird photographs. It is **recommended** that the steering group clarify the objectives of future seabird sighting surveys and develop an instruction manual in line with the objectives, as well as considering the balance with other high priority tasks of the POWER programme.

#### 9.6 Replacement of sonobuoy antenna cables

The cables currently in use for the sonobuoy antennas were installed in the vessel in 2017. While still in good working condition, they are starting to show signs of age and slightly reduced signal quality. It is **recommended** that the cables be replaced within the next two to three years. AFSC can provide the antenna cable, but installation of new cables will require considerable effort by the ship's crew. It is **recommended** that cables be replaced regularly every 8 to 10 years thereafter.

### 10. CONCLUSIONS

The 14<sup>th</sup> annual IWC-POWER cruise was successfully conducted using the Japanese R/V *Yushin-Maru No.2* under approved international status. Dutch Harbor was the port 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 SC (IWC, 2012c). 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, and digital images with the database will be provided to the IWC secretariat by Koji Matsuoka as confirmed during the post-cruise meeting on 24 September 2023 in Dutch Harbor and 6 October 2023 in Shioyama. The inclusion of acoustic data collection was successfully conducted and detected numerous marine mammal species, including the localization and subsequent sighting of at least four NPRW. The 19 IWC biopsy samples have been shipped to and received by SWFSC for final processing; the other half of samples remained on board the vessel for importing into Japan under the GOJ CITES permit. This cruise provides critical information on the distribution, abundance and stock structure of baleen whale species, in particular blue, fin and sei whales, in a poorly known and logistically difficult area. Additional information on other cetacean species, in particular sperm whales, found to be widely distributed in the whole research area 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 the POWER program and whale management research in the near future.

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### REFERENCE

- Anon. 2023a. 2023 IWC/POWER Cruise, Information for Researchers. 55pp. Available from the IWC Secretariat.  
Anon. 2023b. Report of the pre-cruise meeting for the 2023 IWC-POWER Cruise in Shioyama. 8pp. Available from the IWC Secretariat.

- Anon. 2023c. Report of the pre-cruise meeting for the 2023 IWC-POWER Cruise in Dutch Harbor. 9pp. Available from the IWC Secretariat.
- Anon. 2023d. Lightroom processing during cruise. 10pp. Available from the IWC Secretariat.
- 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. Species Res.* 34: 251-267.
- Institute of Cetacean Research, 2013. The Outline of the ICR Accurate information System (ICRAS). 13pp. Available from the IWC Secretariat.
- IWC. 2012a. Report of the Intersessional Meeting on the North Pacific Survey Programme. Tokyo 27-28 September 2009. *J. Cetacean Res. Manage.* (Suppl.) 12:413-420.
- IWC. 2012b. Report of the Workshop on Planning for an IWC Co-ordinated North Pacific Research Programme. Tokyo 28 September -1<sup>st</sup> October 2010. *J. Cetacean Res. Manage.* (Suppl.) 13:371-391.
- IWC. 2012c. Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme. *J. Cetacean Res. Manage.* 13 (Suppl.):507-18
- IWC. 2013. Report of the Technical Advisory Group (TAG) meeting on the short and medium term objectives and plans for the IWC-POWER cruises. Tokyo 26-28 September 2011. *J. Cetacean Res. Manage.* (Suppl.) 14:341-356.
- IWC. 2014. Report of the Planning Meeting for the 2013 IWC-POWER Cruise. Tokyo 25-26 October 2012. *J. Cetacean Res. Manage.* (Suppl.) 15:425-435.
- IWC. 2016a. Report of the meeting of the IWC-POWER Technical Advisory Group (TAG). *J. Cetacean Res. Manage.* (Suppl.) 17:443-458. 16pp.
- IWC. 2016b. Report of the Planning Meeting for the 2014 IWC-POWER Cruise in the North Pacific, *J. Cetacean Res. Manage.* (Suppl.) 17:459-470. 12pp.
- IWC. 2017a. Report of the meeting of the IWC-POWER Technical Advisory Group (TAG). *J. Cetacean Res. Manage.* (Suppl.) 18:461-475.
- IWC. 2017b. Report of the Planning Meeting for the 2016 IWC-POWER Cruise in the North Pacific, *J. Cetacean Res. Manage.* (Suppl.) 18:477-488.
- IWC. 2019a. Report of the Planning Meeting for the 2017 IWC-POWER Cruise in the North Pacific with Initial Discussions for the 2019 and 2019 cruises. *J. Cetacean Res. Manage.* (Suppl.) 19:493-506.
- IWC. 2019b. Report of the Planning Meeting for the 2019 and 2019 IWC-POWER Cruises in the North Pacific, SC/67B/Rep04.27pp. (unpublished).
- IWC. 2020a. Report of the meeting of the IWC-POWER Technical Advisory Group (TAG). Paper SC/68B/Rep01 presented to the 68B IWC Scientific Committee, April-May 2020.24pp. (unpublished).
- IWC. 2020b. Report of the Planning Meeting for the 2020 IWC-POWER cruise. Paper SC/68B/Rep02 presented to the 68B IWC Scientific Committee, April-May 2020. 15pp. (unpublished).
- IWC. 2021a. Report of the Meeting of the IWC-POWER Technical Advisory Group (TAG), January 2020. *J. Cetacean Res. Manage.* (Suppl.) 22:233-257.
- IWC. 2021b. Report of the Meeting of the IWC-POWER Technical Advisory Group (TAG) and 2021 Planning Meeting: November 2020. Paper SC/68C/REP/01Rev01 presented to the IWC Scientific Committee, April-May 2021, (unpublished). 24pp.
- IWC. 2024a. Report of the IWC-POWER Planning Meeting, 6-10 September 2022, Tokyo, Japan. *J. Cetacean Res. Manage.* (Suppl.) in press.
- IWC. 2024b. 2024 Scientific Committee Report (SC69A). *J. Cetacean Res. Manage.* (Suppl.) in press.
- Kato, H., An, Y.R, Bravington, M., Brownell, B., Clapham, P., Donovan, G., Ensor, P., Matsuoka, K., Miyashita, Murase, and Walløe. 2011. Research plan for the 2012 IWC / Japan Joint Cetacean Sighting Survey Cruise in the North Pacific. SC/63/O7. 12pp.
- Larsen, F. 1998. Development of a biopsy system primarily for use on large cetaceans. International Whaling Commission Scientific Committee paper SC/50/O 15. 7 pp.
- Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14.



## TABLES AND FIGURES

Table 1a. The 2023 cruise itinerary. Area code and no. of trackline were used for the effort record for this cruise.

Date (UTC) y/m/d	Time (UTC)	Date (SMT) y/m/d	Time (SMT)	Area code	Ttack Line	Leg No	Position		Remark
2023/7/28	0:20	2023/7/28	9:20	-	-	-	-	-	Departed Shiogama Japan
2023/7/29	15:00	2023/7/29	1:00	-	-	-	39° 06.0'N	145° 08.9'E	Adjusted ship's Time, repeated date of 28th July
2023/7/28	20:30	2023/7/28	6:30	1	1	001	39° 24.1'N	146° 25.5'E	Started transit survey to Dutch Harbor (D.H.)
2023/8/2	5:00	2023/8/1	18:00	1	1	001	47° 58.7'N	173° 56.4'E	Finished transit survey to Dutch Harbor (D.H.)
2023/8/2	11:59	2023/8/2	0:59	11	1	001	48° 28.9'N	175° 40.0'E	US EEZ in
2023/8/3	5:17	2023/8/2	19:17	11	1	001	49° 43.0'N	180° 00.0'	Crossed the meridian of 180° (Date Line)
2023/8/5	20:10	2023/8/5	12:10	-	-	-	-	-	Arrived D.H.
2023/8/7	17:00	2023/8/7	9:00	-	-	-	-	-	Departed D.H.
2023/8/8	16:10	2023/8/8	7:10	11	1	001	53° 23.9'N	159° 52.9'W	Started transit survey from D.H. to R.A
2023/8/9	3:00	2023/8/8	18:00	11	1	001	52° 39.9'N	157° 02.3'W	Finished transit survey from D.H. to R.A
2023/8/9	7:26	2023/8/8	22:26	1	1	001	52° 20.0'N	155° 37.2'W	US EEZ out
2023/8/9	16:00	2023/8/9	6:00	88	1	101	52° 12.8'N	155° 00.2'W	Started survey in research area
2023/9/14	0:38	2023/9/13	13:38	88	1	127	47° 56.2'N	175° 08.7'W	Finished survey in research area
2023/9/14	0:38	2023/9/13	13:38	2	1	002	47° 56.2'N	175° 08.7'W	Started transit from R.A to D.H.
2023/9/14	7:45	2023/9/13	20:45	12	1	002	48° 40.8'N	173° 21.6'W	US EEZ in
2023/9/17	16:55	2023/9/17	7:25	12	1	901	57° 13.5'N	155° 21.9'W	Started NPRW survey (transit from R.A to D.H.)
2023/9/21	3:30	2023/9/20	18:00	12	1	901	55° 05.3'N	158° 34.1'W	Finished NPRW survey (transit from R.A to D.H.)
2023/9/22	3:00	2023/9/21	18:00	12	1	002	54° 21.8'N	165° 17.0'W	Finished transit from R.A to D.H.
2023/9/22	22:30	2023/9/22	14:30	-	-	-	-	-	Arrived D.H.
2023/9/25	21:00	2023/9/25	13:05	-	-	-	-	-	Departed D.H.
2023/9/27	19:17	2023/9/27	9:17	12	1	002	50° 24.7'N	180° 00.0'	Crossed the meridian of 180° (Date Line)
2023/9/28	18:31	2023/9/28	7:31	12	1	002	49° 03.3'N	172° 53.4'E	US EEZ out
2023/9/28	19:25	2023/9/28	8:25	2	1	002	49° 01.2'N	172° 36.7'E	Started transit survey from D.H. to Shiogama
2023/10/4	3:00	2023/10/3	12:00	2	1	002	38° 58.5'N	144° 10.9'E	Finished transit survey from D.H. to Shiogama
2023/10/4	16:00	2023/10/4	1:00	-	-	-	38° 14.3'N	141° 16.0'E	Skipped date of 4 October
2023/10/4	23:30	2023/10/5	8:30	-	-	-	-	-	Arrived Shiogama Japan

Table 1b. Summary of the “Ship's Time Adjustment” Schedule during the 2023 Cruise. JST: Japan standard time.

Date	Ah'd/Ab'k	Balance	Ship's time	Remarks
2023/7/28	-	UTC+9.0h	JST	Departed Japan (Shiogama)
2023/7/29	Ab'k 23hours	UTC-14.0h	JST-23.0h	Repeated date of 28 July
2023/7/29	Ah'd 1hour	UTC-13.0h	JST-22.0h	Transit to Dutch Harbor (D.H)
2023/7/31	Ah'd 1hour	UTC-12.0h	JST-21.0h	-
2023/8/1	Ah'd 1hour	UTC-11.0h	JST-20.0h	-
2023/8/2	Ah'd 1hour	UTC-10.0h	JST-19.0h	-
2023/8/3	Ah'd 1hour	UTC-9.0h	JST-18.0h	-
2023/8/4	Ah'd 1hour	UTC-8.0h	JST-17.0h	-
2023/8/8	Ab'k 1hour	UTC-9.0h	JST-18.0h	Transit from D.H to Research Area (R.A)
2023/8/9	Ab'k 1hour	UTC-10.0h	JST-19.0h	-
2023/8/14	Ab'k 1hour	UTC-11.0h	JST-20.0h	-
2023/9/15	Ah'd 0.5hours	UTC-10.5h	JST-19.5h	-
2023/9/16	Ah'd 0.5hours	UTC-10.0h	JST-19.0h	-
2023/9/17	Ah'd 0.5hours	UTC-9.5h	JST-18.5h	-
2023/9/21	Ah'd 0.5hours	UTC-9.0h	JST-18.0h	-
2023/9/22	Ah'd 1hour	UTC-8.0h	JST-17.0h	-
2023/9/26	Ab'k 1hour	UTC-9.0h	JST-18.0h	-
2023/9/27	Ab'k 1hour	UTC-10.0h	JST-19.0h	-
2023/9/28	Ab'k 1hour	UTC-11.0h	JST-20.0h	-
2023/9/29	Ab'k 1hour	UTC-12.0h	JST-21.0h	-
2023/9/30	Ab'k 1hour	UTC-13.0h	JST-22.0h	-
2023/10/1	Ab'k 1hour	UTC-14.0h	JST-23.0h	-
2023/10/2	Ab'k 1hour	UTC-15.0h	JST-24.0h	-
2023/10/4	Ah'd 24hours	UTC+9.0h	JST	Skipped date of 4 October
2023/10/5	-	UTC+9.0h	JST	Arrived Japan (Shiogama)

Table 1c. Way Points (WP) and each survey mode in the research area. The planned original cruise track line distance in the research area was 1,745.0 n.miles. Also see Figure 1c.

WP	Latitude	Longitude	Co.	Distance	Mode
101	52°12.7'N	155°00.0'W	330°	7.6	NSP
102	52°19.3'N	155°06.3'W	330°	7.7	IO
103	52°25.9'N	155°12.6'W	-	-	-
104	52°25.9'N	155°12.8'W	210°	61.5	NSP
105	51°32.7'N	156°02.9'W	210°	61.5	IO
106	50°39.5'N	156°52.1'W	210°	61.5	NSP
107	49°46.3'N	157°40.3'W	210°	61.5	IO
108	48°53.1'N	158°27.7'W	210°	61.5	NSP
109	47°59.9'N	159°14.2'W	210°	61.5	IO
110	47°06.7'N	160°00.0'W	210°	61.5	NSP
111	46°13.5'N	160°45.0'W	210°	61.6	IO
112	45°20.2'N	161°29.3'W	210°	61.5	NSP
113	44°27.0'N	162°12.9'W	210°	61.5	IO
114	43°33.7'N	162°55.8'W	210°	61.4	NSP
115	42°40.5'N	163°38.1'W	210°	61.5	IO
116	41°47.2'N	164°19.8'W	210°	61.5	NSP
117	40°53.9'N	165°00.9'W	210°	62.2	IO
118	40°00.0'N	165°42.0'W	319°	66.1	NSP
119	40°50.0'N	166°38.8'W	319°	66.2	IO
120	41°40.1'N	167°36.4'W	319°	66.1	NSP
121	42°30.1'N	168°34.7'W	319°	66.1	IO
122	43°20.1'N	169°33.8'W	319°	66.1	NSP
123	44°10.1'N	170°33.7'W	319°	66.1	IO
124	45°00.1'N	171°34.4'W	319°	66.1	NSP
125	45°50.1'N	172°36.0'W	319°	66.1	IO
126	46°40.1'N	173°38.6'W	319°	66.1	NSP
127	47°30.1'N	174°42.1'W	319°	66.4	IO
128	48°20.4'N	175°47.1'W	-	-	-
129	48°15.6'N	176°41.9'W	221°	51.7	NSP
130	47°36.5'N	177°32.4'W	221°	51.7	IO
131	46°57.4'N	178°22.3'W	221°	51.7	NSP
132	46°18.3'N	179°11.5'W	221°	51.5	IO
133	45°39.4'N	180°00.0'	-	-	-
Total				<b>1,745.0</b>	

Table 1d. List of area code and leg number code used for the effort record during the 2023 cruise.

Area Code	Definition
1	Transit survey from Shiogama to Dutch Harbor (D.H.) and transit from D.H. to research area (All High Sea)
11	Transit survey from Shiogama to D.H. and transit from D.H. to research area (All US-EEZ)
88	Research Area (original track line WP101-WP133)
12	Transit from R.A to D.H. (including NPRW survey ) and transit survey from D.H. to Shiogama ( All US EEZ)
2	Transit survey from D.H. to Shiogama (High Sea)

Leg.No	Definition
001	Transit survey from Shiogama to D.H. and transit D.H. to R.A (WP101)
101-132	Research Area (original track line)
002	Transit from R.A (WP133) to D.H and transit survey from D.H. to Shiogama
901	NPRW survey (transit from R.A to D.H.)
999	Off-effort transit from WP103 to WP104, WP128 to WP129 and other (staying port)

Table 1e. Summary of the searching effort (time and distance) and experimental time (hours) by each survey with the area code conducted during the 2023 Cruise.

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 D.H. (Leg 001)	1	001	28-Jul.	1-Aug.	0:00:00	0.00	0:00:00	0.00	0:00:00	0.00	0:00:00	0:00:00
	High Sea	-	6:30	18:00								
Shiogama to D.H. and D.H to R.A (Leg 001)	11	001	2-Aug.	8-Aug.	0:00:00	0.00	0:00:00	0.00	0:00:00	0.00	0:00:00	0:00:00
	US EEZ	-	7:50	18:00								
Research Area (Leg 101 - 132)	88	101	9-Aug.	13-Sep.	64:27:50	742.29	63:25:17	734.28	127:53:07	1476.57	16:29:19	10:12:30
	All High Sea	127	6:00	13:38								
R.A to D.H (Leg 002)	2	002	13-Sep.	13-Sep.	0:00:00	0.00	0:00:00	0.00	0:00:00	0.00	0:00:00	0:00:00
	High Sea	-	13:38	17:50								
R.A to D.H (Leg 002)	12	002	14-Sep.	16-Sep.	0:00:00	0.00	0:00:00	0.00	0:00:00	0.00	0:00:00	0:00:00
	US EEZ	-	7:00	17:40								
NPRW survey (transit from R.A to D.H.) (Leg 901)	12	901	17-Sep.	20-Sep.	8:37:01	101.67	0:00:00	0.00	8:37:01	101.67	3:28:02	0:00:00
	US EEZ	-	7:25	18:00								
R.A to D.H and D.H. to Shiogama (Leg 002)	12	002	20-Sep.	28-Sep.	0:00:00	0.00	0:00:00	0.00	0:00:00	0.00	0:00:00	0:00:00
	US EEZ	-	18:00	7:31								
D.H to Shiogama (Leg 002)	2	002	28-Sep.	3-Oct.	5:37:23	71.13	0:00:00	0.00	5:37:23	71.13	0:00:00	0:00:00
	High Sea	-	8:25	12:00								
Total			28-Jul.	3-Oct.	78:42:14	915.09	63:25:17	734.28	142:07:31	1,649.37	19:57:21	10:12:30
			6:30	12:00								

Table 2a. Number of sightings for all species observed in the research area (Original trackline and transit tracklines in research area between WP) by effort mode. 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. Transit between R.A. and D.H. and Shiogama and D.H. are summarized in Table 2b.

Species	NSP			IO			OE			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Blue whale	1	1	0	8	8	0	0	0	0	9	9	0
Fin whale	28	44	3	40	59	2	2	6	0	70	109	5
Like fin	0	0	0	2	3	0	0	0	0	2	3	0
Sei whale	34	49	0	27	31	0	2	2	0	63	82	0
Like sei	1	2	0	1	1	0	0	0	0	2	3	0
Common minke whale	2	2	0	0	0	0	0	0	0	2	2	0
Humpback whale	0	0	0	1	1	0	0	0	0	1	1	0
Sperm whale	12	13	0	12	12	0	1	1	0	25	26	0
Like sperm	0	0	0	1	1	0	0	0	0	1	1	0
Mesoplodon	0	0	0	1	3	0	0	0	0	1	3	0
Ziphiidae	3	8	0	4	4	0	0	0	0	7	12	0
Killer whale	3	5	0	0	0	0	0	0	0	3	5	0
Risso's dolphin	1	13	0	0	0	0	0	0	0	1	13	0
Common dolphin	3	143	13	1	66	3	0	0	0	4	209	16
Pacific white-sided dolphin	5	250	11	1	19	1	0	0	0	6	269	12
Northern right whale dolphin	2	72	4	1	13	1	0	0	0	3	85	5
Dalli type Dall's porpoise	4	22	1	7	22	0	1	4	0	12	48	1
Unid. type Dall's porpoise	6	24	0	2	5	0	0	0	0	8	29	0
Unid. large baleen whale	5	5	0	14	14	0	1	1	0	20	20	0
Unid. dolphin	2	35	0	1	4	0	0	0	0	3	39	0
Unid. large cetacean	2	2	0	4	4	0	0	0	0	6	6	0
Unid. small cetacean	0	0	0	2	2	0	0	0	0	2	2	0
Unid. cetacean	2	2	0	4	4	0	0	0	0	6	6	0

Table 2b. Number of sightings for all species observed during the entire 2023 cruise. Numbers of Individuals includes number of calves.

Species	Transit to Dutch Harbor (D.H.) (High Sea, area code 1, leg 001)			Transit to D.H. (US EEZ, area code 11, leg 001)			Transit from D.H. to Research Area (R.A) (US EEZ, area code 11, leg 001)			Research Area (All High Sea, area code 88)			Transit from R.A to D.H. (High Sea, area code 2, leg 002)			NPRW survey (transit from R.A to D.H.) (All US EEZ, area code 12, leg 901)			Transit from R.A to D.H. (US EEZ, area code 12, leg 002)			Transit to Shioyama (US EEZ, area code 12, leg 002)			Transit to Shioyama (High Sea, area code 2, leg 002)			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Blue whale	0	0	0	0	0	0	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9	0
Fin whale	0	0	0	0	0	0	0	0	0	70	109	5	0	0	0	45	83	1	0	0	0	0	0	0	1	1	0	116	193	6
Like fin	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	5	6	0	0	0	0	0	0	0	0	0	0	7	9	0
Sei whale	0	0	0	0	0	0	0	0	0	63	82	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	66	85	0
Like sei	1	1	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0
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	0	0
Common minke whale	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
Like minke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0
Humpback whale	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
North Pacific right whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	0	0	0	0	0	0	0	0	0	0	4	5	0
Sperm whale	0	0	0	0	0	0	0	0	0	25	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	26	0
Like sperm	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Mosoplodon	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
Ziphiidae	0	0	0	0	0	0	0	0	0	7	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	12	0
Killer whale	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	3	8	0	0	0	0	0	0	0	1	3	0	7	16	0
Risso's dolphin	0	0	0	0	0	0	0	0	0	1	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0
Common dolphin	0	0	0	0	0	0	0	0	0	4	209	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	209	16
Pacific white-sided dolphin	0	0	0	0	0	0	0	0	0	6	269	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	269	12
Northern right whale dolphin	0	0	0	0	0	0	0	0	0	3	85	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	85	5
Dalli type Dall's porpoise	0	0	0	0	0	0	0	0	0	12	48	1	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	13	52	1
Unid.type Dall's porpoise	0	0	0	0	0	0	0	0	0	8	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	29	0
Unid. large baleen whale	0	0	0	0	0	0	0	0	0	20	20	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	21	21	0
Unid. Dolphin	0	0	0	0	0	0	0	0	0	3	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	39	0
Unid. large cetacean	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	0
Unid. small cetacean	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
Unid. cetacean	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	7	7	0
Total	1	1	0	0	0	0	0	0	0	257	982	39	0	0	0	61	109	1	0	0	0	0	0	0	5	7	0	324	1,099	40

Table 2c. Identification of duplicate sightings (main species) observed during survey in Independent Observer (IO) mode (original trackline). 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	8	4	2	0	0	2
Fin whale	57	26	18	0	0	8
Sei whale	32	14	6	0	0	8
Humpback whale	1	1	0	0	0	1
Sperm whale	19	10	8	0	0	2

Table 3. Minimum, maximum range, and 25<sup>th</sup> to 75<sup>th</sup> quartiles of sea surface temperatures in degrees Celsius for each species sighted during the survey in the research area (original trackline). Also noted are the number of sightings for each species.

Species	Number of sightings	Minimum SST	Maximum SST	Temperature range	25 <sup>th</sup> to 75 <sup>th</sup> Quartile
Blue whale	9	12.9	18.5	5.6	13.1-14.8
Fin whale	70	11.6	23.1	11.5	12.9-14.8
Sei whale	63	11.3	17.4	6.1	11.8-14.5
Common minke whale	2	11.8	12.0	0.2	11.9-12.0
Humpback whale	1	12.9	12.9	0.0	-
Sperm whale	25	11.6	23.3	11.7	12.8-17.4
Killer whale	3	11.8	20.7	8.9	16.3-20.7
Ziphiidae	7	13.2	22.8	9.6	15.6-20.5
Common dolphin	4	18.5	22.1	3.6	20.1-22.0
Pacific white-sided dolphin	6	11.6	15.8	4.2	13.5-15.3
Northern right whale dolphin	3	13.2	14.8	1.6	13.8-14.6
Dall's type Dall's porpoise	12	11.4	13.0	1.6	12.1-12.7

Table 4a. Summary of the number of Photo-ID'd individuals by each species.

Photo-ID	Blue	Fin	Sei	Humpback	Right	Killer	Total
Transit from Japan to Dutch Harbor (D.H.) (High Sea, area code 1)	0	0	0	0	0	0	0
Transit from Japan to D.H. (US EEZ, area code 11)	0	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (US EEZ, area code 11)	0	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (High Sea, area code 1)	0	0	0	0	0	0	0
R.A (All High Sea, area code 88)	7	30	9	0	0	0	46
Transit from R.A to D.H. (High Sea, area code 2)	0	0	0	0	0	0	0
NPRW survey (transit from R.A to D.H. (US EEZ, area code 12)	0	0	0	0	2	0	2
Transit from R.A to D.H. (US EEZ, area code 12)	0	0	0	0	0	0	0
Transit from D.H. to Japan (US EEZ, area code 12)	0	0	0	0	0	0	0
Transit from D.H. to Japan (High Sea, area code 2)	0	0	0	0	0	0	0
Sub-total (US-EEZ)	0	0	0	0	2	0	2
Sub-total (High Sea)	7	30	9	0	0	0	46
Total	7	30	9	0	2	0	48

Table 4b. Summary of the number of biopsy samples collected by each species.

Biopsy samples	Blue	Fin	Sei	Humpback	Right	Killer	Total
Transit from Japan to Dutch Harbor (D.H.) (High Sea, area code 1)	0	0	0	0	0	0	0
Transit from Japan to D.H. (US EEZ, area code 11)	0	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (US EEZ, area code 11)	0	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (High Sea, area code 1)	0	0	0	0	0	0	0
R.A (All High Sea, area code 88)	4	8	7	0	0	0	19
Transit from R.A to D.H. (High Sea, area code 2)	0	0	0	0	0	0	0
NPRW survey (transit from R.A to D.H. (US EEZ, area code 12)	0	0	0	0	0	0	0
Transit from R.A to D.H. (US EEZ, area code 12)	0	0	0	0	0	0	0
Transit from D.H. to Japan (US EEZ, area code 12)	0	0	0	0	0	0	0
Transit from D.H. to Japan (High Sea, area code 2)	0	0	0	0	0	0	0
Sub-total (US-EEZ)	0	0	0	0	0	0	0
Sub-total (High Sea)	4	8	7	0	0	0	19
Total	4	8	7	0	0	0	19



Table 4c. Summary of North Pacific right whale sightings, photography (unique individuals) and biopsy effort during the cruise.

North Pacific. Right whale	Total Sightings		Ind. Biopsy	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.				
Transit from Shiogama to Dutch Harbor (D.H.) (High Sea)	0	0	0	0	0	0
Transit from Shiogama to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (US EEZ)	0	0	0	0	0	0
Transit from D.H. to R.A (High Sea)	0	0	0	0	0	0
R.A (All High Sea)	0	0	0	0	0	0
Transit from R.A to D.H. (High Sea)	0	0	0	0	0	0
NPRW survey (transit from R.A to D.H. (US EEZ)	4	5	0	4	4	2
Transit from R.A to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (High Sea)	0	0	0	0	0	0
<b>Total</b>	<b>4</b>	<b>5</b>	<b>0</b>	<b>4</b>	<b>4</b>	<b>2</b>

Table 4d. Summary of blue whale sightings, photography (unique individuals) and biopsy effort during the cruise.

Blue whale	Total Sightings		Ind. Biopsy	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.				
Transit from Shiogama to Dutch Harbor (D.H.) (High Sea)	0	0	0	0	0	0
Transit from Shiogama to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (US EEZ)	0	0	0	0	0	0
Transit from D.H. to R.A (High Sea)	0	0	0	0	0	0
R.A (All High Sea)	9	9	4	7	7	7
Transit from R.A to D.H. (High Sea)	0	0	0	0	0	0
NPRW survey (transit from R.A to D.H. (US EEZ)	0	0	0	0	0	0
Transit from R.A to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (High Sea)	0	0	0	0	0	0
<b>Total</b>	<b>9</b>	<b>9</b>	<b>4</b>	<b>7</b>	<b>7</b>	<b>7</b>

Table 4e. Summary of fin whale sightings, photography and biopsy effort during the cruise.

Fin whale	Total Sightings		Ind. Biopsy	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.				
Transit from Shiogama to Dutch Harbor (D.H.) (High Sea)	0	0	0	0	0	0
Transit from Shiogama to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (US EEZ)	0	0	0	0	0	0
Transit from D.H. to R.A (High Sea)	0	0	0	0	0	0
R.A (All High Sea)	70	109	8	18	33	30
Transit from R.A to D.H. (High Sea)	0	0	0	0	0	0
NPRW survey (transit from R.A to D.H. (US EEZ)	45	83	0	0	0	0
Transit from R.A to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (High Sea)	0	0	0	0	0	0
<b>Total</b>	<b>115</b>	<b>192</b>	<b>8</b>	<b>18</b>	<b>33</b>	<b>30</b>

Table 4f. Summary of sei whale sightings, photography and biopsy effort during the cruise.

Sei whale	Total Sightings		Ind. Biopsy	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.				
Transit from Shiogama to Dutch Harbor (D.H.) (High Sea)	0	0	0	0	0	0
Transit from Shiogama to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Research Area (R.A) (US EEZ)	0	0	0	0	0	0
Transit from D.H. to R.A (High Sea)	0	0	0	0	0	0
R.A (All High Sea)	63	82	7	9	11	9
Transit from R.A to D.H. (High Sea)	0	0	0	0	0	0
NPRW survey (transit from R.A to D.H. (US EEZ)	0	0	0	0	0	0
Transit from R.A to D.H. (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (US EEZ)	0	0	0	0	0	0
Transit from D.H. to Shiogama (High Sea)	0	0	0	0	0	0
<b>Total</b>	<b>63</b>	<b>82</b>	<b>7</b>	<b>9</b>	<b>11</b>	<b>9</b>

Table 5. Summary of Photographed Sightings with Photo-ID results for Individuals, and Biopsy results for Sightings. Primary ID features are main, species-specific identification characteristics. Secondary ID features, and features in brackets, are useful but not enough alone for identification. Body part codes: FL = Flukes, LD = Left dorsal fin, RD = Right dorsal fin, LL = Left lateral, RL = Right lateral, HD = Head, DM = Distinctive marking, OT = Other (e.g., ped = peduncle, PBH = post blowhole callosity). View direction codes: D = Dorsal, V = Ventral, L = Left, R = Right. Body part codes always precede view direction codes. ID Form No = natural marking datasheet form number. BY Form No = Biopsy datasheet form number. S/No = Biopsy sample number is concatenated: Year (23) | Species code (e.g., Blue whale 06) | Boat code (1) | Serial number (consecutive number for all samples throughout the cruise starting at 001). If S/No is N/A no biopsy attempt was made. If S/No is ‘No Sample’ a biopsy attempt was made; i.e., shooters were on standby, but no sample was collected (shots may or may not have been fired). Biopsy sampling encounter duration was calculated using effort code “BX” (on standby with equipment) and “EX” (darts collected time).

Survey Date (Y/M/D)	Sighting Number	Species	School Size	Photographed	Photo Identified	Letters of whale	Results of Primary ID features	Results of Secondary ID features	Biopsied	Letter of Biopsied	ID Form Number	BY Form Number	S/No	Encounter Duration (min)	Photo-ID Notes
2023/8/10	002	Fin whale	5	5	5	A	LD, RD		0	N/A	ID001	001	No sample	30	
						B	LD, RD								
						C	LD, RD								
						D	LD, RD								
						E	LD, RD								
2023/8/10	006	Fin whale	6	3	3	A	LD		1	A	ID002	006	23051001	19	
						B	RD								
						C	RD								
2023/8/14	010	Fin whale	1	1	0	A		LL, HD	0	N/A	ID003	003	No sample	7	21.8m est TL
2023/8/16	003	Fin whale	1	1	1	A	LD	LL, HD	1	A	ID004	004	23051002	4	19.6m est TL. Cookie cutter shark bite scar at bottom trailing edge of dorsal fin
2023/8/18	002	Sei whale	2	2	2	A	LD, RD	LL	1	A	ID005	005	23041001	8	14.6m est TL. Prominent cookie cutter bite scars on left flank
						B	LD								14.2m est TL
2023/8/21	009	Fin whale	1	1	1	A	LD, RD	HD	1	A	ID006	006	23051003	20	17.3m est TL. Very fresh cookie cutter shark bites along dorsal peduncle
2023/8/27	001	Blue whale	1	1	1	A	LD, RD	RL, LL, HD	1	A	ID007	007	23061001	49	17.3m est TL. Animal was very active, even before approached, and surfaced vertically, performing a chin slap almost every time
2023/8/27	006	Sei whale	1	1	1	A	LD		1	A	ID008	008	23041002	17	14.7m est TL. Animal has white round marks (approximately 10cm in diameter) spread over visible parts of its body
2023/8/31	003	Sei whale	1	1	1	A		LL, HD	1	A	ID009	009	23041003	9	12.8m est TL. Animal has white round marks (approximately 10cm in diameter) spread over visible parts of its body. It has a small hole near the trailing edge of the dorsal fin, approximately a third of the way from the bottom
2023/8/31	004	Sei whale	1	1	1	A	LD	LL	1	A	ID010	010	23041004	11	15.9m est TL. Small nick in trailing edge of dorsal fin. Skin is covered in small dimples and small bumps
2023/8/31	005	Fin whale	1	1	1	A	LD, RD	LL, RL	1	A	ID011	011	23051004	19	16.8m est TL. Animal has a series of small bumps on the right flank and a round lesion on the left flank, just posterior to the base of the dorsal fin
2023/8/31	007	Fin whale	2	2	0	A			0	N/A	ID012	012	N/A	21	None of the photos show any identifiable characteristics
						B									
2023/9/1	001	Fin whale	1	1	1	A	RD	RL	0	N/A	ID013	013	N/A	9	20.4m est TL. Many cookie cutter shark bite scars on left flank; dorsal fin bent and scarred by probably killer whale bites
2023/9/1	002	Fin whale	1	1	1	A	LD	LL	0	N/A	ID014	014	N/A	50	Many cookie cutter shark bite scars all over the body; a small hole near the trailing edge of the dorsal fin; a series of small bumps just below and behind the caudal edge of the dorsal fin on the left flank
2023/9/1	004	Fin whale	3	3	3	A	LD		1	A	ID015	015	23051005	49	22.3m est TL. Many cookie cutter bite scars
						B	LD, RD								Calf. 13.1m est TL

Survey Date (Y/M/D)	Sighting Number	Species	School Size	Photographed	Photo Identified	Letters of whale	Results of Primary ID features	Results of Secondary ID features	Biopsied	Letter of Biopsied	ID Form Number	BY Form Number	S/No	Encounter Duration (min)	Photo-ID Notes
						C	LD								19.4m est TL. Unusual mottling pattern to skin, reminiscent of a blue whale
2023/9/1	003	Fin whale	4	4	4	A	RD		0	N/A	ID16	016	N/A	31	Missing tip to dorsal fin
						B	RD								Moderately large hole near trailing edge of dorsal fin, many cookie cutter bite scars on peduncle
						C	LD								Slightly mottled skin pattern
						D	LD								Cookie cutter shark bite scars and superficial scrapes over much of the body
2023/9/1	006	Fin Whale	3	3	3	A	LD, RD		1	A	ID017	017	23051006	6	Cow. 21.8m est TL. Many cookie cutter shark bite scars
						B	LD, RD								Calf. 14m est TL. Faint scratch marks on flank
						C	LD, RD								20.7m est TL. Many cookie cutter bite scars; straight trailing edge to wavy dorsal fin, small hole near trailing edge of dorsal fin and small scoop near bottom of trailing edge of dorsal fin
2023/9/1	007	Fin whale	1	1	1	A	LD, RD		0	N/A	ID018	018	N/A	7	17.8m est TL. Many cookie cutter bite scars
2023/9/1	010	Fin whale	1	1	1	A	RD		0	N/A	ID019	019	N/A	9	20.7m est TL. "Hook" tip to very falcate dorsal fin; Pennella on right flank
2023/9/1	012	Sei whale	1	1	1	A	LD		1	A	ID020	020	23041005	5	9.7m est TL. Prominent cookie cutter shark bite scars on many parts of the body, especially on left flank, below dorsal fin; moderate nick and possible tear in trailing edge of dorsal fin
2023/9/2	001	Fin whale	1	1	1	A	LD, RD		1	A	ID021	021	23051007	12	9.8m est TL. Dorsal fin tall, erect, and slightly bent to the left; prominent, narrow blaze on sides (bottom of chevron); possible diatom film on skin
2023/9/2	002	Blue whale	1	1	1	A	LD, RD	HD	1	A	ID022	022	23061002	61	20.3m est TL. Scattered cookie cutter shark bite marks scattered on body; small, triangular dorsal fin
2023/9/2	008	Fin whale	1	1	1	A	LD, RD		1	A	ID023	023	23051008	15	17.3m est TL.
2023/9/2	010	Fin whale	1	1	1	A	LD, RD		0	N/A	ID024	024	N/A	56	23.1m est TL. Hole through dorsal fin near trailing edge; bump (abscess?) on left side of dorsal fin; also bumps on skin, especially right side of peduncle
2023/9/2	012	Blue whale	1	1	1	A	LD, RD		1	A	ID025	025	23061003	62	23.8m est TL. Many cookie cutter shark bite scars, especially on peduncle and flanks below dorsal fin
2023/9/3	012	Blue whale	1	1	1	A	LD, RD		1	A	ID026	026	23061004	60	24.1m est TL. Notch in trailing edge near bottom of dorsal fin; moderate amount of cookie cutter shark bite scars on flanks; "bump" in area of left shoulder blade
2023/9/3	018	Fin whale	2	2	2	A	LD, RD		0	N/A	ID027	027	N/A	24	Moderate amount of cookie cutter shark bite scars on flanks, as well as some raised "welts;" superficial scratches and gauges
						B	LD								2About 2/3 of the dorsal fin is missing, apparently sliced off in a fairly straight cut;
2023/9/4	028	Sei whale	1	1	1	A	LD		0	N/A	ID028	028	N/A	2	15.2m est TL. Notch on the trailing edge of the dorsal fin near the bottom; some fairly large indentations on the back, anterior to the dorsal fin
2023/9/4	033	Sei whale	2	2	2	A	LD		1	A	ID029	029	23041006	2	14.3m est TL.
						B	LD								13.7m est TL. "Hook" at the tip of very falcate dorsal fin
2023/9/10	002	Blue whale	1	1	1	A	LD, RD		0	N/A	ID030	N/A	N/A	11	22.7m est TL.
2023/9/10	004	Blue whale	1	1	1	A	LD, RD		0	N/A	ID031	N/A	N/A	9	17.9m est TL. Small dorsal fin is deformed and missing a considerable chunk along the lower trailing edge; broad linear marks in skin
2023/9/10	029	Blue whale	1	1	1	A	LD		0	N/A	ID032	030	N/A	20	24.2m est TL. Many cookie cutter bite scars; a couple of mall scoops missing from trailing edge of dorsal fin; anterior edge of dorsal fin appears slightly deformed
2023/9/13	001	Sei whale	1	1	1	A	LD		0	N/A	ID033	031	N/A	25	10.7m est TL. Many cookie cutter shark bite scars
2023/9/13	004	Sei whale	2	1	0	A		LL	1	A	ID034	032	23041007	2	14.1m est TL.
						B									
2023/9/19	026	Right whale	1	1	1	A	HD, PBH		0	N/A	ID035	033	N/A	76	17.2m est TL.
2023/9/20	009	Right whale	1	1	0	A			0	N/A	ID036	N/A	N/A	7	Never saw more than blows
2023/9/20	010	Right Whale	1	1	1	A	HD	Hd	0	N/A	ID037	N/A	N/A	30	15.6m est TL. Wavy right lower lip; 3 golf ball sized bumps below right blowhole
2023/9/20	011	Right Whale	2	2	2	A	HD		0	N/A	ID038	N/A	N/A	30	Appears to have a callosity along the leading edge of the left blowhole
						B	HD								Long callosity paralleling left lower jaw

Table 6a. Success rate per sonobuoy type, manufacturer, and manufacture year for the 2023 IWC-POWER cruise.

Manuf.	Year	Type	# deployed	# successful	% success rate
SPW	2020	53G	57	57	100%
	2014	53F	89	86	96.6%
<b>Total</b>			<b>146</b>	<b>143</b>	<b>97.9%</b>

Table 6b. Weekly summary of successful sonobuoy deployments (total # deployed sonobuoys), recording hours, and species detected on # of buoys (possible detections).

Dates	# successful # deployed)	Recording time (hh:mm:ss)	Fin whale	Killer whale	Sperm whale	NPRW	Humpback whale	Blue whale	Sei whale	Common dolphins	Pacific white- sided dolphin	Other
6-12 August	18 (18)	57:02:57	8	8	15	0	3 (2)	0	0	0	0	
13-19 August	21 (21)	94:28:25	8	11	15	0	0	2 (1)	0	0	0	Baird's beaked whale - 1
20-26 August	23 (23)	76:33:20	1	6	16	0	0	0	0	6	0	
27 August - 2 September	16 (17)	59:41:05	10	1	16	0	0	0	0	4	4	Northern right whale dolphin - 2 Earthquake - 1
3-9 September	19 (20)	101:52:10	13	10	19	0	0	12	2	0	2	Unidentified dolphins - 2
10-16 September	26 (27)	65:15:20	21	8	24	0	0	19	2 (1)	0	0	Earthquake - 2 Unknown grunts - 1
17-22 September	20 (20)	83:23:26	20	9	2	7	5 (2)	0	0	0	0	
<b>TOTAL</b>	<b>143 (146)</b>	<b>538:16:43</b>	<b>81</b>	<b>53</b>	<b>107</b>	<b>7</b>	<b>8 (4)</b>	<b>33 (1)</b>	<b>4 (1)</b>	<b>10</b>	<b>6</b>	Baird's beaked whale - 1 Northern right whale dolphin - 2 Unidentified dolphins - 2 Earthquake - 2

Table 7. Summary of marine debris observations in the research area. 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
134	Single fishing float	25	13	38
136	Wood plank	1	0	1
142	Metal can, 1 litre or less	1	2	3
143	Metal can, 1-50 litres	2	0	2
145	Metal can, 150-250 litres	1	0	1
147	Styrofoam, unidentified	1	1	2
148	Styrofoam board, less than 1 square metre	3	4	7
151	Styrofoam box (at least 2 sides)	1	0	1
161	Plastic, unidentified	2	2	4
162	Plastic, less than 1 square metre	6	2	8
165	Plastic bag, small	0	1	1
166	Plastic garbage bag, empty	1	0	1
199	Other	12	14	26
<b>Total</b>		<b>56</b>	<b>39</b>	<b>95</b>

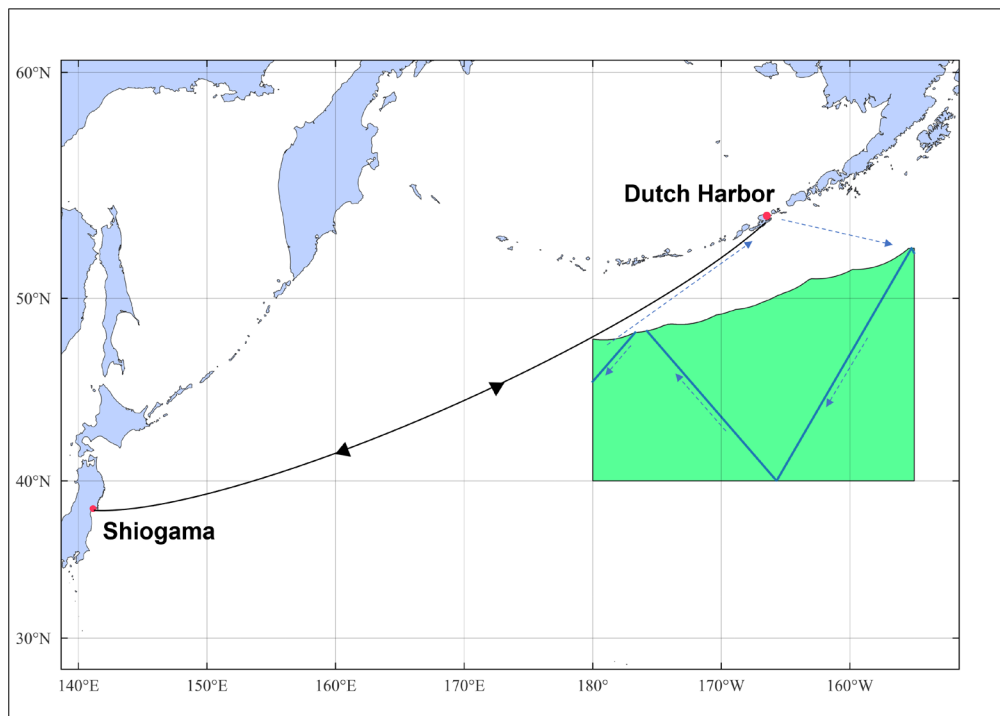


Figure 1a. Research area (green) for the 2023 IWC-POWER cruise.

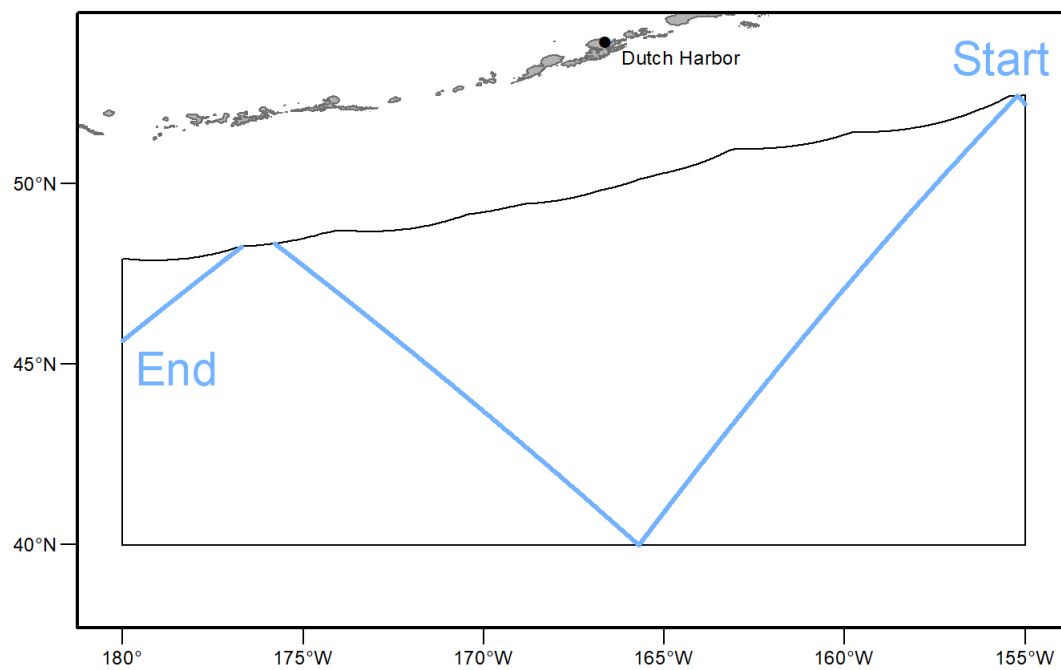


Figure 1b. Predetermined cruise track lines and start and end points within the main survey area for the 2023 IWC-POWER cruise survey.

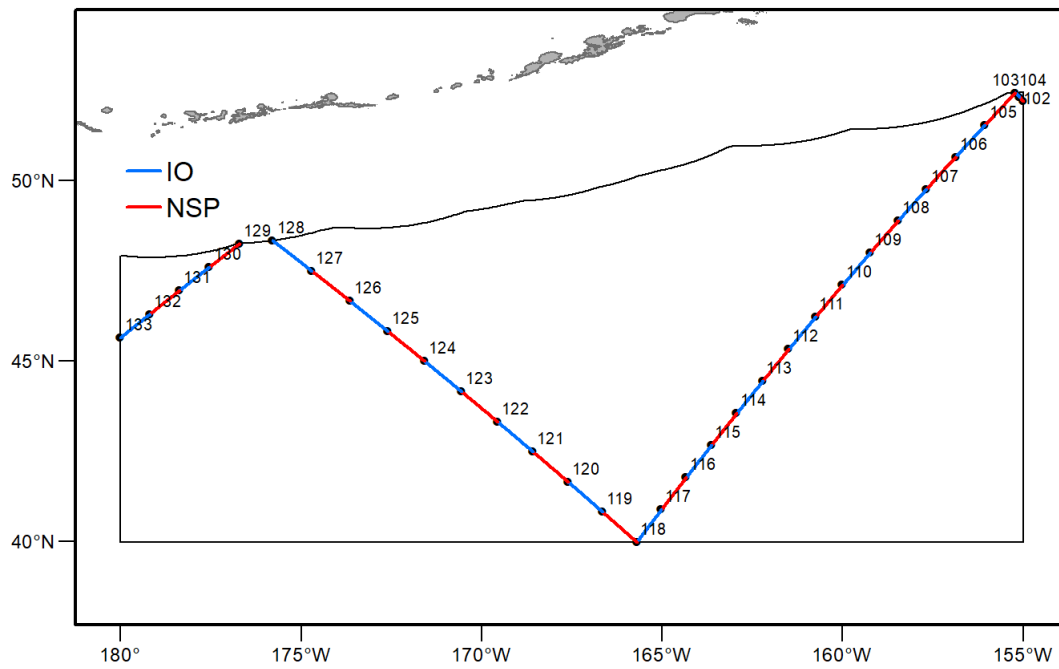


Figure 1c. The waypoint number and course directions taken within the main survey area for the 2023 IWC-POWER cruise survey. The survey modes (IO and NSP) were switched at each waypoint.

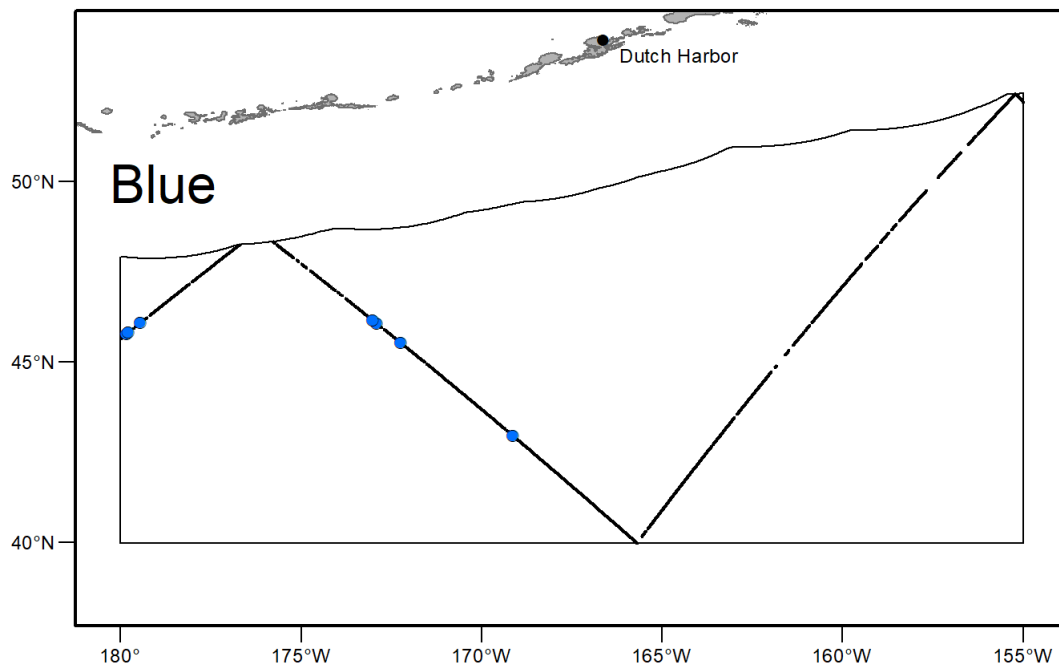


Figure 2a. The searching effort (thin line) and primary sighting positions (blue circles) of blue whales during the 2023 IWC-POWER cruise.

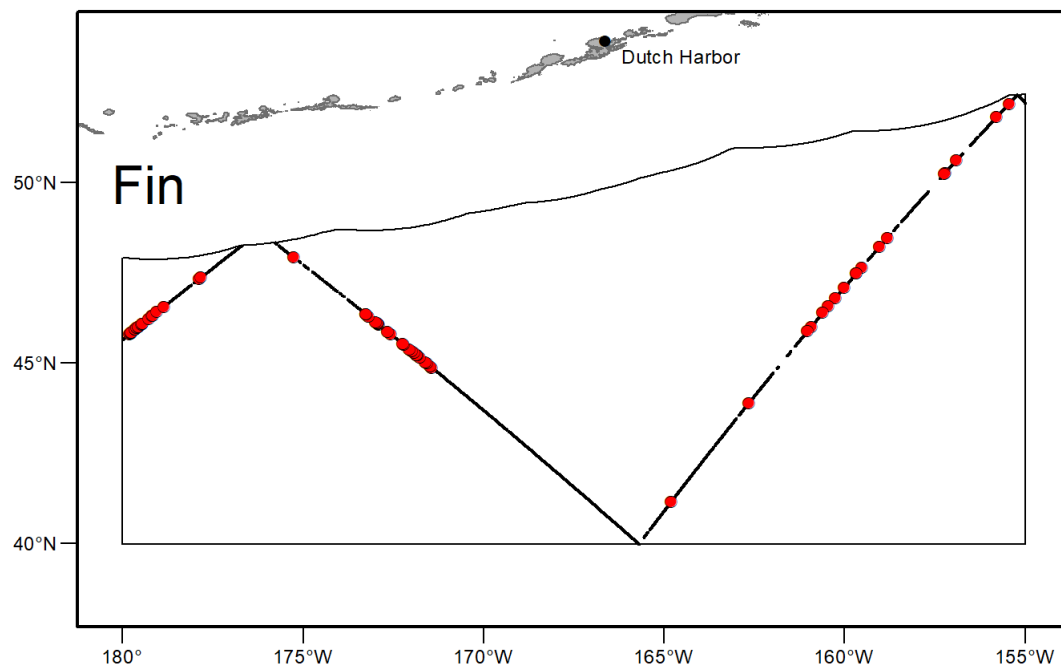


Figure 2b. The searching effort (thin line) and primary sighting positions (red circles) of fin whales during the 2023 IWC-POWER cruise.

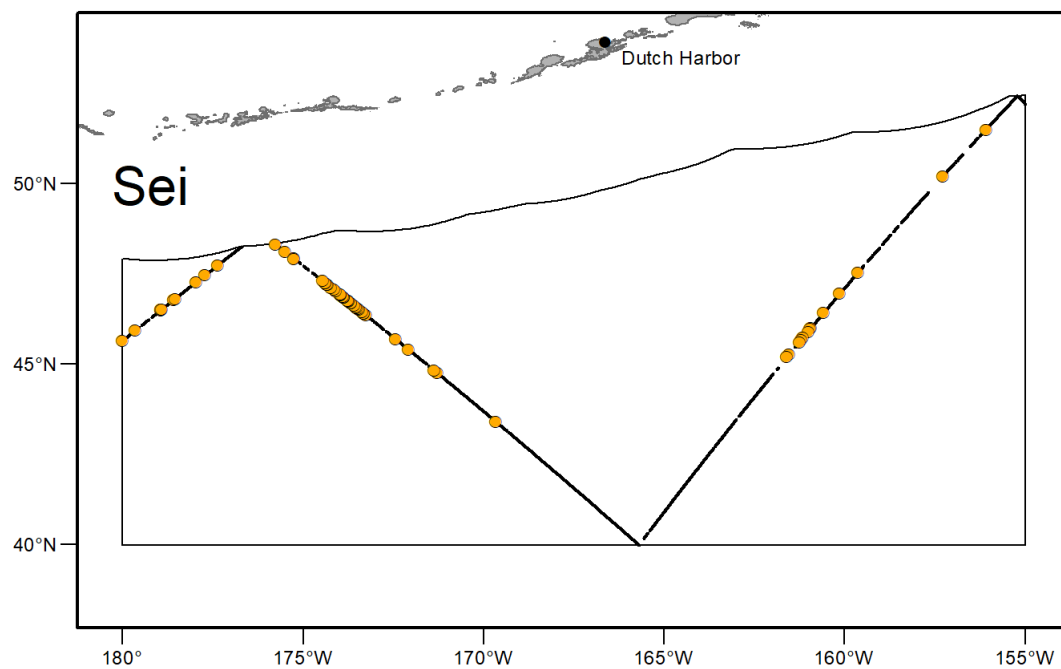


Figure 2c. The searching effort (thin line) and primary sighting positions (orange circles) of sei whales during the 2023 IWC-POWER cruise.



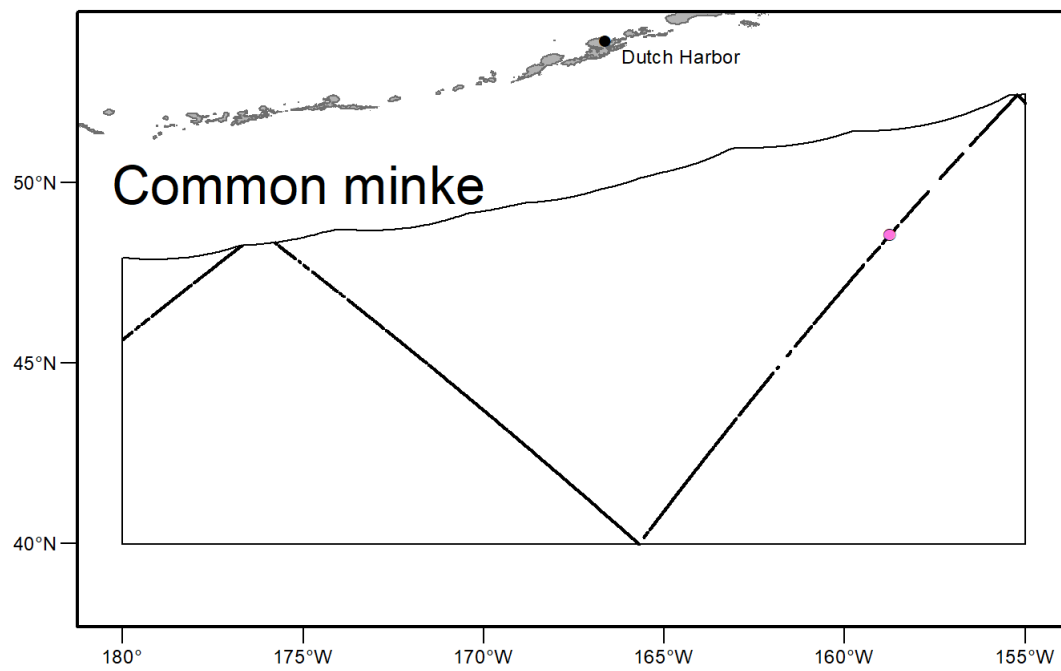


Figure 2d. The searching effort (thin line) and primary sighting positions (pink circles) of common minke whales during the 2023 IWC-POWER cruise.

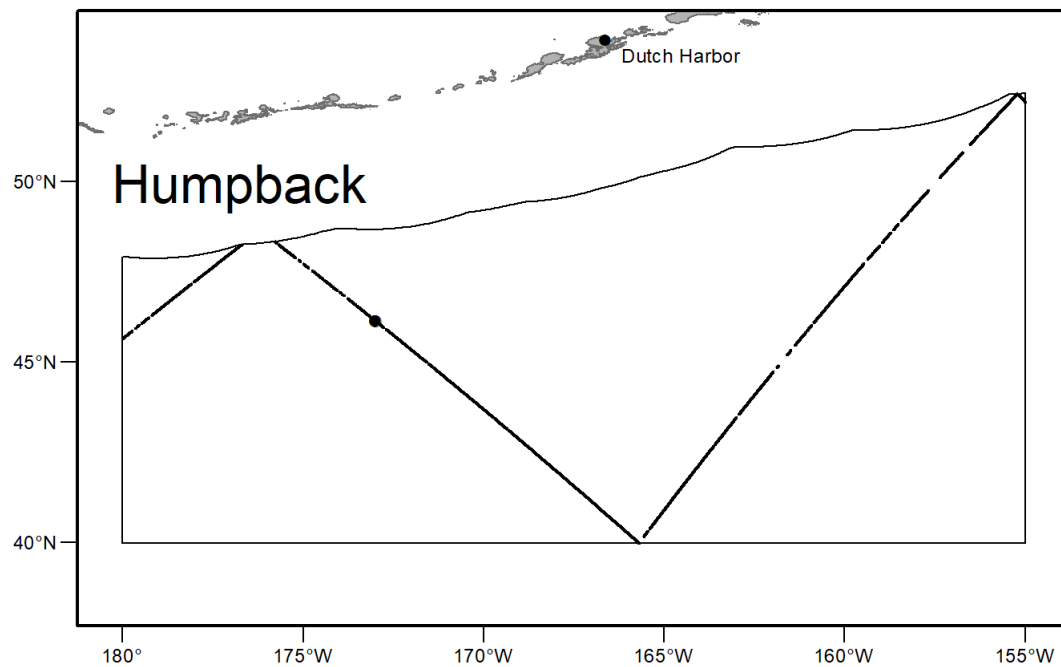


Figure 2e. The searching effort (thin line) and primary sighting positions (black circles) of humpback whales during the 2023 IWC-POWER cruise.

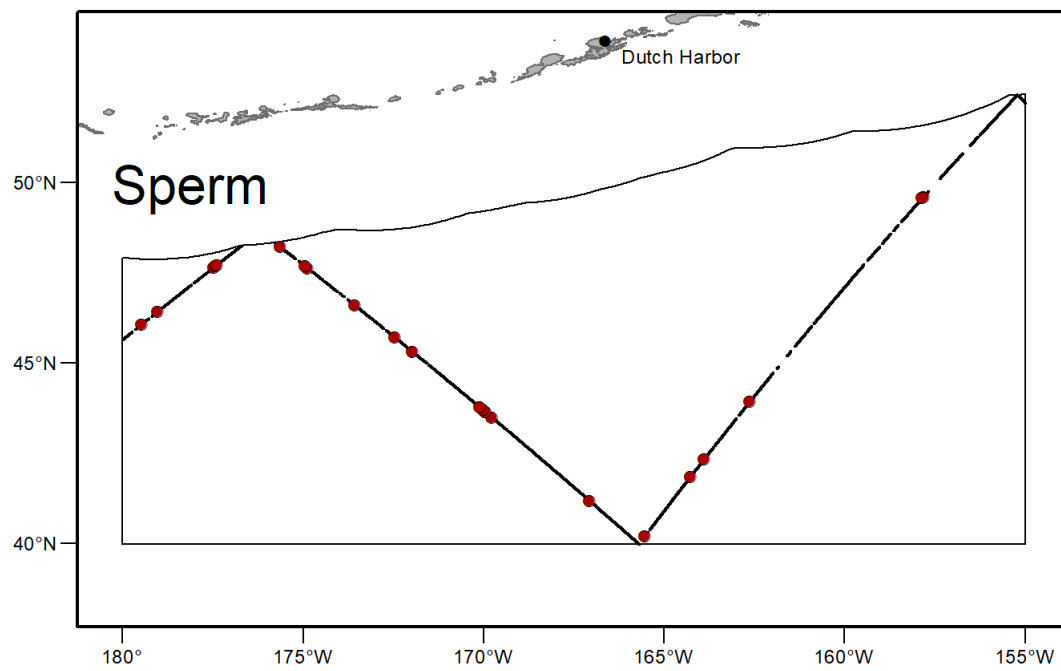


Figure 2f. The searching effort (thin line) and primary sighting positions (brown circles) of sperm whales during the 2023 IWC-POWER cruise.

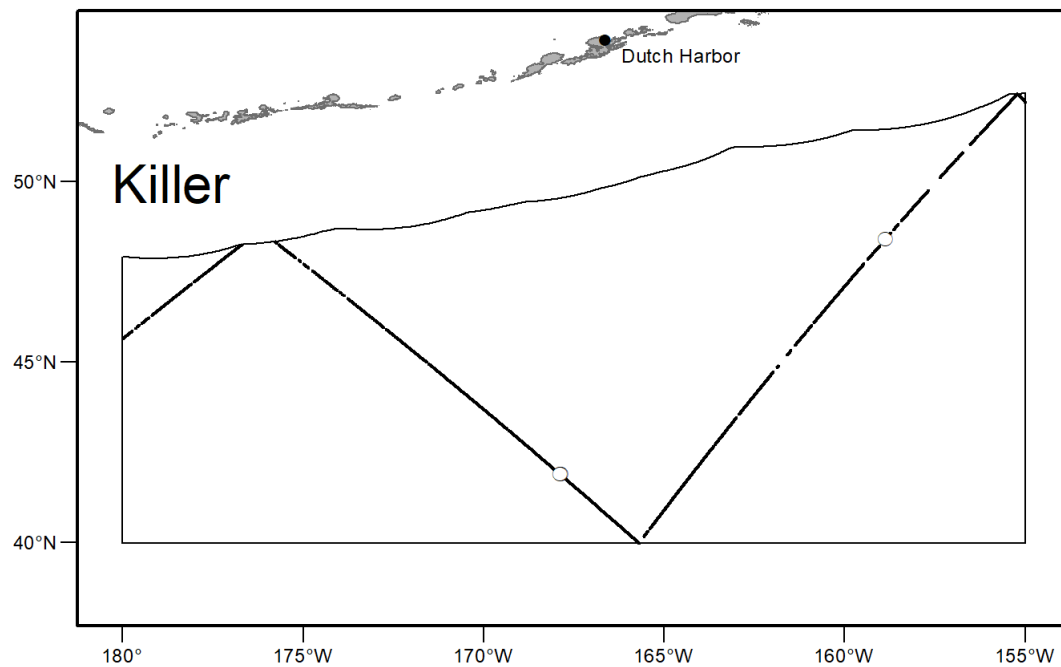


Figure 2g. The searching effort (thin line) and primary sighting positions (white circles) of killer whales during the 2023 IWC-POWER cruise.

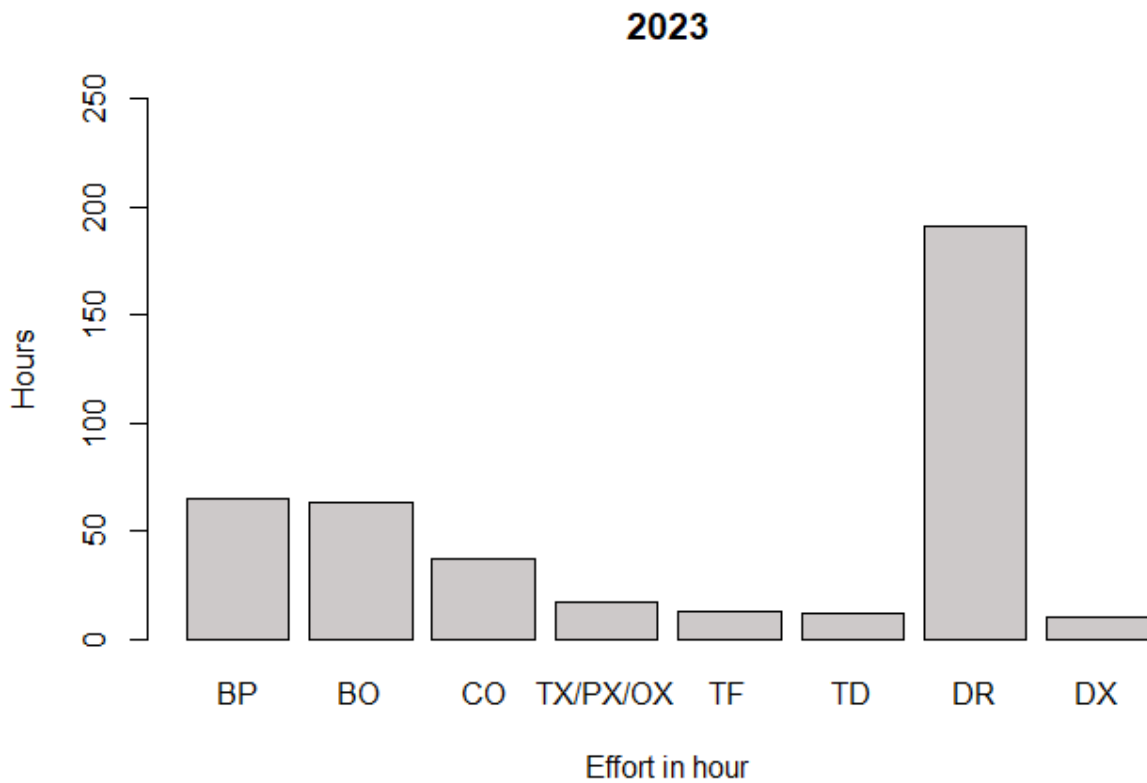


Figure 3. Breakdown of research time in hours, by effort code in the research area during the 2023 POWER cruise (Original trackline, Area code: 86 and 87). BP: Passing mode searching, BO: Independent Observer mode, CO: Confirmation of school, TX/PX: Biopsy / Photo-ID experiments, TF: Time back to trackline, TD: Top down steaming, DR: Drifting, DX: Distance and angle estimate experiment.

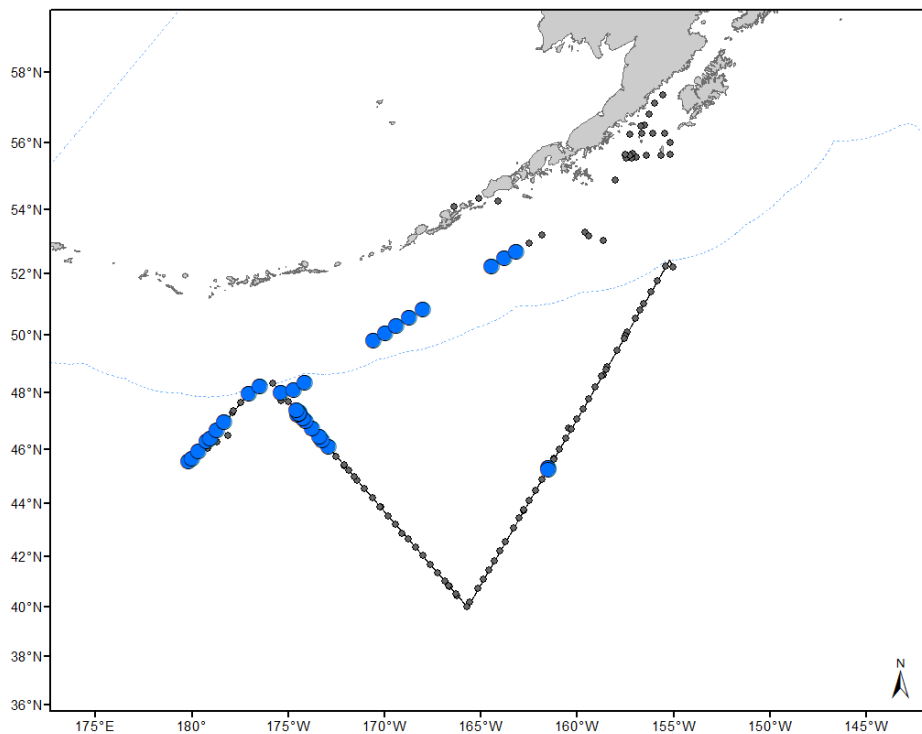


Figure 4a. Blue whale detections (blue circles) and sonobuoy deployments (black dots) during the 2023 POWER cruise.

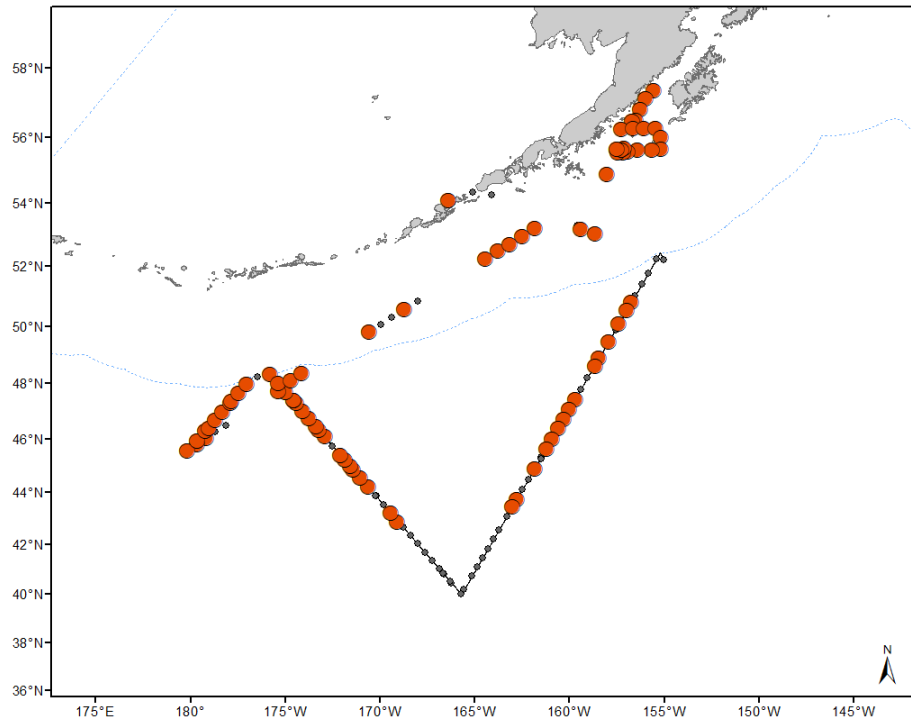


Figure 4b. Fin whale detections (red circles) and sonobuoy deployments (black dots) during the 2023 POWER cruise.

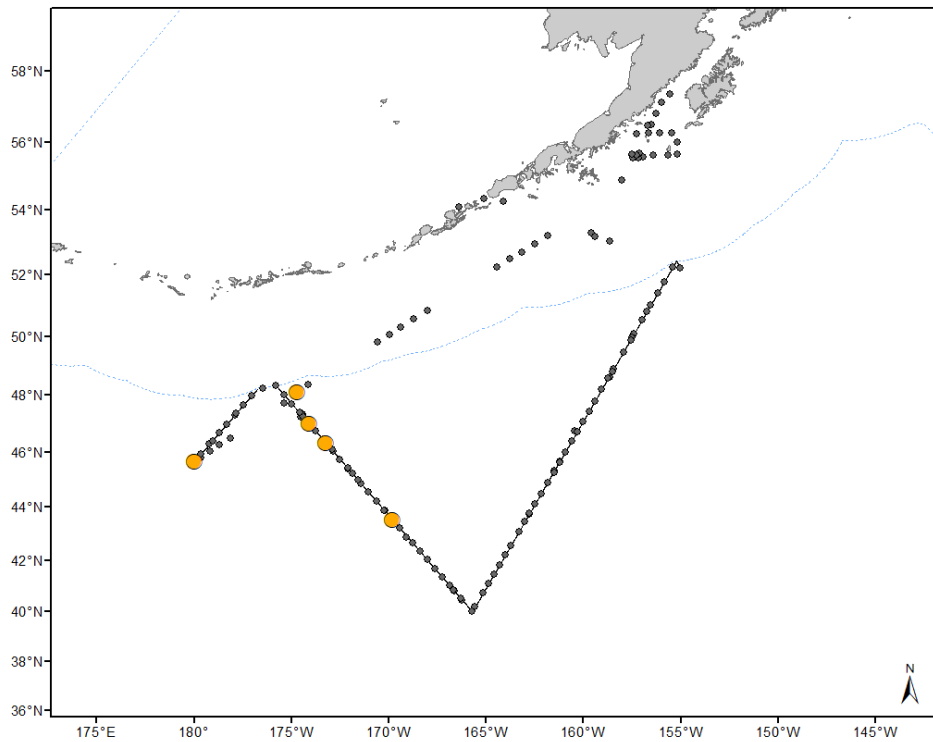


Figure 4c. Sei whale detections (orange circles) and sonobuoy deployments (black dots) during the 2023 POWER cruise.

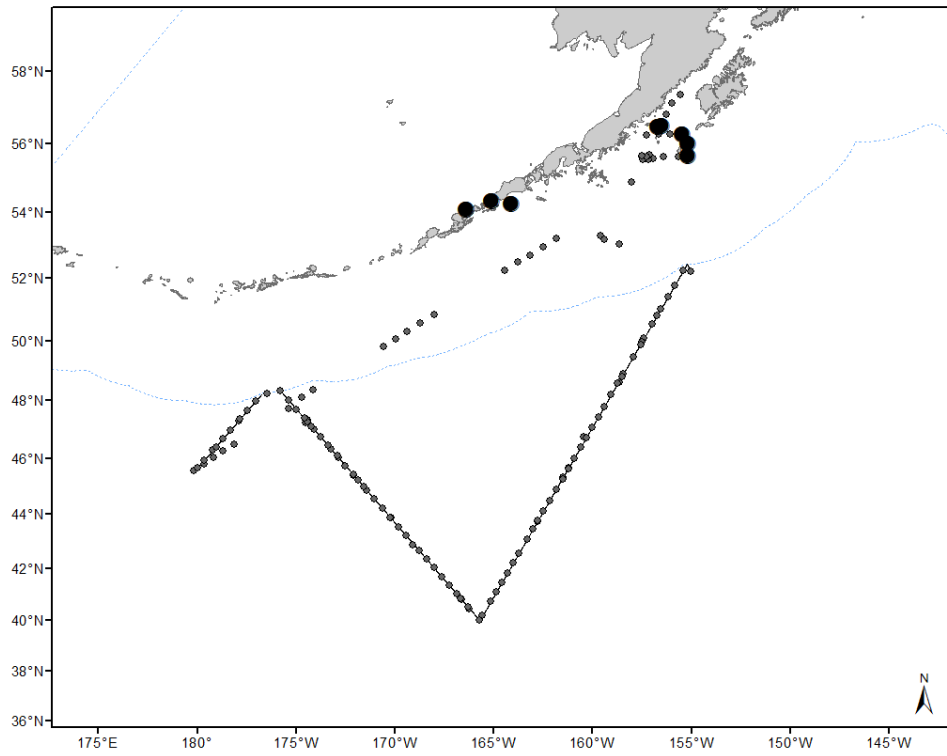


Figure 4d. Humpback whale detections (black circles) and sonobuoy deployments (black dots) during the 2023 POWER cruise.

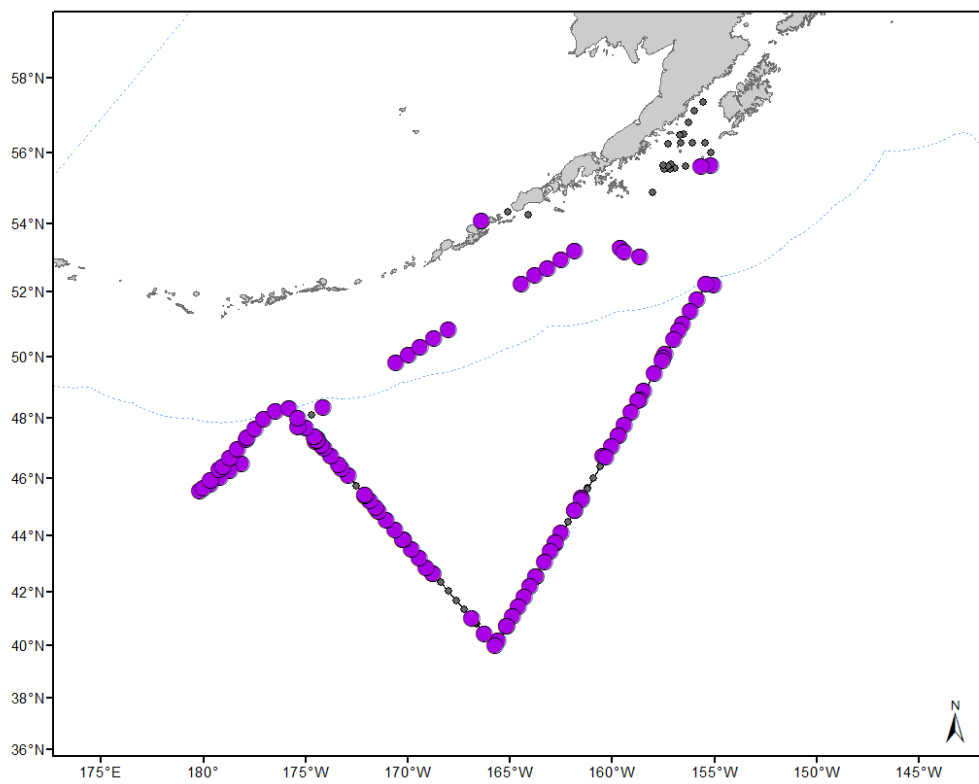


Figure 4e. Sperm whale detections (purple circles) and sonobuoy deployments (black dots) during the 2023 POWER cruise.

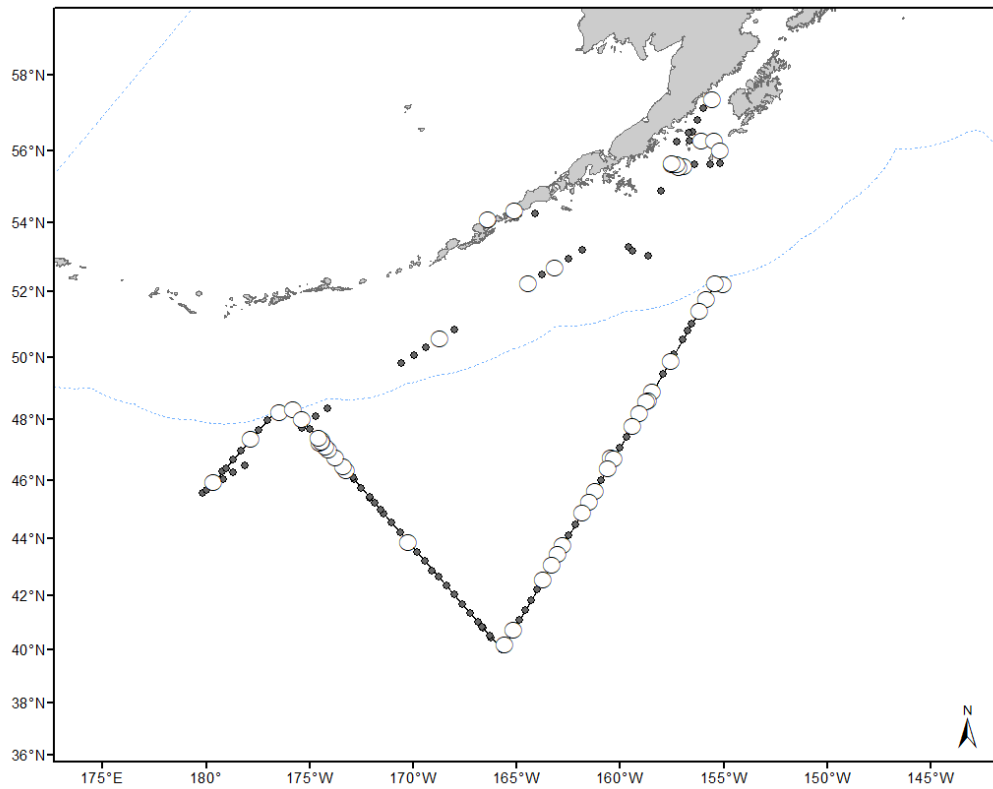


Figure 4f. Killer whale detections (white circles) and sonobuoy deployments (black dots) during the 2023 POWER cruise.

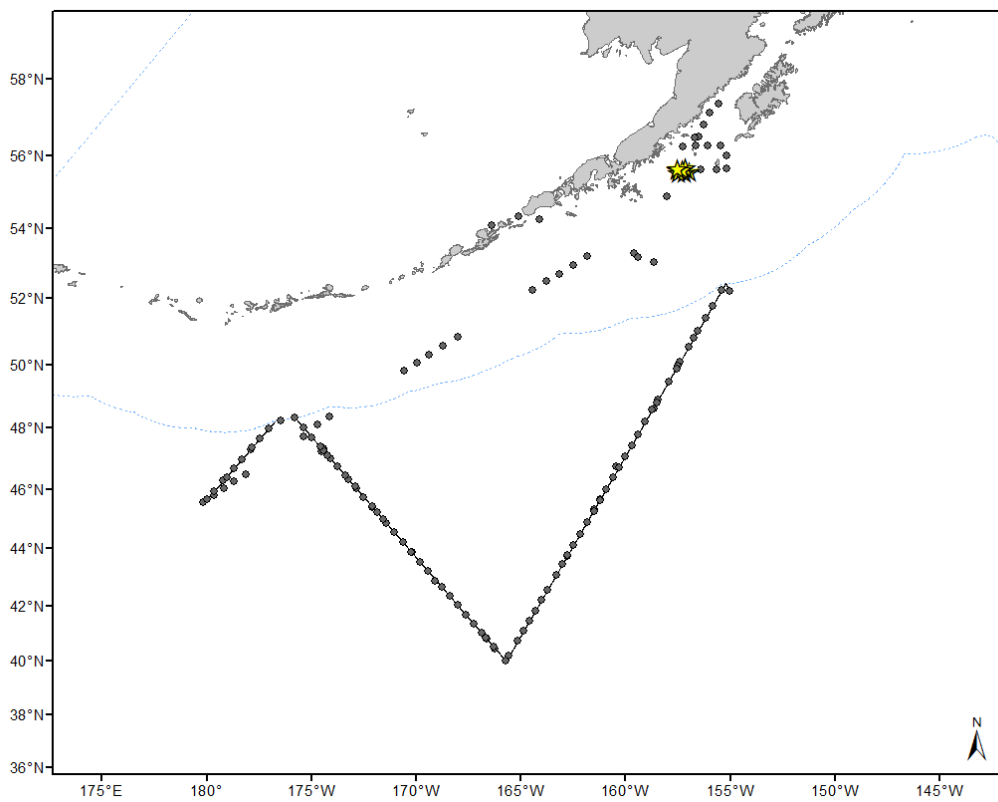


Figure 4g. North Pacific right whale detections (yellow stars) and sonobuoy deployments (black dots) during the 2023 POWER cruise.

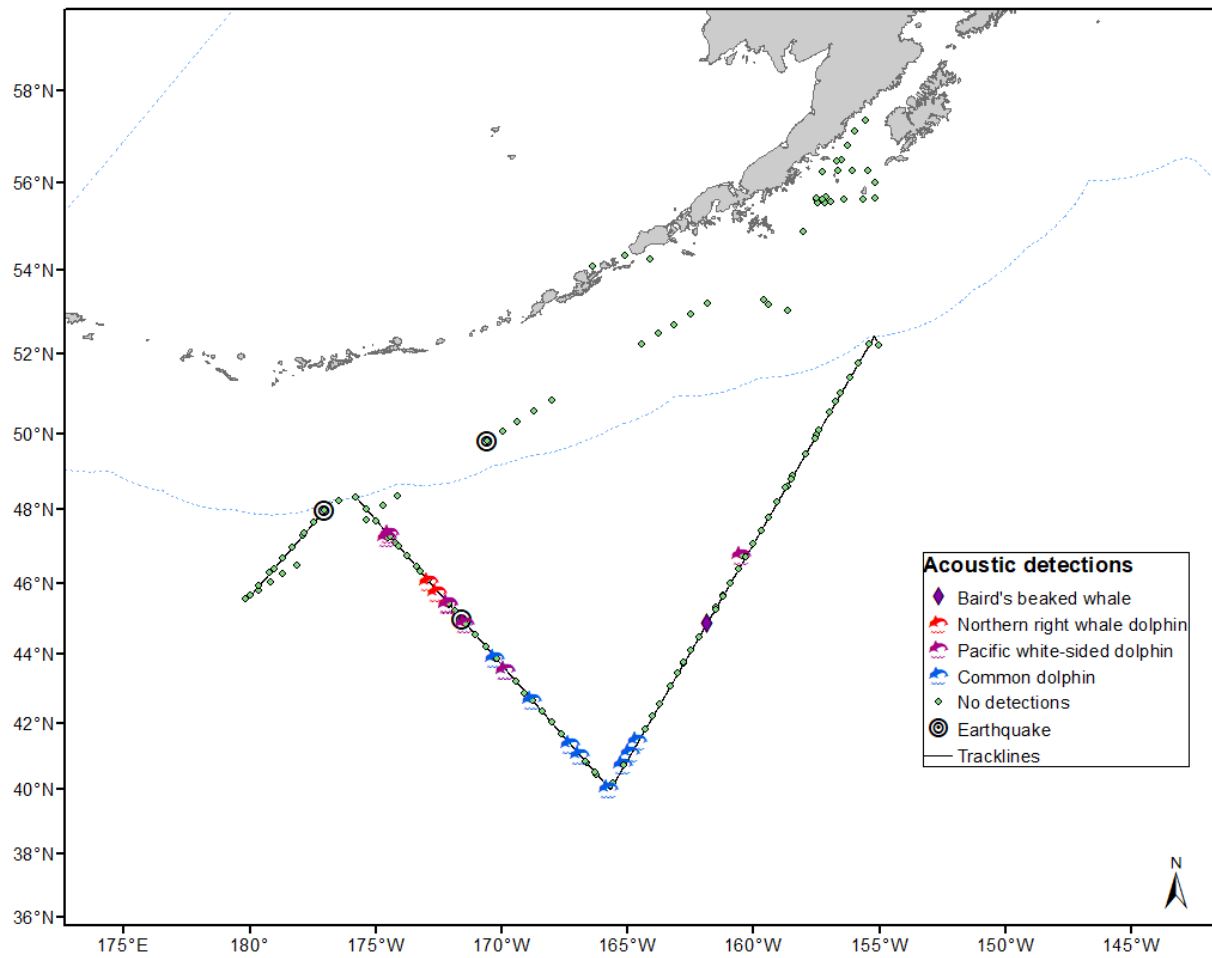


Figure 4h. Baird's beaked whale (purple triangle), northern right whale dolphin (red dolphin), Pacific white-sided dolphin (purple dolphin), common dolphin (blue dolphin), and earthquake (black circles) detections, and sonobuoy deployments (green dots) during the 2023 POWER cruise.

## APPENDICES

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

Ship photo:



Ship specifications:

	<i>Yushin-Maru No.2</i>
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	<i>Yushin-Maru No.2</i>
Captain	Chikamasa Okoshi
Chief Officer	Masahiko Nagamine
First Officer	Futoshi Yamaguchi
Chief Engineer	Shigeki Miyamoto
First Engineer	Koji Takamatsu
Second Engineer	Yuya Yoshii
Third Engineer	Kanta Sawajiri
Chief Operator/Purser	Jun Kuwaoka
Boatswain	Masahiko Abe
Quartermaster	Yamato Sekine
Quartermaster	Atsuo Yamasaki
Quartermaster	Junnosuke Ikeno
Sailor	Hiroto Konishi
Sailor	Ryo Taguchi
Chief Steward	Kei Oki
Steward	Reiji Suzuki



## Appendix B. Comparison of weather conditions (wind speed / visibility) among past cruises (2010-2023).

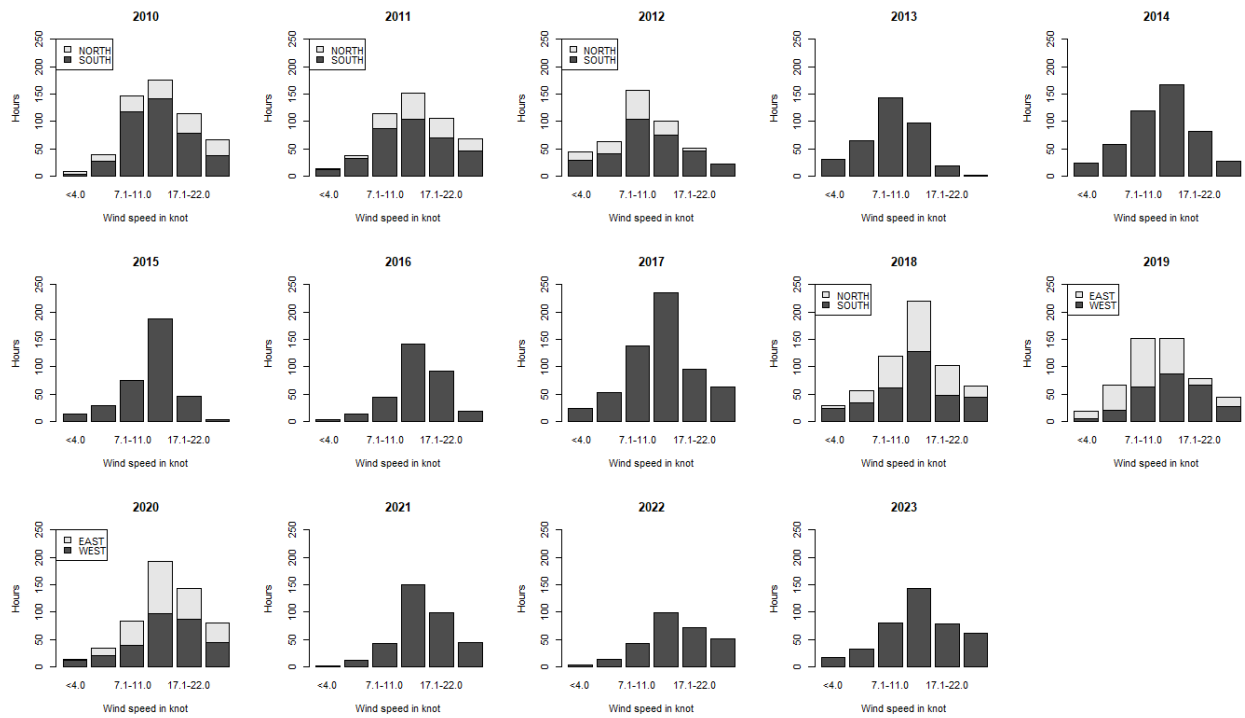


Figure B1. Breakdown of research time in hours during 2010 to 2023 surveys in research area by wind speed (in knots).

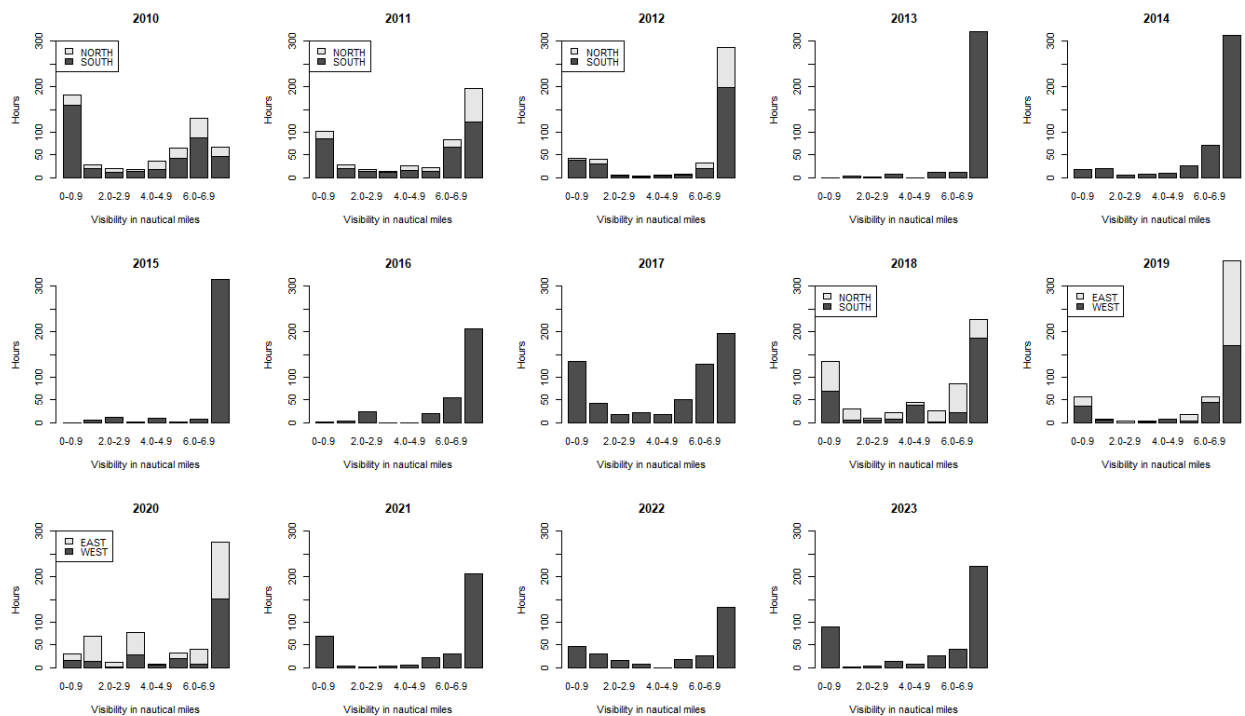


Figure B2. Breakdown of research time in hours during 2010 to 2023 surveys in research area by visibility (in nautical miles).

**Appendix C1.** Complete list of all sonobuoy deployments and species detected in the high seas during the 2023 POWER cruise. Success: 1 = successful, 0 = not successful. ADT = Alaska Daylight Time. Detections: 0 = not detected, 1 = detected, 2 = maybe.

Buoy #	Success?	Deploy Date	Deploy Time (ADT)	Latitude °N	Longitude °W	Water depth (m)	Hump	Fin	Orca	Sperm	Blue	Sei	Beaked	Common dolphin	Lags	Other
7	1	9-Aug-23	8:01:22	52.216	-155.005	4000	0	0	1	1	0	0	0	0	0	
8	1	9-Aug-23	10:36:56	52.226	-155.41	4000	0	0	1	1	0	0	0	0	0	
9	1	9-Aug-23	14:07:23	51.771	-155.836	4000	0	0	1	1	0	0	0	0	0	
10	1	9-Aug-23	17:56:45	51.404	-156.181	4000	0	0	1	1	0	0	0	0	0	
11	1	9-Aug-23	20:36:47	51.015	-156.542	4000	0	0	0	1	0	0	0	0	0	
12	1	10-Aug-23	8:01:34	50.816	-156.724	4000	0	1	0	1	0	0	0	0	0	
13	1	10-Aug-23	16:08:55	50.532	-156.985	4000	0	1	0	1	0	0	0	0	0	
14	1	10-Aug-23	20:00:26	50.078	-157.396	4000	0	1	0	1	0	0	0	0	0	
15	1	11-Aug-23	7:57:40	49.977	-157.522	4000	0	0	0	1	0	0	0	0	0	
16	1	12-Aug-23	14:08:22	49.86	-157.531	4000	0	0	1	1	0	0	0	0	0	
17	1	12-Aug-23	16:45:23	49.485	-157.929	4000	0	1	0	1	0	0	0	0	0	
18	1	12-Aug-23	20:32:04	48.903	-158.446	4000	0	1	1	1	0	0	0	0	0	
19	1	13-Aug-23	8:48:34	48.821	-158.518	4000	0	0	0	0	0	0	0	0	0	
20	1	13-Aug-23	14:18:42	48.63	-158.654	4000	0	1	1	1	0	0	0	0	0	
21	1	14-Aug-23	9:02:02	48.582	-158.728	4000	0	0	1	1	0	0	0	0	0	
22	1	14-Aug-23	11:52:08	48.214	-159.047	4000	0	0	1	1	0	0	0	0	0	
23	1	14-Aug-23	14:54:29	47.807	-159.404	4000	0	0	1	1	0	0	0	0	0	
24	1	14-Aug-23	19:03:56	47.45	-159.702	4000	0	1	0	1	0	0	0	0	0	
25	1	15-Aug-23	15:17:43	47.461	-159.705	4000	0	0	0	1	0	0	0	0	0	
26	1	15-Aug-23	17:53:26	47.098	-160.038	4000	0	1	0	1	0	0	0	0	0	
27	1	15-Aug-23	21:07:27	46.778	-160.451	4000	0	0	1	1	0	0	0	0	1	
28	1	16-Aug-23	9:01:04	46.727	-160.327	4000	0	1	1	1	0	0	0	0	0	
29	1	16-Aug-23	11:32:10	46.392	-160.609	4000	0	1	1	0	0	0	0	0	0	
30	1	16-Aug-23	15:05:40	46.016	-160.927	4000	0	1	0	0	0	0	0	0	0	
31	1	16-Aug-23	19:15:44	45.676	-161.211	4000	0	0	0	0	0	0	0	0	0	
32	1	17-Aug-23	8:59:10	45.656	-161.224	4000	0	1	1	0	0	0	0	0	0	
33	1	17-Aug-23	11:31:35	45.332	-161.478	4000	0	0	0	1	1	0	0	0	0	
34	1	18-Aug-23	8:59:06	45.277	-161.508	4000	0	0	1	1	1	0	0	0	0	
35	1	18-Aug-23	18:55:28	44.923	-161.827	4000	0	1	1	1	2	0	1	0	0	
36	1	19-Aug-23	9:00:06	44.904	-161.827	4000	0	0	0	1	0	0	0	0	0	
37	1	19-Aug-23	15:07:59	44.5	-162.172	4000	0	0	0	0	0	0	0	0	0	
38	1	19-Aug-23	17:26:29	44.12	-162.483	4000	0	0	0	1	0	0	0	0	0	
39	1	19-Aug-23	20:52:24	43.755	-162.767	4000	0	1	0	1	0	0	0	0	0	
40	1	20-Aug-23	8:57:41	43.768	-162.775	4000	0	0	1	1	0	0	0	0	0	
41	1	20-Aug-23	14:51:21	43.457	-163.015	4000	0	1	1	1	0	0	0	0	0	
42	1	20-Aug-23	17:11:13	43.078	-163.315	4000	0	0	1	1	0	0	0	0	0	
43	1	20-Aug-23	20:41:03	42.569	-163.714	4000	0	0	1	1	0	0	0	0	0	
44	1	21-Aug-23	9:11:36	42.566	-163.722	4000	0	0	0	1	0	0	0	0	0	
45	1	21-Aug-23	11:24:26	42.202	-164.006	4000	0	0	0	1	0	0	0	0	0	

Buoy #	Success?	Deploy Date	Deploy Time (ADT)	Latitude °N	Longitude °W	Water depth (m)	Hump	Fin	Orca	Sperm	Blue	Sei	Beaked	Common dolphin	Lags	Other
46	1	21-Aug-23	13:39:26	41.834	-164.292	4000	0	0	0	1	0	0	0	0	0	
47	1	21-Aug-23	15:58:53	41.455	-164.585	4000	0	0	0	1	0	0	0	1	0	
48	1	21-Aug-23	18:39:50	41.098	-164.863	4000	0	0	0	1	0	0	0	1	0	
49	1	21-Aug-23	20:52:34	40.736	-165.134	4000	0	0	0	1	0	0	0	1	0	
50	1	22-Aug-23	17:25:13	40.737	-165.139	4000	0	0	1	1	0	0	0	0	0	
51	1	22-Aug-23	20:45:56	40.189	-165.558	4000	0	0	1	1	0	0	0	0	0	
52	1	23-Aug-23	10:11:19	40.008	-165.708	4000	0	0	0	1	0	0	0	1	0	
53	1	23-Aug-23	20:33:07	40.473	-166.236	4000	0	0	0	1	0	0	0	0	0	
54	1	24-Aug-23	9:23:36	40.511	-166.279	4000	0	0	0	0	0	0	0	0	0	
55	1	24-Aug-23	11:25:36	40.807	-166.617	4000	0	0	0	0	0	0	0	0	0	
56	1	25-Aug-23	15:01:23	40.837	-166.653	4000	0	0	0	0	0	0	0	0	0	
57	1	26-Aug-23	9:31:10	41.037	-166.879	4000	0	0	0	1	0	0	0	1	0	
58	1	26-Aug-23	11:39:29	41.356	-167.247	4000	0	0	0	0	0	0	0	1	0	
59	1	26-Aug-23	13:49:06	41.682	-167.622	4000	0	0	0	0	0	0	0	0	0	
60	1	26-Aug-23	16:11:02	42.024	-168.02	4000	0	0	0	0	0	0	0	0	0	
61	1	26-Aug-23	18:48:47	42.34	-168.39	4000	0	0	0	0	0	0	0	0	0	
62	1	26-Aug-23	21:02:43	42.679	-168.779	4000	0	0	0	1	0	0	0	0	0	
63	1	27-Aug-23	9:33:48	42.669	-168.775	4000	0	0	0	1	0	0	0	1	0	
64	1	27-Aug-23	13:12:10	42.896	-169.109	4000	0	1	0	1	0	0	0	0	0	
65	1	27-Aug-23	15:34:34	43.239	-169.448	4000	0	1	0	1	0	0	0	0	0	
66	1	27-Aug-23	18:53:57	43.549	-169.817	4000	0	0	0	1	0	1	0	1	1	
67	1	27-Aug-23	21:09:05	43.878	-170.225	4000	0	0	1	1	0	0	0	0	0	
68	1	28-Aug-23	9:31:45	43.868	-170.19	4000	0	0	0	1	0	0	0	0	0	
69	1	31-Aug-23	9:46:48	43.883	-170.219	4000	0	0	0	1	0	0	0	1	0	
70	1	31-Aug-23	12:02:24	44.213	-170.617	4000	0	1	0	1	0	0	0	0	0	
71	0	31-Aug-23	15:03:11	44.541	-171.014	4000	0	0	0	0	0	0	0	0	0	
72	1	31-Aug-23	15:09:02	44.555	-171.03	4000	0	1	0	1	0	0	0	0	0	
73	1	31-Aug-23	18:40:40	44.882	-171.425	4000	0	1	0	1	0	0	0	0	1	
74	1	1-Sep-23	9:52:13	45.007	-171.58	4000	0	1	0	1	0	0	0	0	0	Earthquake
75	1	1-Sep-23	15:57:18	45.232	-171.855	4000	0	1	0	1	0	0	0	0	0	
76	1	1-Sep-23	20:31:06	45.423	-172.098	4000	0	1	0	1	0	0	0	0	1	
77	1	2-Sep-23	9:51:43	45.43	-172.1	4000	0	0	0	1	0	0	0	0	1	
78	1	2-Sep-23	14:52:52	45.756	-172.506	4000	0	0	0	1	0	0	0	0	0	Lisso's
79	1	2-Sep-23	18:15:50	46.048	-172.864	4000	0	1	0	1	0	0	0	0	0	Lisso's
80	1	3-Sep-23	9:55:55	46.095	-172.924	4000	0	1	0	1	1	0	0	0	0	unid dolphin
81	1	3-Sep-23	17:19:50	46.352	-173.245	4000	0	1	1	1	1	1	0	0	0	
82	1	4-Sep-23	10:00:45	46.457	-173.379	4000	0	1	1	1	1	0	0	0	0	
83	0	4-Sep-23	14:28:30	46.738	-173.731	4000	0	0	0	0	0	0	0	0	0	
84	1	4-Sep-23	14:35:17	46.755	-173.752	4000	0	1	1	1	1	0	0	0	0	
85	1	4-Sep-23	18:52:48	47.029	-174.099	4000	0	1	1	1	1	1	0	0	0	
86	1	5-Sep-23	9:52:28	47.132	-174.243	4000	0	0	1	1	1	0	0	0	0	

Buoy #	Success?	Deploy Date	Deploy Time (ADT)	Latitude °N	Longitude °W	Water depth (m)	Hump	Fin	Orca	Sperm	Blue	Sei	Beaked	Common dolphin	Lags	Other
87	1	5-Sep-23	20:53:37	47.268	-174.523	4000	0	0	1	1	1	0	0	0	1	
88	1	6-Sep-23	10:00:24	47.317	-174.443	4000	0	1	1	1	1	0	0	0	0	
89	1	6-Sep-23	20:17:36	47.347	-174.424	4000	0	0	1	1	1	0	0	0	1	
90	1	7-Sep-23	9:59:52	47.303	-174.446	4000	0	0	1	1	1	0	0	0	0	
91	1	7-Sep-23	21:02:06	47.407	-174.585	4000	0	1	0	1	1	0	0	0	0	unid dolphin
92	1	8-Sep-23	9:57:46	47.409	-174.549	4000	0	1	1	1	0	0	0	0	0	
93	1	8-Sep-23	15:44:28	47.714	-174.976	4000	0	1	0	1	0	0	0	0	0	
94	1	8-Sep-23	21:39:29	47.725	-175.39	4000	0	1	0	1	0	0	0	0	0	
95	1	9-Sep-23	10:30:07	46.496	-178.15	4000	0	0	0	1	0	0	0	0	0	
96	1	9-Sep-23	12:59:48	46.262	-178.686	4000	0	0	0	1	0	0	0	0	0	
97	1	9-Sep-23	15:17:28	46.034	-179.175	4000	0	1	0	1	0	0	0	0	0	
98	1	9-Sep-23	17:31:31	45.81	-179.661	4000	0	1	0	1	0	0	0	0	0	
99	1	9-Sep-23	20:01:15	45.572	179.8182	4000	0	1	0	1	1	0	0	0	0	
100	1	10-Sep-23	10:38:18	45.664	179.996	4000	0	0	0	1	1	1	0	0	0	
101	1	10-Sep-23	15:00:52	45.941	-179.652	4000	0	1	1	1	1	0	0	0	0	
102	1	10-Sep-23	20:24:16	46.299	-179.214	4000	0	1	0	1	1	0	0	0	0	
103	1	11-Sep-23	10:33:06	46.413	-179.056	4000	0	1	0	1	1	0	0	0	0	
104	1	11-Sep-23	14:44:18	46.709	-178.683	4000	0	1	0	1	1	0	0	0	0	
105	1	11-Sep-23	17:49:37	47.004	-178.309	4000	0	1	0	1	1	0	0	0	0	
106	1	11-Sep-23	20:50:29	47.317	-177.912	4000	0	1	0	1	0	0	0	0	0	
107	1	12-Sep-23	10:26:02	47.382	-177.831	4000	0	1	1	1	0	0	0	0	0	
108	1	12-Sep-23	15:22:37	47.662	-177.466	4000	0	1	0	1	0	0	0	0	0	
109	1	12-Sep-23	17:41:53	47.993	-177.043	4000	0	1	0	1	1	0	0	0	0	Earthquake
110	1	12-Sep-23	20:13:13	48.262	-176.472	4000	0	0	1	1	1	2	0	0	0	
111	1	13-Sep-23	10:15:00	48.339	-175.783	4000	0	1	1	1	0	0	0	0	0	
112	1	13-Sep-23	14:00:31	48.017	-175.366	4000	0	1	1	1	1	0	0	0	0	
113	1	13-Sep-23	18:23:04	48.115	-174.715	4000	0	1	0	0	1	1	0	0	0	
114	0	13-Sep-23	20:36:35	48.35	-174.153	4000	0	0	0	0	0	0	0	0	0	
115	1	13-Sep-23	20:44:50	48.364	-174.119	4000	0	1	0	1	1	0	0	0	0	

**Appendix C2.** Complete list of all sonobuoy deployments and species detected in the US EEZ during the 2023 POWER cruise. Success: 1 = successful, 0 = not successful. ADT = Alaska Daylight Time. Detections: 0 = not detected, 1 = detected, 2 = maybe.

Station	Success	Deploy Date	Deploy Time (ADT)	Latitude (°N)	Longitude (°W)	Depth (m)	NP Right	Humpback	Fin	Orca	Sperm	Blue	Other
1	1	7-Aug-23	10:45:03	54.084	-166.404	85	0	1	1	1	1	0	
2	1	7-Aug-23	15:17:09	54.347	-165.098	145	0	1	0	1	0	0	
3	1	7-Aug-23	18:17:54	54.253	-164.089	72	0	1	0	0	0	0	
4	1	8-Aug-23	9:22:41	53.306	-159.568	5000	0	2	0	0	1	0	
5	1	8-Aug-23	11:14:00	53.187	-159.397	5000	0	2	1	0	1	0	
6	1	8-Aug-23	13:58:26	53.051	-158.635	3000	0	0	1	0	1	0	
116	1	14-Sep-23	10:38:05	49.812	-170.596	4000	0	0	1	0	1	1	Earthquake
117	1	14-Sep-23	13:07:31	50.066	-169.963	4000	0	0	0	0	1	1	
118	1	14-Sep-23	15:25:01	50.308	-169.365	4000	0	0	0	0	1	1	
119	1	14-Sep-23	17:57:17	50.572	-168.701	4000	0	0	1	1	1	1	
120	1	14-Sep-23	20:29:37	50.834	-168.029	4000	0	0	0	0	1	1	
121	1	15-Sep-23	10:09:22	52.235	-164.438	3000	0	0	1	1	1	1	
122	1	15-Sep-23	12:39:16	52.491	-163.763	3000	0	0	1	0	1	1	Unknown grunts
123	1	15-Sep-23	14:46:10	52.715	-163.174	3000	0	0	1	1	1	1	
124	1	15-Sep-23	17:13:30	52.972	-162.508	1000	0	0	1	0	1	0	
125	1	15-Sep-23	19:45:45	53.233	-161.809	850	0	0	1	0	1	0	Low frequency rumble
126	1	16-Sep-23	13:58:47	54.91	-158.015	620	0	2	1	0	0	0	
127	1	17-Sep-23	10:17:13	57.362	-155.56	300	0	0	1	1	0	0	
128	1	17-Sep-23	16:03:47	57.134	-155.998	210	0	0	1	0	0	0	
129	1	17-Sep-23	17:57:28	56.811	-156.249	200	0	0	1	0	0	0	
130	1	17-Sep-23	19:34:42	56.498	-156.498	200	0	1	1	0	0	0	
131	1	18-Sep-23	7:34:05	56.481	-156.69	160	0	1	1	0	0	0	
132	1	18-Sep-23	10:01:15	56.247	-157.251	150	0	2	1	0	0	0	
133	1	18-Sep-23	13:26:38	56.266	-156.632	150	0	0	1	0	0	0	
134	1	18-Sep-23	15:02:31	56.271	-156.057	260	0	0	1	1	0	0	
135	1	18-Sep-23	16:41:37	56.264	-155.45	60	0	1	1	1	0	0	
136	1	18-Sep-23	18:48:00	55.998	-155.192	55	0	1	1	1	0	0	
137	1	19-Sep-23	8:59:58	55.666	-155.158	500	0	1	1	0	1	0	
138	1	19-Sep-23	10:39:49	55.625	-155.653	160	0	0	1	0	1	0	
139	1	19-Sep-23	13:05:21	55.625	-156.388	270	0	2	1	0	0	0	
140	1	19-Sep-23	14:52:31	55.577	-156.942	70	1	0	1	1	0	0	
141	1	19-Sep-23	15:38:22	55.552	-157.179	90	1	0	1	1	0	0	
142	1	19-Sep-23	18:47:04	55.63	-157.515	100	1	0	1	1	0	0	
143	1	19-Sep-23	19:25:08	55.558	-157.449	100	1	0	1	0	0	0	
144	1	20-Sep-23	8:18:45	55.683	-157.133	90	1	0	1	0	0	0	
145	1	20-Sep-23	9:09:52	55.642	-157.28	97	1	0	1	1	0	0	
146	1	20-Sep-23	14:52:49	55.666	-157.5	107	1	0	1	1	0	0	

## **Appendix D. Report of feasibility experiment of satellite tagging**

Hiroto Murase

### **BACKGROUND**

During the 2021 IWC-POWER planning meeting, a possibility of carrying out a feasibility study on satellite tagging target species was considered and agreed to be voluntarily conducted by Japan with an understanding that it might be a way to address specific questions on cetacean dive behaviour in the future (IWC, 2021b). According to this agreement, the deployment of satellite linked dive behavior tags was experimentally conducted during the 2021 and 2022 cruises at the discretion of Japan. Tags were successfully deployed and the dive data obtained from the tags were important to understanding and estimating availability bias. The feasibility experiment was continued for the 2023 cruise. In addition to the behavior tag, deployment of tags for monitoring horizontal movement was also attempted during the 2023 cruise.

### **SHORT DESCRIPTION OF THE METHODOLOGY**

As appropriate and decided by the cruise leader, research time was dedicated to deploying satellite tags. SPOT 177S (Wildlife Computers Inc., US) tags for monitoring the horizontal movement were loaded on YS2, and the target species was blue whales with assumption that the data could be used to identify migration routes of this species within the central North Pacific. SPLASH-f-333 (Wildlife Computers Inc., US) tags were also deployed on fin and sei whales for recording dive data with assumption that those data could be used to estimate availability bias. The following equipment was available: ten SPOT 177S tags, twelve SPLASH10-F-333 tags, two Aerial Rocket Transmitter Systems (ARTS) and darts. All the equipment was provided courtesy of ICR. All tags were loaded in Auto-start mode. Natural marking biopsy and satellite tagging experiments were conducted simultaneously. One shooter used an LK-ARTS for the tagging, while the other used a Larsen biopsy gun. This experiment was conducted at the discretion of the cruise leader with the understanding that the line transect survey was the highest priority.

### **RESULTS AND DISCUSSION**

The results of the tagging experiments of SPOT 177S and SPLASH-f-333 are summarized in Tables D1 and D2, respectively. SPOT 177S tags were deployed on 4 blue whales out of 5 targeted individuals (success rate: 80.0 %), although 2 tags were lost in water during the experiments. Five SPLASH-f-333 tags each were deployed on fin and sei whales, out of 12 and 6 targeted individuals, respectively (success rate, fin whale: 41.7 % and sei whale: 83.3 %), although one tag each was lost in water during the experiments.

Detailed analyses of the tag data will be conducted by Japanese scientists, and the results will be reported to relevant scientific communities. The results will also be presented to the TAG/planning meetings in reference to the future work of this program.

Table D1. Summary of the feasibility experiment of deployment of SPOT 177S tags in the 2023 POWER cruise.

Date	Sighting #	Species	School size	Serial #	PTT ID	Deployment	Letters attached of ind.	Data acquisition	Biopsy (sample #)	Experiment duration	Remarks
2023/8/27	1	Blue whale	1	22U2876	244035	Yes	A	No	Yes 23061001	0:54:12	-
2023/9/2	2	Blue whale	1	23U1547 22U2874	244039 244034	No Yes	- A	- Yes	Yes 23061002	0:23:59	2 shots, 1 hit, 1 miss, deployed. Lost a tag (PTT ID 244039)
2023/9/2	12	Blue whale	1	22U2887	244038	Yes	A	Yes	Yes 23061003	0:14:52	-
2023/9/3	12	Blue whale	1	20U1032 22U2867	244030 244031	No Yes	- A	- No	Yes 23061004	1:03:22	Lost a tag (PTT ID 244030).
2023/9/10	29	Blue whale	1	22U2870	244032	No	-	-	No	0:41:34	No chance to shoot. The tag was not used.

Table D2. Summary of the feasibility experiment of deployment of SPLASH-f-333 type tags in the 2023 POWER cruise.

Date	Sighting #	Species	School size	Serial #	PTT ID	Deployment	Letters deployed on ind.	Data acquisition	Biopsy (sample #)	Experiment duration	Remarks
2023/8/10	2	Fin whale	5	21A0301	227944	No	-	-	No	0:40:19	No chance to shoot. The tag was not used.
2023/8/10	5	Fin whale	6	21A0301	227944	Yes	A	-	Yes 23051001	0:26:46	-
2023/8/14	10	Fin whale	1	23A0497	244040	No	-	-	No	0:30:11	No chance to shoot. The tag was not used.
2023/8/16	3	Fin whale	1	23A0497	244040	No	-	-	Yes 23051002	0:17:55	1 shot, 1 miss, not deployed. Miss shot and bounced on the water. Lost the tag in the water (PPT ID . 244040).
2023/8/18	2	Sei whale	2	20A0021	204641	Yes	A	Yes	Yes 23041001	0:13:44	-
2023/8/21	9	Fin whale	1	21A0350	220896	Yes	A	Yes	Yes 23051003	0:21:48	-
2023/8/27	6	Sei whale	1	23A0846	244048	Yes	A	Yes	Yes 23041002	0:25:22	-
2023/8/31	3	Sei whale	1	23A0501 23A0843	244044 244045	No Yes	- A	- No	Yes 23041003	0:19:25	The tag (PTT ID 244044) miss shot and bounced on the water. Lost the tag in the water.
2023/8/31	4	Sei whale	1	23A0500	244043	Yes	A	Yes	Yes 23041004	0:16:31	-
2023/8/31	5	Fin whale	1	23A0847	244049	Yes	A	Yes	Yes 23051004	0:22:40	-
2023/8/31	7	Fin whale	2	23A0498	244041	No	-	-	No	0:26:05	No chance to shoot. The tag was not used.
2023/9/1	1	Fin whale	1	21A0601	224703	No	-	-	No	0:22:43	No chance to shoot. The tag was not used.
2023/9/1	2	Fin whale	1	21A0601	224703	No	-	-	No	0:57:50	1 shot, 1 miss, not deployed. Miss shot but picked up the tag. The tag was not used.
2023/9/1	4	Fin whale	3	21A0601	224703	Yes	A	No	Yes 23051005	0:32:10	Mother and calf pair. The tag was deployed on mother individual.
2023/9/1	3	Fin whale	4	23A0845	244047	No	-	-	No	0:36:02	No chance to shoot. The tag was not used.
2023/9/1	6	Fin whale	3	23A0845	244047	Yes	A	Yes	Yes 23051006	0:14:41	-
2023/9/13	1	Sei whale	1	23A0498	244041	No	-	-	No	0:58:35	No chance to shoot. The tag was not used.
2023/9/13	4	Sei whale	2	23A0498	244041	Yes	A	Yes	Yes 23041007	0:10:51	-

## Appendix E. Report of deployment of Long-term Drifting Buoy Recorder (LT-DBR)

Jessica Crance

### BACKGROUND

During the Planning meeting for the 2023 survey, the feasibility of deploying long-term drifting buoy recorders (LT-DBR) during the survey area on behalf of Jay Barlow (funded by SWFSC and OSU) was discussed. These buoys are designed to drift at sea for a year or more collecting acoustic recordings along its path. The buoys are affixed with two satellite tracking systems, an anchor, vertical line, depth sensor, and a SoundTrap ST600HF high frequency acoustic recorder (Figure E1). The SoundTrap will record at a sampling rate of 384 kHz, allowing for the detection of all marine mammal species, including beaked whales (target species) as well as porpoises. Once the buoys drift closer to land, they will be retrieved and the data analyzed.

### SHORT DESCRIPTION OF THE METHODOLOGY

The recorders were programmed to record on a duty cycle of 1 minute every 6, to allow for a full year of recording. Once the recorders were programmed and had started recording, the drifter buoys were assembled on deck for deployment. A weight was attached to the bottom of the pole, followed by the attachment of the nylon vertical line. The depth sensor and anchor were already attached to the line. The buoy was secured to the pole using bolts and the collars provided. The SPOT trace satellite tracker and the Smartone Solar tracker were installed at the top of the pole. Finally, the recorder was installed one meter below the depth sensor and above the anchor. Once assembled, the buoy was deployed by first lowering the buoy and pole system into the water, followed by the anchor, then the remainder of the vertical line.

### RESULTS AND DISCUSSION

The first of the two drifter buoys (nickname: POWER Ranger) was deployed on 20 August 2023 at 16:01 ship time at 42°47.17'N, 163° 32.85'W. The second buoy (nickname: Akabo) was deployed on 23 August 2023 at 09:53 ship time at 39°59.3'N, 165°41.5'W. Total deployment time for the first buoy was approximately 20 minutes. The second buoy took approximately 40 minutes, as a hole needed to be drilled in the top of the pole for the satellite tracker. Given the ease of assembly and the quick deployment time, this was an efficient way to deploy a buoy for collaborators without impacting the success of the visual survey.

The two drifting buoy recorders continue their slow drifts in a generally East (POWER Ranger) and NE direction (Akabo, Figure E2). Their average speeds over ground are over 0.4 kts, but their net speeds are considerably slower. Both have been taking very convoluted routes, with circular paths (likely due to inertial oscillations). Akabo went west for a while. The acoustic data collected by the recorders will greatly increase our knowledge of beaked whale distribution in the central North Pacific, an area that is poorly understood. Barlow expressed his thanks to the researchers, crew and officers of the *Yushin Maru No. 2* for making this project possible.

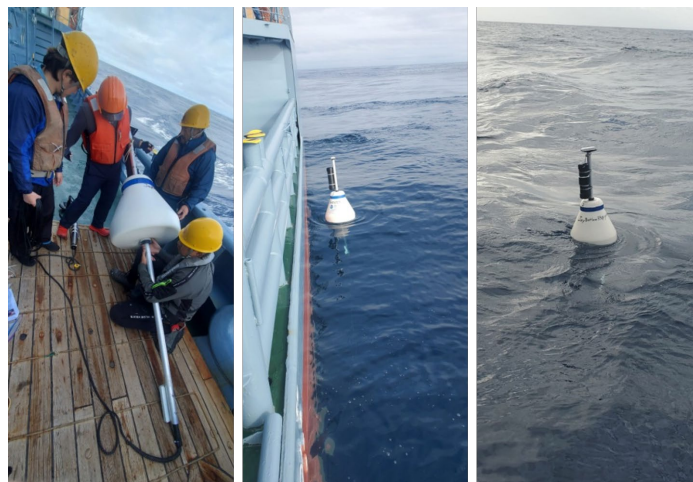


Figure E1. Long-term Drifting Buoy Recorder (LT-DBR): Preparation (left), deployment (middle), deployed (right).



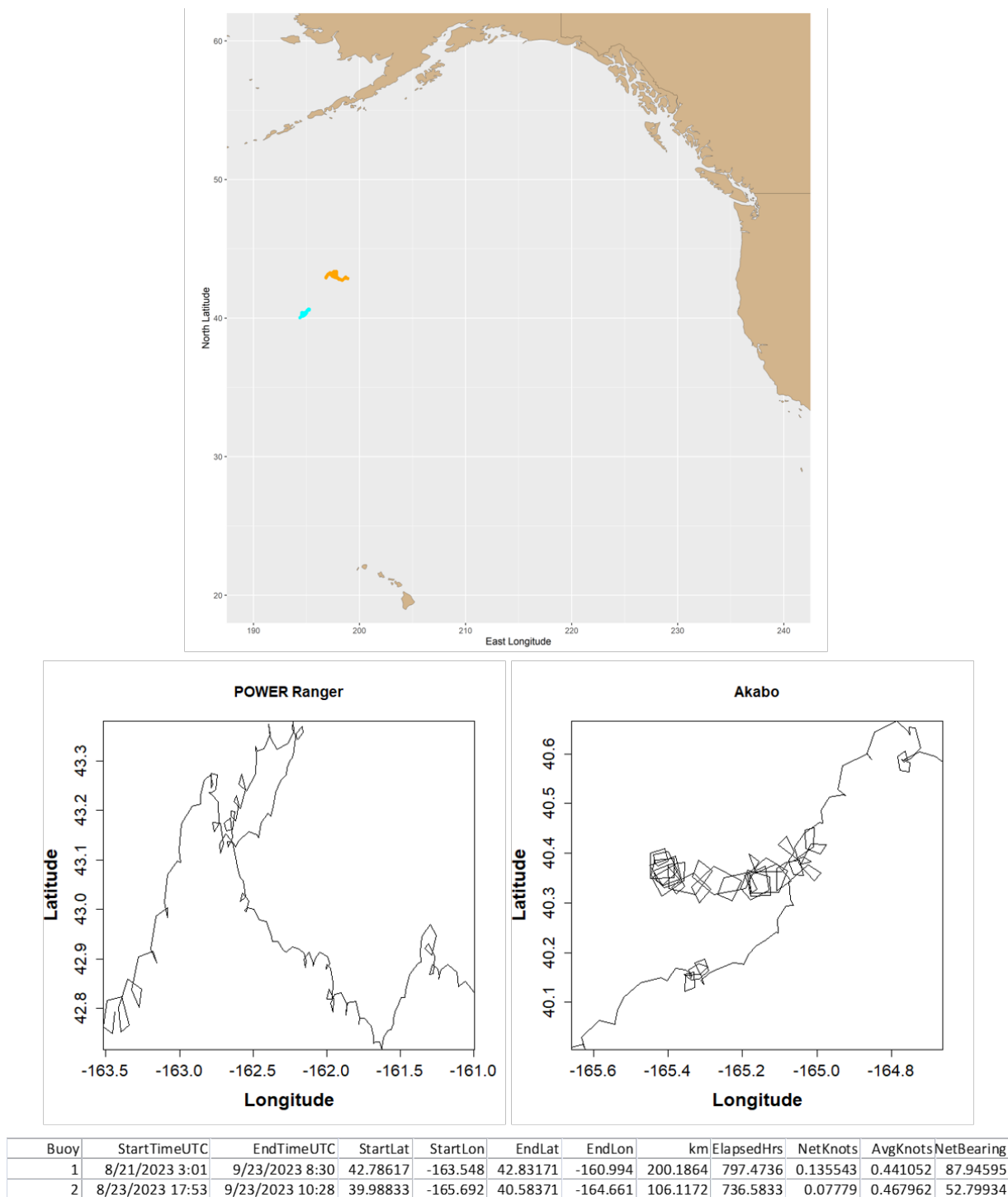


Figure E2. Trajectories of Long-term Drifting Buoy Recorders (LT-DBRs). Trajectories of POWER Ranger (orange) and Akabo (sky blue) in a small scale map (bottom) and in a large scale map (top) with positions up to 23 September 2023 in UTC (table at bottom).

## Appendix F. Report of a feasibility study of seabird sighting survey

Bernardo Alps

Seabird surveys were conducted by the Photo ID Specialist, who was also acting as Marine Mammal Observer during on-transect effort. All observations were conducted from the upper bridge, at a height of 11.5m. Seating on the upper bridge was assigned, with the Seabird Observer in the starboard position. There was no possibility to move positions to avoid glare. Seabird surveys were started on the hour when the YS2 was on effort on the track line and lasted for 15 minutes, or until the vessel turned from the track line to confirm a sighting or interrupted the effort for any other reason.

During the seabird survey time blocks, all bird species and numbers were recorded in a quadrant of 90°, from directly ahead to abeam starboard, out to a distance of 300 m from the observer. The 300 m distance was estimated using a Heinemann range finder pencil, and calibrated near the beginning of the voyage using a floating target. Birds were counted individually, unless a large flock size made it impossible, in which case birds were counted in multiples of 10 and an estimate was obtained by extrapolating to the part of the flock within the survey area. This happened only once. Sun glare in the survey quadrant was categorized as None, Light, Moderate, Strong, and Extreme. Most of the time there was no glare, either because of cloud cover or the position of the sun. Data from survey periods with Strong or Extreme glare were not used. All bird species observed, even away from the transect line or outside of survey hours, were recorded daily.

All sightings of short-tailed albatross (STAL) would have been recorded, regardless of when they occurred. An attempt would have been made to document all visibly banded or otherwise marked birds. No STAL or marked birds were identified.

A pair of handheld Fujinon 7x50 FMTR-SX binoculars were used for observation, with a pair of Eagle Optics 8x42 Ranger ED binoculars used as backup. Birds were opportunistically photographed for documentation, to confirm ID, and in some cases to determine ID. All bird photos are separated in sub-folders by species and archived with the POWER photos.

A total of 115 survey blocks along tracklines with up-to 15 minutes long was covered with sightings of 27 species (466 individuals). Additionally, the only tern seen during the cruise could not be identified to species; it was likely an Arctic tern, but common tern and Aleutian tern could not be ruled out. The only non-seabird species seen was likely a Pacific golden plover but was not seen well enough for a positive identification. Six of the 27 species were recorded only opportunistically and not recorded during one of the survey periods.

The sightings are summarized in two tables. Table F1 (saved as “POWER\_2023\_Bird\_Survey.xlsx”) lists every survey time block with starting and end time. It can be cross referenced with the cruise log for location and weather data. Latitude and longitude of the starting point of each survey time block and the corresponding weather conditions are saved as “POWER\_2023\_Bird\_Survey\_Effort.xlsx”. Glare category is listed. Numbers for each species recorded are shown along the row for each time block. All numbers represent an exact count, except for 50 Buller’s shearwaters at 12:00 on 16 August, which is a reliable estimate. Species seen only outside of the survey time blocks are listed in the “Seen outside survey” column for the entire day. Four-letter codes are taken from Pyle and DeSante, The Institute for Bird Populations, 2023 (Table F2, saved as “POWER\_English\_Bird\_Names\_4-letter.docx”). Table F3 (saved as “POWER\_2023\_Bird\_Survey\_FULL\_Species.xlsx”) lists all species seen and all survey days. Numbers are given for species seen during the sum of bird survey time blocks for the day, and are an exact count, with the exception mentioned above. An “x” denotes species seen outside of the bird survey time blocks. An “o” denotes species seen on days when no surveys were conducted.

We observed 1 hatch-year red-tailed tropicbird at 42°33.64’N, 163°43.89’W with a SST of 20.1°C; red-footed boobies at 46°15.68’N, 160°43.27’W with a SST of 14.4°C, at 45°31.99’N, 172°13.62’W with a SST of 14.8°C, and at 46°07.60’N, 172°57.51’W with a SST of 12.9°C; and a brown booby at 42°31.12’N, 168°35.85’W with a SST of 20.1°C. Also interesting to note was the sudden appearance of black-legged kittiwakes offshore on 11, 12, and 13 November. This species leaves the breeding grounds to winter on the open ocean. Tight flocks of short-tailed shearwaters were seen rapidly moving south on the same dates. This species migrates from the feeding grounds in the Bering Sea and Gulf of Alaska to their southern hemisphere breeding grounds in a tight window.

Table F1. Species are listed along the top in taxonomic order (a few species groups are excluded from the table but retained in the original excel file). Numbers indicate an exact count of each species or species group seen during each time interval listed on the left. The “Seen outside survey” (AD) column lists species or species groups that were recorded on a given day outside of the bird survey time blocks. The Glare (E) column list glare in categories, None, Light, or Moderate. Data from periods of Strong or Extreme glare was not included.

Date	Time	End	Minutes	Glare	RNP	REP	BLK	SPSK	PAJA	BFAL	LAAL	LESP	TRSP	FTSP	NOFU	COPE	MOPE	HAPE	MUPE	PRPE	BULS	SOSH	STTS	RFBO	BRBO	posPAGP	MU/PRPE	ST/SOSH
2023/8/9	6:00	6:15	15	none											6							2						
	7:00	7:15	15	none											1													
	8:00	8:15	15	none								2			2												1	
	15:00	15:11	11	none								1		3								1						
	16:00	16:15	15	none	1							17		3					1	1								
	17:00	17:15	15	none								6					2											
2023/8/10	18:00	18:15	15	light, moderate								7							4			1						
	6:05	6:20	15	none				1			3	2							1			2						
2023/8/12	13:00	13:15	15	none	1							1																
	15:00	15:15	15	moderate		2		1				1																
	16:00	16:15	15	light, none								1								1								
2023/8/13	7:00	7:15	15	none																								
2023/8/14	6:00	6:09	9	none								1		2														
	8:00	8:05	5	none																								
	9:00	9:15	15	none								1										1						
	10:00	10:15	15	none														1				3						
	11:00	11:15	15	none																								
	13:00	13:10	10	light							1																	
	15:00	15:06	6	none							1										1	5						
	16:00	16:03	3	none																								
2023/8/15	13:00	13:15	15	light																		20						
	14:00	14:04	4	moderate																								
2023/8/16	6:00	6:15	15	none								1										2					1	1
	7:00	7:15	15	none										1							8	25				1		
	8:00	8:05	5	none																								
	11:00	11:15	15	none														1				5						
	12:00	12:15	15	none														1			50							
2023/8/17	15:00	15:15	15	light, moderate														1				7						
2023/8/18	6:00	6:15	15	none					1							1					3	6						3
	8:00	8:11	11	none																	2	11						
2023/8/19	12:00	12:15	15	none		1						2																
	13:00	13:15	15	light								4				3												
	14:00	14:15	15	none		2						11	2															
	15:00	15:15	15	none																								
2023/8/20	17:00	17:15	15	none																								
	9:00	9:15	15	none								3				1												
	10:00	10:15	15	none																								
	13:00	13:15	15	none								6																
	14:00	14:15	15	light		1												1										
2023/8/21	15:00	15:15	15	light								7	2			1												
	7:00	7:15	15	none								1				6		2										
	8:00	8:15	15	none		2																						

Date	Time	End	Minutes	Glare	RNPH	REPH	BLKI	SPSK	PAJA	BFAL	LAAL	LESP	TRSP	FTSP	NOFU	COPE	MOPE	HAPE	MUPE	PRPE	BULS	SOSH	STTS	RFBO	BRBO	posPAGP	MU/PRPE	ST/SOSH
	9:00	9:15	15	none												1												
	10:00	10:15	15	none		8						1				2												
	12:00	12:15	15	light		1																						
	13:00	13:15	15	light												1												
	14:00	14:15	15	light																								
2023/8/22	15:00	15:15	15	moderate/light																								
	18:00	18:15	15	none																								
2023/8/23	15:00	15:15	15	none						1						1												
	17:00	17:15	15	none						1						1												
2023/8/24	7:00	7:15	15	none																								
	8:00	8:15	15	none												1												
2023/8/25	12:00	12:15	15	none												4												
	13:00	13:15	15	none																								
2023/8/26	7:00	7:15	15	none						1		2																
	8:00	8:15	15	none						2																		
	9:00	9:15	15	none						1	3	1																
	10:00	10:15	15	none																								
	12:00	12:15	15	none												4												
	13:00	13:15	15	none		1																						
	15:00	15:15	15	none								1				8					1				1			
	17:00	17:15	15	none								1													1			
2023/8/27	7:00	7:15	15	none																								
	9:00	9:07	7	none												1												
	11:00	11:15	15	none		1										1												
	12:00	12:15	15	none																								
	13:00	13:15	15	none								2				4												
	16:00	16:15	15	none												2												
	17:00	17:15	15	none								3				3												
2023/8/28	NA										1																	
2023/8/29	NA																											
2023/8/30	NA																											
2023/8/31	7:00	7:15	15	none								4				4												
	8:00	8:15	15	none												4												
	9:00	9:15	15	none								1																
	10:00	10:15	15	none								2																
	11:00	11:15	15	none						3						3						1						
	12:00	12:15	15	none																								
	13:00	13:15	15	none					1																			
2023/9/1	7:00	7:08	8	none																								
	10:00	10:15	15	none													1											
	13:00	13:05	5	none					1																			
	14:00	14:10	10	none																								
2023/9/2	7:00	7:15	15	none																								
	8:00	8:04	4	none																								
	11:00	11:15	15	none													1							1				
	12:00	12:15	15	none																								
	13:00	13:15	15	none													6											
2023/9/3	11:00	11:03	3	none																								
	12:00	12:15	15	none																		1					1	

Date	Time	End	Minutes	Glare	RNPH	REPH	BLKI	SPSK	PAJA	BFAL	LAAL	LESP	TRSP	FTSP	NOFU	COPE	MOPE	HAPE	MUPE	PRPE	BULS	SOSH	STTS	RFBO	BRBO	posPAGP	MU/PRPE	ST/SOSH
	13:00	13:08	8	none																		3						
2023/9/4	7:00	7:01	1	none																								1
	8:00	8:03	3	none																		1						
	13:00	13:01	1	none																								
	16:00	16:14	14	none								1										3						
2023/9/5	NA																											
2023/9/6	NA																											
2023/9/7	NA																											
2023/9/8	NA																											
2023/9/9	NA																											
2023/9/10	8:00	8:15	15	none								1																
	9:00	9:03	3	none																								
	14:00	14:15	15	none								4																
	16:00	16:15	15	none						1												2						
	18:00	18:15	15	none								1																
2023/9/11	8:00	8:12	12	none						4												1						
	12:00	12:15	15	none																								
	14:00	14:02	2	none																								
	16:00	16:15	15	none													1											
	17:00	17:15	15	none						2																		
	18:00	18:10	10	none																								
2023/9/12	8:00	8:02	2	none																								
	12:00	12:15	15	none													1						21					
	14:00	14:15	15	none																								
	15:00	15:15	15	none																								
	16:00	16:15	15	none																								
2023/9/13	9:00	9:09	9	none			5																					
	10:00	10:08	8	none			1																					
	11:00	11:15	15	none							1	2																

Table F2. Four-letter Alpha Codes, in accordance with the 64th AOS Supplement (2023) by Peter Pyle and David F. DeSantis, The Institute for Bird Populations. “\*” denotes non-intuitive codes, i.e. not the first letter of every part of the name.

Four letter code	Common name
BFAL	Black-footed Albatross
BLKI	Black-legged Kittiwake
BRBO	Brown Booby
BULS*	Buller’s Shearwater
COPE	Cook’s Petrel
FFSH	Flesh-footed Shearwater
FTSP	Fork-tailed Storm-Petrel
HAPE	Hawaiian Petrel
LAAL	Laysan Albatross
LESP	Leach’s Storm-Petrel
LTJA	Long-tailed Jaeger
MOPE	Mottled Petrel
MUPE	Murphy’s Petrel
NOFU	Northern Fulmar
PAGP	Pacific Golden Plover
PAJA	Parasitic Jaeger
PFSH	Pink-footed Shearwater
POJA	Pomarine Jaeger
PRPE	Providence Petrel
REPH	Red Phalarope
RFBO	Red-footed Booby
RNPH	Red-necked Phalarope
RTTR	Red-tailed Tropicbird
SBAG*	Slaty-backed Gull
SOSH	Sooty Shearwater
SPSK	South Polar Skua
STTS*	Short-tailed Shearwater
TRSP	Tristram’s Storm-Petrel

Table F2. Survey dates are listed in rows 1 and 2, from 9 August to 13 September. All species and species groups recorded are listed in column A. A number indicates how many individuals of a species were recorded during the sum of all bird survey time blocks in a given day. An “x” indicates that a species or species group was seen that day, outside of the bird survey time blocks. An “o” indicates species seen on days with no survey effort.

Month	Aug																															Sep																					
Date	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13																	
Red-necked phalarope	1			x		x																																															
Red phalarope		1		2		x	x	x			3	1	11					1	1								x																										
Black-legged kittiwake	x	x																																							x	x		6									
Slaty-backed gull																																															x						
South polar skua		1		1	x		x																					x																		x							
Pomarine jaeger						x																																									x						
Parasitic jaeger									1														1	1	x																												
Long-tailed jaeger	x	x							x									x																																			
Red-tailed tropic bird													x																																								
Black-footed albatross	x			x		x	x	x	x		x	x	x	x	2	x	x	4	x	o	o	o	3	x	x	x	x	x		x																							
Laysan albatross	x	3		x	x	2	x	x	x	x		x	x				x	3							x	x	x	x																									
Leach's storm-petrel	33	3		2	x	2	x	1	x	x	17	16	2	x	x	x		5	6	o	o	o	7	x	x		1	x																									
Tristram's storm-petrel							x	x	x		2	2											x				x																										
Fork-tailed storm petrel	6					2		1	x																		x	x																									
Northern fulmar	9																																																				
Cook's petrel									1	x	3	2	10	x	2	1	4	12	11					11	x	x	x	x																									
Mottled petrel	2	x		x		x																			1	7	x	x	x																								
Hawaiian petrel					x	1		3				1	2												x		x	x																									
Murphy's petrel	5	1																																																			
Providence petrel	1	1		1																																																	
Flesh-footed shearwater																																																					
Buller's shearwater				x		1	1	58	3	2	x							1	x																																		
Pink-footed shearwater							x																																														
Sooty shearwater	4	2		x		9	20	37	6	11								x	x	x					1	x	x	3	4	x																							
Short-tailed shearwater						x																						x																									
Red-footed booby								x																																													
Brown booby																		1																																			
Phalarope sp.							x													x																																	
Tern sp.																																																					
Jaeger sp.									x																																												
storm-petrel sp.																																																					
SOSH/STTS	x	x		x	x		x		3									x						x				1	x																								
MUPE/PRPE	1							2																																													

**Appendix G. Sightings in the US-EEZ with locations and sea surface temperature (SST).**

Date	Sighting No.	Species	Sch. size	Calf	Lat.	Long.	SST (°C)
2023 / 9 / 17	001	Fin whale	6	0	57 ° 26.3 ' N	155 ° 36.2 ' W	10.5
2023 / 9 / 17	002	Like fin	1	0	57 ° 22.6 ' N	155 ° 40.8 ' W	10.5
2023 / 9 / 17	003	Fin whale	1	0	57 ° 21.7 ' N	155 ° 41.5 ' W	10.4
2023 / 9 / 17	004	Fin whale	1	0	57 ° 21.3 ' N	155 ° 41.9 ' W	10.4
2023 / 9 / 17	005	Fin whale	2	0	57 ° 13.6 ' N	155 ° 50.1 ' W	10.8
2023 / 9 / 17	006	Fin whale	1	0	57 ° 13.6 ' N	155 ° 50.1 ' W	10.8
2023 / 9 / 17	007	Fin whale	1	0	57 ° 10.2 ' N	155 ° 54.4 ' W	10.6
2023 / 9 / 17	008	Like fin	2	0	57 ° 10.1 ' N	155 ° 55.1 ' W	10.6
2023 / 9 / 17	009	Fin whale	2	0	57 ° 07.7 ' N	156 ° 00.0 ' W	10.6
2023 / 9 / 17	010	Killer whale	2	0	57 ° 05.3 ' N	155 ° 57.4 ' W	10.8
2023 / 9 / 17	011	Fin whale	1	0	57 ° 03.9 ' N	155 ° 58.9 ' W	10.8
2023 / 9 / 17	012	Like fin	1	0	56 ° 57.4 ' N	156 ° 07.0 ' W	10.8
2023 / 9 / 17	013	Fin whale	1	0	56 ° 45.7 ' N	156 ° 18.6 ' W	10.9
2023 / 9 / 17	014	Fin whale	1	0	56 ° 41.4 ' N	156 ° 20.3 ' W	10.8
2023 / 9 / 17	015	Fin whale	1	0	56 ° 35.3 ' N	156 ° 24.9 ' W	10.6
2023 / 9 / 17	016	Fin whale	3	0	56 ° 35.3 ' N	156 ° 24.9 ' W	10.6
2023 / 9 / 17	017	Fin whale	3	0	56 ° 35.3 ' N	156 ° 24.9 ' W	10.6
2023 / 9 / 17	018	Fin whale	1	0	56 ° 34.6 ' N	156 ° 25.5 ' W	10.6
2023 / 9 / 18	001	Fin whale	1	0	56 ° 18.0 ' N	157 ° 11.9 ' W	10.0
2023 / 9 / 18	002	Fin whale	2	0	56 ° 17.8 ' N	157 ° 12.8 ' W	10.0
2023 / 9 / 18	003	Killer whale	3	0	56 ° 09.3 ' N	155 ° 09.0 ' W	8.5
2023 / 9 / 18	004	Killer whale	3	0	56 ° 07.8 ' N	155 ° 10.2 ' W	8.5
2023 / 9 / 19	001	Fin whale	2	0	55 ° 39.6 ' N	155 ° 16.4 ' W	9.2
2023 / 9 / 19	002	Fin whale	1	0	55 ° 41.2 ' N	155 ° 24.6 ' W	9.8
2023 / 9 / 19	003	Fin whale	1	0	55 ° 40.9 ' N	155 ° 28.5 ' W	10.0
2023 / 9 / 19	004	Fin whale	3	0	55 ° 40.9 ' N	155 ° 32.1 ' W	9.3
2023 / 9 / 19	005	Fin whale	1	0	55 ° 40.6 ' N	155 ° 33.8 ' W	9.2
2023 / 9 / 19	006	Fin whale	1	0	55 ° 38.1 ' N	155 ° 35.9 ' W	9.2
2023 / 9 / 19	007	Fin whale	3	1	55 ° 37.1 ' N	155 ° 38.8 ' W	9.3
2023 / 9 / 19	008	Fin whale	1	0	55 ° 39.3 ' N	155 ° 40.2 ' W	9.3
2023 / 9 / 19	009	Fin whale	1	0	55 ° 39.6 ' N	155 ° 46.4 ' W	9.3
2023 / 9 / 19	010	Fin whale	2	0	55 ° 39.0 ' N	155 ° 50.9 ' W	9.8
2023 / 9 / 19	011	Fin whale	1	0	55 ° 37.8 ' N	156 ° 00.5 ' W	10.0
2023 / 9 / 19	012	Fin whale	2	0	55 ° 39.6 ' N	156 ° 08.3 ' W	9.7
2023 / 9 / 19	013	Fin whale	2	0	55 ° 39.9 ' N	156 ° 13.7 ' W	10.0
2023 / 9 / 19	014	Dalli type Dall's porpoise	4	0	55 ° 37.5 ' N	156 ° 23.7 ' W	9.8
2023 / 9 / 19	015	Fin whale	2	0	55 ° 37.3 ' N	156 ° 25.9 ' W	9.9
2023 / 9 / 19	016	Fin whale	2	0	55 ° 36.2 ' N	156 ° 28.6 ' W	9.9
2023 / 9 / 19	017	Like fin	1	0	55 ° 35.9 ' N	156 ° 30.2 ' W	10.0
2023 / 9 / 19	018	Fin whale	2	0	55 ° 35.8 ' N	156 ° 31.0 ' W	10.0
2023 / 9 / 19	019	Fin whale	1	0	55 ° 35.6 ' N	156 ° 38.5 ' W	10.1
2023 / 9 / 19	020	Fin whale	2	0	55 ° 34.6 ' N	156 ° 41.1 ' W	10.1
2023 / 9 / 19	021	Fin whale	1	0	55 ° 34.6 ' N	156 ° 46.7 ' W	10.1
2023 / 9 / 19	022	Fin whale	3	0	55 ° 34.6 ' N	156 ° 47.9 ' W	10.1
2023 / 9 / 19	023	Fin whale	1	0	55 ° 34.5 ' N	157 ° 01.4 ' W	9.9
2023 / 9 / 19	024	Like fin	1	0	55 ° 34.0 ' N	157 ° 04.8 ' W	10.0



Date	Sighting No.	Species	Sch. size	Calf	Lat.	Long.	SST (°C)
2023 / 9 / 19	025	Fin whale	6	0	55 ° 33.3 ' N	157 ° 11.0 ' W	9.8
2023 / 9 / 19	026	North Pacific right whale	1	0	55 ° 34.5 ' N	157 ° 12.6 ' W	9.9
2023 / 9 / 19	027	Fin whale	7	0	55 ° 36.2 ' N	157 ° 15.7 ' W	9.9
2023 / 9 / 19	028	Fin whale	1	0	55 ° 38.6 ' N	157 ° 27.5 ' W	10.0
2023 / 9 / 20	001	Fin whale	1	0	55 ° 38.8 ' N	157 ° 17.2 ' W	9.8
2023 / 9 / 20	002	Fin whale	1	0	55 ° 38.2 ' N	157 ° 17.7 ' W	9.8
2023 / 9 / 20	003	Fin whale	1	0	55 ° 37.8 ' N	157 ° 20.8 ' W	9.7
2023 / 9 / 20	004	Fin whale	1	0	55 ° 38.0 ' N	157 ° 20.7 ' W	9.7
2023 / 9 / 20	005	Unid. large baleen whale	1	0	55 ° 38.7 ' N	157 ° 20.3 ' W	9.8
2023 / 9 / 20	006	Like minke	1	0	55 ° 39.2 ' N	157 ° 20.1 ' W	9.8
2023 / 9 / 20	007	Fin whale	2	0	55 ° 39.4 ' N	157 ° 20.0 ' W	9.9
2023 / 9 / 20	008	Unid. Cetacean	1	0	55 ° 42.5 ' N	157 ° 16.8 ' W	10.0
2023 / 9 / 20	009	North Pacific right whale	1	0	55 ° 42.5 ' N	157 ° 19.9 ' W	10.0
2023 / 9 / 20	010	North Pacific right whale	1	0	55 ° 43.1 ' N	157 ° 21.6 ' W	10.1
2023 / 9 / 20	011	North Pacific right whale	2	0	55 ° 43.3 ' N	157 ° 24.1 ' W	10.1